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CALIFORNIA ENERGY COMMISSION

TRANSPORTATION LEAD COMMISSIONER WORKSHOP

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| In the Matter of: | ) | Docket No. 15-MISC-04 |
| Technology Merit Review: | ) | |
| Medium and Heavy Duty Vehicle | ) | |
| Project Success | ) | |
| | ) | |

CALIFORNIA ENERGY COMMISSION

FIRST FLOOR, ART ROSENFELD HEARING ROOM

1516 NINTH STREET

SACRAMENTO, CALIFORNIA

WEDNESDAY, DECEMBER 2, 2015

9:00 A.M.

Reported by:

Peter Petty

# APPEARANCES

## COMMISSIONERS PRESENT

Janea Scott, Lead Commissioner, Transportation Committee

## CEC STAFF PRESENT

Tim Olson, Fuels and Transportation Division

Larry Rillera, Vehicle Technology Development, Manufacturing and Business Development

Hieu Nguyen

## PRESENTERS

Tom Hodek, Cummins Westport, Inc.

Joe Impullitti, SCAQMD

Ian Wright, Wrightspeed, Inc.

Mike Simon, Transportation Power Inc. (TransPower)

Jim Castelaz, Motiv Power Systems, Inc.

Kent Leacock, Proterra, Inc.

Rob Del Core, Hydrogenics USA, Inc.

## REVIEWERS/COMMENTERS

Robert Nguyen, California Air Resources Board

Kevin Walkowicz, National Renewable Energy Laboratory

Kuang Wei, United States Environmental Protection Agency

Margo Melendez, National Renewable Energy Laboratory

Matt Miyasato, South Coast Air Quality Management District

APPEARANCES

PUBLIC COMMENT

Ryan Schuchard, CalStart

Jerry Wiens, Retired Annuitant, CEC

P R O C E E D I N G S

9:03 A.M.

SACRAMENTO, CALIFORNIA, WEDNESDAY, DECEMBER 2, 2015

(The meeting commenced at 9:03 a.m.)

COMMISSIONER SCOTT: Welcome. We are going to go ahead and get started. I am going to turn the introductions over to Tim Olson.

MR. OLSON: Thank you, Commissioner.

Good morning. We would like to begin our workshop today to discuss the Medium and Heavy Duty Vehicle Project Successes. This workshop will be led by Commissioner Janea Scott who is the, by the way of introduction, is the Commissioner's -- is the Energy Commission's Lead Commissioner on Transportation Topics and Issues.

My name is Tim Olson of the Fuels and Transportation Division and I'll be a co-moderator today.

The workshop should last most of the day. And we'll have one -- one break at lunch hour. Feel free to use the restrooms located outside the front door here to the left. And there's a snack bar on the second floor. If you need to use that, go up the steps to the second floor.

In case of an emergency, go out of the room here, out the door to the left. And then we'll convene in the park across the street at 9th and B Streets.

And just this workshop is the second in a series of activities we've been conducting. And it's part of kind of a new ongoing function at the Energy Commission that we're referring to it as a Technology Merit Review. We will focus on the merits of truck and bus demonstration and deployment projects co-funded by the Energy Commission's Alternative and Renewable Fuels and Vehicle Technology Program. We refer to that as the ARFVTP; you'll hear that several times today. And to begin, Commissioner Scott will provide some overarching remarks about the program. And Larry Rillera will describe some of the historical spending and the kind of near-term plans for -- for our effort on medium and heavy duty vehicles.

You -- you may have the agenda in front of you. You can see from that that the rest of the workshop will involve a series of presentations by funding recipients, and comments from independent reviewers after each presentation. The agenda lists the order of each presentation and comment period, which we hope will last no more than 45 minutes for each session. And we'll kind of remind you if we start going over.

COMMISSIONER SCOTT: We will remind you.

MR. OLSON: After all the presentations and review comments are completed we have scheduled an open public comment period. And if you would like to speak during

that -- that general comment period, please fill out a blue card, there are little cards that we have back on the -- on the front table, I'll bring those out, if you're in the room. And if you're participating remotely, please identify yourself, either on WebEx or by -- on the phone.

And I'd like to remind you that -- that a verbatim transcript is being developed for this -- for this workshop. It will be made available on our public docket. And the audio and PowerPoint presentation are broadcast through WebEx.

So if you're speaking in the room, please use the microphone and speak clearly so we can -- everybody can hear you. And the transcriber will probably ask many of you for your business card, just to make sure your name is correct. He's sitting right at the from there.

You may also submit comments and/or public record through an e-filing process. That's -- the instruction on how to do that is in the workshop notice. And that will go into our docket.

In the back of the room toward the -- as you walk in the door here you've got the agenda, copies of all the presentations. And all those items are either posted now or will be posted on our website under the Transportation Alternative Fuels Technology Merit Review. That's how you'll find that.

So now I'd like to go back to Commissioner Scott and we can begin the workshop.

COMMISSIONER SCOTT: Great. Thank you very much, Tim.

I would just like to say welcome to all of our reviewers and our project presenters this morning and give you a little overview of our program. And then we'll turn it over to Larry.

As you all know, the Energy Commission's Alternative and Renewable Fuels and Vehicle Technology Program, or ARFVTP, was created by Assembly Bill 118. And we've provided about $100 million a year since 2009 to develop and deploy innovative technologies that transform California's fuel and vehicle types to help attain the state's climate change policies.

The ARFVTP funding compliments actions undertaken through AB 32, the Global Warming Solution Act of 2006, the Low Carbon Fuel Standard, and Governor Brown's recently Sustainable Freight Executive Order, in addition to other federal, state and local government policies and programs.

The Commission has awarded $172 million for vehicle development and deployment projects from 2009 to 2015, including 42 truck and bus demonstrations and buy-down incentives supporting the introduction of about 4,500 natural gas trucks in California. We also note that each

funding recipient contributes private investment equal to and often times greater amounts of matched funding to help supplement the ARFVTP awards. In addition, the Commission has awarded funds for renewable fuel production projects and alternative and renewable infrastructure projects to help compliment the vehicles' successes.

We appreciate the contributions that all of our funding recipients have made to achieve multiple policy objectives. And today we will hear from seven companies or partners that have agreed to highlight key ingredients for progress and success and, in part, their experience and knowledge about lessons learned and pitfalls to avoid. Through their efforts we have begun to see the introduction of an array of all-electric, natural gas, hydrogen and hybrid technologies used in transit, school bus, refuse trucks, shuttle bus, drayage trucks, and many other applications. It's exciting.

We would like to thank the five independent reviewers who will offer comments and advice about the progress of current efforts and future expansion of the program's success. We expect the findings and conclusions we learn about today to help inform our future funding efforts, provide insights to consider for upcoming integrated energy policy reports, and feed into the Sustainable Freight Executive Order to transition to zero

and near zero-emission vehicles for goods movement.

So I want to thank you again for joining the workshop. I look forward to all of the presentations, all of the questions and the comments. I would -- for the -- for the folks around the table, if your microphone is green, that means it's on. So if you're not speaking you might want to have it off. And when you are speaking, please make sure that it's green so that it's on.

And for the folks on the WebEx, as we get into the discussion from our reviewers it would be helpful if you'll remember to say your name and where you're from, just so that they -- the people who are on the WebEx can follow along.

So let me turn it now over to Larry Rillera who is going to give us an overview of the Medium and Heavy Duty Vehicles Technology Projects.

Go ahead, Larry. Good morning.

MR. RILLERA: Great. Thank you, Commissioner.

My name is Larry Rillera. I'm the Lead Staff for Vehicle Technology Development, Manufacturing and Business Development. As soon as this is loaded up we'll -- we'll get started on my presentation. It will focus on landscape and context for our investments under the Alternative and Renewable Fuel and Vehicle Technology Program. We will cover several dimensions that will be important to the

discussion for the rest of the day with respect to the specific projects and elements that will tease up some of those unlodged thoughts as you awake this morning, as well.

With respect to the -- the authority for the program, it was established under AB 118 in 2007. It was extended through our AB 8, Assembly Bill 8, and provides, essentially, $100 million through 2024. Its purpose is to transform our transportation market with respect to alternative fuels and technologies, and to reduce petroleum dependence. Specifically, in the code we are to develop and deploy innovative technologies that transform California's fuel and vehicle types to attain the state's climate change policies.

Some of the key drivers that the companies that this program has supported and continues to turn into viable products in the market include several executive orders with respect to greenhouse gas reduction, zero-emission vehicle mandate, or we will refer to ZEV, the Federal Clean Air Act and its provisions with respect to NOx, and more recently the California Sustainable Freight Strategy through executive order issued this year, and the GHG reduction targets issued through executive order this year, as well. I would also note that these are formal policy articulations.

There are several areas of engagement, and I will call them less formal but certainly significant in terms of administrator processes that drive this program. And one of them would be the ARFVTP Investment Plan. That is an investment -- annual document prepared by Staff with -- in a collaborative fashion with our stakeholders to identify those funding priorities and the issues that are driving those investment decisions.

The second one is the Integrated Energy Policy Report, or referred to as our IEPR, which is a development document, a policy document across the Commission and it includes issues related to transportation.

The discussion today will center around medium and heavy duty vehicles and vocations. We are -- we are not primarily concerned with respect to this discussion on the light duty side. That being said, we're looking at Class 3 through Class 8, as this represents about three percent of the vehicles in California. But more significantly, it represents a huge opportunity to address GHG emissions. And given the -- the plethora of platforms, vehicle sizes, duty cycles, this represents a challenge and a great opportunity for us to continue to leverage investments and continue investments, not only with our program but as the companies leverage private investment, as well.

This is a little bit of a busy slide, but I want

to set some context for this because it draws in the dimensions of not only private financing, public financing, but it articulates sort of the product development continuum that companies are addressing now. This is based on a construct through some work I had done on renewables with respect to Bloomberg and the Pew Charitable Trust. At the top is, essentially, the conventions for the technology and the stages and the various nomenclature for -- for those areas.

In the middle section, beginning with TRL and MRL, those are the federal conventions for Technology Readiness Levels and the Manufacturing Readiness Levels. Conventional private financing in the various stages on the private side. And then the last row in green is the public funding that's available for the various stages of product development. In gray we have sort of a snapshot history of what we have funded at the Energy Commission, a little bit on the PIER, our Research and Development Division, as well as what we have done here through the ARFVTP program.

Starting back in 2010, 2009 were our initial solicitations in demonstration and manufacturing. We have -- we offer both sort of funding for the technology creation through early commercial, if you will, or more mature commercial product development. One of the things I would highlight in the commercial box, the bottom and the

green to the right is that our sister agencies also provide funding for financing solutions for -- for the -- for you, and that would include Carl Moyer under -- with ARB program, the Prop 1B, CPCFA is the California Pollution Financing Control Authority, as well as CAEATFA, the California Advanced Energy Transportation Finance Authority [sic]. They offer sales and use tax exemption which many of the companies here and in other areas of the ARFVTP have leveraged. And, of course, some of the DOE funding opportunities, as well.

I would draw your attention to one of the other sort of more mature financings we have here at the Energy Commission, and that would be the second box in gray from the bottom which is our 2015 Pilot EVCS Financing Program. This is the Electric Vehicle Charger -- Charging Station Financing Program that is to finance through a credit enhancement, through the Treasurer's Office, CPCFA. Most of the engagement for -- for borrowers in this area have come from actually the medium duty. There's some interest in light duty, but medium duty has been a significant discussant with the Treasurer's Office and this financing.

The last row down here is the pending solicitation we have now, and I'll go into a little bit more detail later on -- on the next solicitation, the one that's in development and will be issued here within the next quarter

or so. You would note that it spans the width of your demonstration pilot, very early scale post-prototype development to full commercial solution. The investment plan identifies funding for demonstration or for manufacturing or scale-up.

Our demonstration portfolio includes 42 projects over 250 units or vehicles or pieces of equipment worth $90 million. We've seen the technologies and the vehicle types grow since the program's inception. And we continue to see a lot of diversity in not only the platforms, but also the -- the applications and the fuel types that are -- are -- will go into this portfolio. And this is the context also for the -- for the companies that will be speaking today and will be -- and will be vetted, as well.

With respect to the most recent solicitation which was issued almost a year ago with the last agreement going to the full Commission for approval in September, this is the list of projects I put up here in the next slide. I want to highlight not just the recipient and the title. You can tell what product they're -- technology they're demonstrating. But I want to draw attention to the column on -- on partners. I think when we hear the voices of those that present and speak today, know that there is a strong and cohesive project team behind each one of these efforts. And I simply wanted to highlight some of them here and some

of them on the -- on the next page.

We issued 11, excuse me, 11 projects, approved 11 projects worth $31 million effecting 42 vehicles. Estimated total demonstration miles is over 1 million. We estimate also that the total demonstration hours was over half-a-million. Total demonstration length is almost 650 months over the life of the $31 million investment, and that is the just the demonstration period. That is when the -- the product, the technology will be in the field demonstrated. This is not the frontend work and this is not the post-data collection, post-demonstration data collection work.

Estimated -- estimates for the GHG reduction and petroleum reduction, the number of jobs retained. And I will also draw your attention that all these projects will either be conducted within or benefit disadvantaged communities. And that is a significant policy articulation that the Energy Commission and the ARFVTP Program subscribes to and incorporates into its solicitation.

We also issued a solicitation for $10 million for manufacturing. The following companies are noted. We will hear from Proterra which is establishing a new line here in California. And then TransPower, EDI, Efficient Drivetrains, and Zero will be expanding manufacturing capacity to scale up.

I would note that for the third project we had --

of course, we're capped at $10 million. We work with the potential application, the recipient, to identify if whatever residual amount of money is available, if they're -- if they're all in. And in this case Zero Motorcycles was all in for the residual amount of money and continues to support their plans for expansion.

The other dimension of our portfolio includes natural gas vehicle deployment. Here's some articulation of the various solicitations and agreements that have been developed. As Commissioner Scott had indicated through her opening remarks, we have over 4,500 vehicles, approximating $65 hundred million dollars in value.

There's a little error. Staff, I own it, proposed 2015-16. This is actually the proposed 2016-2017 Investment Plan. This is what is on the street right now. Staff has prepared this in its current investment plan. This is to articulate the most recent year investment plan activities and allocations and what is proposed for the new year.

I simply want to tee up the fact that we have funding for infrastructure and that will be significant to the discussion today. We don't want to overlook the value of infrastructure in these field categories to support your -- your demonstrations, and that will be significant.

I also want to articulate the second section there in gray, starting with medium and heavy duty vehicle

technology demonstration and scale-up is combined, both last year and this new year, with manufacturing to the tune of $23 million. So decisions have not been finalized on how we address and incorporate both of those components into a solicitation. Staff continues to work on that and, of course, looks to your feedback in the development of the solicitation in this area.

That being said, a few links to our program, our website. And as we continue the rest of the discussion we'll -- we'll have other information available that you can -- you can leverage. Thank you.

I'll turn it over to Tim.

COMMISSIONER SCOTT: I think we have a couple minutes. Are there any questions from around the table for Larry on any of that? Okay. Great.

Let's turn it over to Tim.

MR. OLSON: Okay. So we're going to start the presentations for today. And what I'm going to do is introduce the first person.

And then after he's completed his presentation -- and, Tom, you can come up here if you want to do that yourself.

And then -- then I'll introduce the reviewers once he's completed his presentation.

So Tom Hodek is our first speaker. He represents

Cummins Westport, Inc. And he's currently Program Leader for New Product Development and has held several positions in the company, including Cummins Global Business -- Bus Business, VPI Product Development. He previously worked as a Design Engineer with Recon Optical. And he's a graduate of Purdue University with a Bachelor's Degree in Mechanical Engineering. And Tom is going to talk about his low-NOx natural gas engine.

MR. HODEK: Thank you, Tim.

Right here? Barred by wire here. Okay.

Good morning, everyone. Again, Tom Hodek with Cummins Westport. And I want to thank the Commission for having us here today to talk about this -- this program. We have some pretty exciting news today. In fact, we even have a truck sitting outside for you to take a look at, put your hands on, and just not too close because it's a refuse truck. But it's something you can actually see some -- some fruits of our labor and -- and your contributions.

Just to set the stage, though, for the discussion, back in 2010 the emissions requirements for NOx emissions, oxides of nitrogen, came down to .2 grams per brake horsepower, and the industry said uncle. They said that's enough. Without redoing all the engines and plants and tooling and everything else we've reached the limits of technology, which -- which EPA and ARB tentatively said,

okay, that's -- that's as good as you can do, fine, but we're not done. They wanted to go further.

And they have subsequently developed new programs. And being on the natural gas side of the business we thought there was some potential there, so we approached really our partners here, AQMD, California Energy Commission and So Cal Gas, and presented and opportunity with some funding to perhaps advance the state of the art. And that's pretty much what we've done right now.

So what I'd like to do is go into a bit of a discussion about where we're going. We did get a contract. This is a contract number through AQMD. And this is actually one of the deliverables. We are to show -- demonstrate in a vehicle near-zero NOx. And what we show you here is -- this is actually down at UC Davis -- I'm sorry, UC -- what's the other one --

UNIDENTIFIED MALE: Riverside.

MR. HODEK: -- Riverside, thank you, and it's right on the side of the van there. Okay. This is a Peterbilt truck from Waste Management. And it's in a chassis dyno right now. You can see the -- the Mobile Emission Laboratory from Riverside is attached to the vehicle, and they're actually measuring emissions right here on a vehicle in -- in a real vehicle in a chassis dyno. So we've completed this about six months ahead of schedule.

But we're also -- the good news here is that we're not just stopping with the demonstration, we're actually going a lot further, and we're going to bring this product to market next year. So this is an opportunity for the -- the air to get a little bit cleaner a little bit sooner. And we still have a lot of work to do, but when we looked at the results, and I'll explain to you kind of our validation process here, we said this makes sense to do now as opposed to wait until later.

You know, why near-zero NOx? It's pretty clear, and this might be a bit redundant for those in the room, but even if all the vehicles today were at the standard on the road we'd still be in non-attainment zone here in Southern California and other places within the state. But on top of that, it's not just really a California play in that there a bunch of non-attainment zones around the country, as well, who do not comply for whatever reason. And there's a bigger market than just Southern California. So this technology can be used -- we're trying to get EPA engaged in this a little bit further and they seem to be receptive, but this is a bigger play than just Southern California. And it's going in the right direction for our climate change opportunities here.

So just a couple of minutes on the Cummins Westport process. There are three levels of developing a

product at the company. And PPT is Product Preceding Technology. And this is where all our scientists and Ph.Ds. and people who are really brainy get together and they develop new concepts and new technologies. And when they're to the point where they've passed their gate reviews they put them on the shelf pretty much and say here's a new technology for all your production guys out there. If you ever want to use it, this is available.

We started this program in the PPT phase. And it was a dollar-for-dollar match agreement with -- with the agencies. And we've put our money in, they've put in the money, and we've taken this product to -- through the PPT phase. There are a lot of things that came out of PPT we're not finished with. There's still a lot more to do. But what they did put on the shelf was things that we could take and bring to market sooner.

So that goes to the next level here which is VPI, which is Value Package Introduction, and that's where we take these PPT ideas and we put them through a rigorous process. It's -- I could bore you with the details, but not today. And we validate the product and get it through all of our processes to make us feel as though we have a producible and marketable and durable product. And that's where are right now with this product.

So the 8.9 liter ISL-G (phonetic) product, we have

taken this and put it in the VPI channel with learnings we've had from our PPT process. And we are in the -- I'll show you a program schedule here in a minute, but we're very close to having this product ready to sell to the marketplace early next year.

And the last level there is production. Once you get through the VPI process, you've done all your field trials and validation, you've done all your PPAPs and FMEAs and everything else that goes along with this and you've got your -- your product to the best point you can before you go to production.

This is a very high-level program schedule for the program. But the red stop signs are called M Reviews. And there are six of those -- actually seven of those in a process. We've actually gone fast enough here where we can double a few of those up.

Just last month we passed our M3 Review which is stable performance. And the blue line on the bottom there is our field test. We've got -- we've got six vehicles running in the refuse business right now, three in Santa Ana, three in Oakland. The truck we have sitting outside is from Oakland. And Waste Management was gracious enough to let us borrow that for the day. And we have six transit buses down in San Diego running, as well. So all these vehicles are running.

The bottom line here is something out of our control which is the OEM readiness line. And we can only put this up to the OEM's, our delivery partners, and say here you. And they've got to come to the market and say, well, invest in the integration of that product and put it on the market.

So the green shaded area is where we are in the program. So it's the end of November, first of December. And you can see here, that looks like by the end of March is where the full production line, the little triangle there at the bottom, starts. So we're -- we're getting pretty close here and so far we're on track.

Just a little bit about the engine. If you're not familiar with the ISL-G, it's an 8.9 liter 6 cylinder, inline 6, charged-air cooling, spark ignited. It's not a duel fuel. It's pure natural gas with a spark ignition. It's a stoichiometric three-way catalyst cooled EGR architecture. It goes up to 320 horsepower and 1,000 foot pounds of torque. It is certified to the current standard of .2. We have recently certified the product to the new optional low-NOx standard of .02, and a PM level of .01, which it's been that way for a long time. We're also certified to the 2016 EPA NHTSA Greenhouse Gas Standards. We do require new after-treatment for this product, and it is manufactured in Rocky Mountain, North Carolina where we

manufacture all of our ISB, C and L products today, both diesel and gas. Okay.

The markets for the product right now, and this is where we're going to be going with it, are transit, refuse, the medium duty class, I'm saying 6 through 8, but the 8, we're on the light end of that, we'll try to keep it out of the 8, vocational, shuttle bus, and school buses, all of which are on the ISL-G today.

And the next picture here is a slide showing our executive orders, both from ARB and EPA. And to help you out a little bit I tried to enlarge this. And hopefully you can -- it's probably still an eye chart. But of interest here is the NOx column.

Will my mouse go -- there we go.

Here's the NOx column, and that's oxides of nitrogen. The standard is -- the optional standard is .02 grams for the transient cycle and .02 grams for the steady state cycle. And we actually certified this product at half of that, so .01 grams, and .004, which rounded up from .0038, on the steady state level. Okay. So we're -- we're well below the near-zero optional certification level with the product as we've certified it.

And down here in the greenhouse gas column, carbon dioxide, the standard is 550 grams. We came in at 465. So we're even really better than the phase two proposed

greenhouse standards that they're floating around right now for 2027. So we're in really good shape on emissions on this product. We still have a long way to go, but we thought this was good enough to get it out to the market as soon as possible.

If you'll indulge me for a minute I have one slide I'd like to build for you, because we keep getting feedback that, hey, we're at .2 grams as an industry and you can't get it any cleaner, and we've put a big dent in this. So I want to give you a visual on -- and you've seen this bar.

So in 1985 is when we first started regulating emissions. And in 1985 you had to be under 11 grams of NOx, and if you didn't you needed to change your product to get there, and that's when this whole thing started. And there are a number of other iterations that I just didn't want to put up here for time. But today we're currently at .02, which is the standard. And a 1985 bus put out as much emissions back then as 54 buses do today, so that's a huge accomplishment. And we've really done a good job in cleaning up the air.

But they say that we're done, we can't do any better. Well, you've done a good job. But when you go to low NOx, the near-zero NOx, here's what happens. So when you go down to .02, that's a ten time reduction which is 540 buses. So you just -- you've accomplished more by going to

low NOx than the whole time you have we've been reducing emissions so far. And if you want to get picky about it, we actually certified at .01, and so that doubles it again, or at 1,080 buses. So -- so where are today is in the red shaded area, okay, so 54 buses. But when you go to the low NOx you get this much value.

So -- so hopefully that takes you out of the decimal point and puts it into a perspective on -- on buses or refuse trucks or whatever you're doing. And so this is a big deal. This is actually helping us with air quality by going to the low NOx standard.

So what we've done with the product right now, this is the change to the product. Okay. This is -- there's a new data plate that goes on the engine to show the NOx levels to which we certify. There's a new calibration that we put in the electronic control module, the ECM, that operates. That's kind of the special sauce in there. There's a three-way catalyst that we produced today for the 12-liter product. And we also sell this engine over in Euro 6 standards that requires the same after-treatment, so the new after-treatment is required.

And then today on the product we have a blow-by tube where all the -- all the gases from the crank case vent to atmosphere. So if we have a misfire event where there's no combustion and that exhaust gas gets around the rings

into the crank case, it goes out to atmosphere eventually as methane, and that's -- that's even worse than carbon dioxide.

So what we've done is we've closed that loop. So there's a closed crank case ventilation system on this project that any misfires, any blow-by gases, any pollutants go through a filter, back into the engine, get re-combusted, and then out the tailpipe. And that's done a lot for achieving the -- the standards.

And then we have -- in 2018 we have an OBD requirement coming, so we're getting the jump on that right now. And we've put a diagnostic sensor on this -- on this pressure, this crank case sensor here so we -- we can tell if it's got any issues. It will turn a light on and tell you where the problem is. So we're getting a head start on OBD for 2018 already.

There's a picture of that -- that closed crank case ventilation system. That's a remote mount filter head that mounts on the vehicle. Then your -- your blow-by gases go through an impactor, they go to the filter, and then they go back to the turbocharger. And everything that falls out, precipitates out gets returned back to the crank case, so it's a totally closed system.

What we're trying to do, and I said there's more to do on this, we're trying to reduce misfire. We're trying

to reduce the interface with the OEM on this piece. This is -- OEMs aren't too happy about having to mount this on their firewalls or on their frame rails. So we're trying to integrate all this into the evidence, and we'll plan on doing that in the future. And there's a lot more to do, even on the emission's side, believe it or not, and we're getting there slowly.

The good news, though, is that through these changes there's no impact to the -- the power or the torque or the speeds. Everything stays identical to where it is today. So we still offer all of our ratings from 250 up to 320, and from 730 foot pounds all the way to 1,000 foot pounds. Nothing is really changing in that regard, so that's -- that's good for transparency.

I mentioned carbon dioxide was down. And typically carbon dioxide and -- and fuel economy are synonymous. So if you can lower your carbon dioxide you also improve your fuel economy. We have lowered the carbon dioxide. We haven't validated this yet in our field testing. But we do expect there to be a one to three percent improvement in fuel economy, on top of the cleaner emissions.

The feedback we're getting from our field test customers and our own in-house testing is that the drivability is unchanged. So we're -- we're getting a

pretty good feedback right now that the -- the improvements we're making for emissions are not compromising the drivability or the fuel economy on the -- on the product side.

One of the things in our VPI process I tried to explain is -- is durability. You know, we have to put this thing through a number of hours and miles and collect a number of warranty periods before we feel comfortable putting it out to the marketplace. What we've got right now, excuse me, are numbers that are showing no difference from today's ISL-G. So we don't expect there to be any -- any change in pressures or wear or anything of that nature that causes this to be a compromised product. And so that's why we're pulling the production launch up sooner, as opposed to pushing it out until later.

From a maintenance perspective there's only one change. I showed you that closed crank case ventilation system. There's a 2,000 hour filter change requirement on that. That's a pretty long time. And what we're doing right now is trying to develop a new system that does not have a filter, or rather it can self-clean itself so you don't ever have to maintain it over the life of the engine.

Again, our launch timing right now is -- we've got our certifications. And really we're the ones holding it back with our -- our VPI launch requirements, but we do plan

to do into production the second quarter of next year. We've been in contact with all the major OEMs. Obviously, you can see Autocar is onboard. They've got one here. That's actually a retrofit. We haven't -- it's not a production vehicle, but they're pretty ready to go, as well.

And we've -- we've come up with a pricing. I can't disclose the pricing here, we have to talk to our distributor folks about that or the OEMs, but that's been communicated already. So I think as we check our list of things we have to accomplish for a launch, we're in pretty good shape right now to hit that -- that March date for next year.

And did I go fast? Okay. That's it for me. Any questions?

MR. OLSON: Well, we're going to go through some --

MR. HODEK: So more stuff?

MR. OLSON: -- with a few panelists.

MR. HODEK: All right.

MR. OLSON: So hang out.

MR. HODEK: All right.

MR. OLSON: And I'll introduce them.

MR. HODEK: All right. Thank you.

MR. OLSON: Yeah. Tom, you can either stay up here or sit at your table down there. It's up to you how

you want to.

So, Commissioner, I'd like to introduce the reviewers who have -- all the reviewers have received information on each one of these projects in advance. And I know it's a lot of information, and I'm sure you read every page and -- so -- and they have -- they're welcome to make any type of comment, pretty much. They're -- I'll kind of introduce each one of them.

Right down in front of me here is Bob Nguyen. Could you raise your hand, Bob, just so people see you. He is currently the -- working in Strategic Planning and Development Section of the Mobile Source Control Division at the California Air Resources Board, and has worked on heavy duty truck hybrid technology and different -- different aspects of that, including certification procedures. He has 25 years of experience working at the Air Board. And he has a Bachelor's Degree in Chemical Engineering and Bachelor of Art's Degree in Social Science, San Jose State and California State University of Sacramento.

And next to him is Kevin Walkowicz who manages the National Renewable Energy Labs Simulation, Testing and Integration Group within the Transportation Hydrogen Systems Center. He has a long career, including work as an intern at Chrysler Corporation. He basically has a pretty strong background in overall transportation and heavy duty and

medium duty vehicles. Has a Bachelor's Degree in Mechanical Engineering and Master's Degree in Engineering from Rensselaer Polytechnic Institute.

Not here yet is Kuang Wei. He's representing USEPA, and should join us here soon, I think. He's the project officer with U.S. Environmental Protection Agency's Transportation and Climate Division.

Next down the list on the table here is Margo Melendez, also with National Renewable Energy Lab in the Transportation Market, Transportation Manager. She is here also representing U.S. Department of Energy, Dennis Smith, at his request. And she has a similar background, Emerging Transportation Technologies. She's been with NREL since 1999. And prior to that worked for Ford Motor Company. Holds a Bachelor's of Science Degree in Mechanical Engineering and a Master's Degree in Engineering Management from University of Michigan.

And at the end of the table is Matt Miyasato, Deputy Executive Officer of the South Coast Air Quality Management District, and has a long career at the South Coast Air District, Master's Degree in Mechanical Engineering, Ph.D. in engineering, UC Irvine. Previously worked for Southern California Edison and General Electric.

So that is our group of reviewers. Thank you all for being here today.

And so I'll turn it back over to you, Commissioner, to start the reviews.

COMMISSIONER SCOTT: Well, let me say welcome again to all of our reviewers. Thank you so much for taking time to kind of dig into these projects. And we'd love to -- I don't know if we want to start with Matt and work our way down or start with Bob and go this way, or however you'd like. But maybe some questions for Cummins.

You want to start, Matt? Go ahead.

MR. MIYASATO: Sure, I can start. I mean, clearly we support the project because we actually put in our funding. And we want to thank the Energy Commission and So Cal Gas for partnering with us, because getting to lower NOx emissions is critical for our region.

But, Tom, just some clarifying questions, some softballs for you. The engine footprint for the 8.9, the .02, I'm assuming is pretty similar to the previous version because you've retrofitted it on these Waste Management trucks. So how -- how --

MR. HODEK: You mean, the physical -- the physical fit?

MR. MIYASATO: The physical footprint --

MR. HODEK: Yes.

MR. MIYASATO: -- for the engine itself. So it should be a pretty seamless retrofit package the OEMs could

incorporate?

MR. HODEK: Yeah. So let me put a little more detail around that for you. Yes, it's an identical footprint, with the exception of that -- that impact where I showed you on top of the valve cover. There's a pressure sensor that goes up there now. That raises that piece by one inch. And then there's the CCV system that mounts on the vehicle somewhere. And the after-treatment is -- is about an inch in diameter larger than the ISL-G today, okay, and that's about it.

MR. MIYASATO: Okay. That's good.

MR. HODEK: Now I do want to make a point, though, that we've not trying to retrofit vehicles, we're trying to repower vehicles. The ISL has had a history, some of it not so good and some of it now is looking pretty good. So what we're trying to do is -- and we haven't tested this recipe on an older version of the engine. We've made a number of improvements on this product over the last three years, let alone the last seven years. So what we're trying to do is not just up-fit and not sure what we get into, but rather do a repower if it's an existing vehicle. And, of course, new is new.

MR. MIYASATO: I agree with that.

MR. HODEK: But the impact to the OEMs should be relatively minimal on refuse.

Transit bus is a little different in that that's all enclosed in the back of the bus there. But they so far are working well with us on that.

MR. MIYASATO: And then finally the -- on one of your slides you indicated that you're using the same catalyst as the 12 liter?

MR. HODEK: That's correct.

MR. MIYASATO: So does that mean the previous 8.9 had a different catalyst chemistry?

MR. HODEK: Yes. It's -- I'm not sure it's the wash coding (phonetic) or the chemistry, it's the size, physical area.

MR. MIYASATO: I see. Thank you.

COMMISSIONER SCOTT: Thanks, Matt. And I would also highlight how much we appreciate the partnership between South Coast and Southern California Gas with the Energy Commission on -- on these engines. So thank you for that.

Let's turn to Margo.

MS. MELENDEZ: So -- thank. I have heard this presentation before, so I don't have a ton of questions. And I love the story of we can't go anymore or we can't do any better, and then policymakers sort of putting a challenge out there and saying that this is what we need and you stepping up. So I think it's a really interesting,

amazing story, albeit a little depressing when I used to look like I could take one bus off the road and make a really big difference. And now I've got put this whole, from the deployment perspective, I've got to put this whole bunch of buses on the road. There's just a lot of buses on there, to think of trying to put all those on the road.

My question is related to volumes. So how many people do you think are going to be -- how many fleets are going to be interested in the .02 grams?

MR. HODEK: Oh, it depends how -- how incentives come along. I think a lot of folks already have raised a hand. I know one bus OEM has already taken an order for 66 units to build at the end of the year, before they even had pricing. So I know that there's an interest in this. I think there's a lot of discussion, at least in refuse and the -- the transit bus business that there are potentially incentives. They're all thinking this way anyway. They've invested in the infrastructure. They've invested in the -- the vehicles. And now they're trying to -- it's all there, so to take it to the next level, it's pretty easy. But it also I think depends on the incentives that come along with it.

MS. MELENDEZ: And do -- and will that be beyond California into like those up states, you think? Are you getting interest or is mostly --

MR. HODEK: We are hearing --

MS. MELENDEZ: -- here in right now?

MR. HODEK: We're --

MS. MELENDEZ: Again, that's probably based on incentives.

MR. HODEK: Yeah.

MS. MELENDEZ: There's probably a lot more here.

MS. MELENDEZ: We're hearing about -- a lot about incentives. But now we're also hearing, and this is very unofficial, it's just -- it's hearsay but I'm seeing it in emails, that there is not just North America but now there's Europe, and as of this morning China has raised their hand saying what's going on kind of a thing. So I think this is paralleling itself with -- with the global climate change flurry of activity that's taken place recently. And news like this travels fast. Who knows where it's going to go.

We're also a manufacturer of diesel engines. And it's not such an easy task to get there, and I think we all need to be sensitive about that. It's not just Cummins, it's -- it's everybody else in the game. And that's, like I said early, they -- they weren't kidding when they said uncle back in 2010 on .2. To get to this level requires a substantial investment in time and resources.

So I'm trying to temper all this and be fair about it. We happen to have natural gas as a fuel and this is

working pretty well right now. We figured out some good things. There's still a lot to do on this, as well. But I think -- I think we've got it cornered to the point where, yeah, other places around the country, if not the world right now, are interested in what's available.

COMMISSIONER SCOTT: Great. Kevin?

MR. WALKOWICZ: Yeah. Thanks, Tom. I'll second the comments on very impressive going from the -- the .2 to the .02. By the way, I only counted 1,079 buses up there.

MR. HODEK: I must have moved the slide too fast --

MR. WALKOWICZ: Yeah.

MR. HODEK: -- because I counted them. It's all there.

MR. WALKOWICZ: No. But it is very impressive. But I'm going to play the part of the skeptic for a minute.

MR. HODEK: Uh-huh.

MR. WALKOWICZ: Do you have any data on the -- the in-use emissions? Or you said you tested the -- the buses at UC Riverside. Do you have any data on performance of that bus versus the .2 version --

MR. HODEK: Yes.

MR. WALKOWICZ: -- versus a diesel or an older -- another older version --

MR. HODEK: Yeah. So --

MR. WALKOWICZ: -- on other drive cycles, chassis dyno drive cycles, besides what you showed the data on the -- the engine cert cycles?

MR. HODEK: That's -- that's a good question. The answer is yes and no. This is a new enough product right now. We haven't done a lot of line haul with it. But we are bound by requirements from the regulators that say there's -- there's a useful life requirement, so you must remain compliant over that useful life period. We do test for that. There's also a deterioration factor they apply to that useful life factor that says you can start here and end there and you get so much of a deterioration factor. We've been assigned that -- that DF value because it's a million dollar test and we didn't have a whole lot of time. But we'll certainly go do a DF test, if necessary, and that will help us better validate the useful life.

MR. WALKOWICZ: But that's based on the transient and steady state engine cycles; correct?

MR. HODEK: That's correct.

MR. WALKOWICZ: Do you have any -- are you planning on doing any real world drive cycles comparing --

MR. HODEK: Well, we do.

MR. WALKOWICZ: -- the vehicles?

MR. HODEK: We currently do.

MR. WALKOWICZ: Do you have the data?

MR. HODEK: Yes.

MR. WALKOWICZ: Where can we find that data?

MR. HODEK: That's a good question. Sorry. Can I get your card? I'll -- yeah.

MR. WALKOWICZ: I told you I was going to play the part of the critic a little.

MR. HODEK: That's -- it's a fair question.

MR. WALKOWICZ: I mean, we -- we do a lot of in-field testing --

MR. HODEK: Uh-huh.

MR. WALKOWICZ: -- looking at the old versus new technology and the difference between the engine cert cycles. And the real world --

MR. HODEK: Right.

MR. WALKOWICZ: -- usage performance is -- there's -- it's never linear, it's always -- there's always some differences there --

MR. HODEK: Always disparity, yeah.

MR. WALKOWICZ: -- depending on how you're using a vehicle. So that would be good to -- to know a little bit more about --

MR. HODEK: Okay.

MR. WALKOWICZ: -- the real world performance. I don't know if that's something --

MR. HODEK: That's a good question.

MR. WALKOWICZ: -- the CEC can --

MS. MELENDEZ: Yeah. In fact, Commissioner, can I --

MR. MIYASATO: Yeah. Can I comment? I believe next week the -- the staff is going to propose to the Commission to support another in-use or add-on in-use emissions testing program that the South Coast has partnered with the Energy Commission on to do something very similar to what you're suggesting, Kevin, is to look at different vocations, diesel, natural gas. I'm not sure we did include the .02 because it may not have been certified at the time, but I think that's a good addition.

MR. WALKOWICZ: Yeah. It's just good data to have.

MR. MIYASATO: Yeah.

MR. HODEK: Great.

COMMISSIONER SCOTT: Any other questions, Kevin?

MR. WALKOWICZ: No.

COMMISSIONER SCOTT: Okay. Bob?

MR. R. NGUYEN: Thank you, Tom, for a very nice presentation. And congratulations on what seems to be a very nice product. And I hope to see it commercialized soon.

I'd like to kind of follow up on Margo's questions on -- on volume. You can have a nice product, and it

appears that you do, but how much are you going to be able to sell it in terms of market penetrations. And it gets back to how much it's going to cost? I don't know whether that's something that you can disclose at this point? Or have you calculated what's a payback period? It doesn't seem like the fuel economy improvement is enough to incentive someone from purchasing this technology.

MR. HODEK: Okay. So -- so in our VPI process we have to calculate volumes and do an MPB for the program to show the company there's a return for this, and we've done a lot of that. And we think there is some -- some market share to gain away from diesel. And we certainly think that if you've already invested in natural gas it's a natural transition. We'll cannibalize ourselves in that regard, but at different margin level. I think it goes without saying, there will be a premium for the product. There are different components that -- that raise the price. And -- and right now that's -- I can't disclose the numbers, I apologize for that. But you can go outside to the table and talk to our distributor who is standing outside showing this vehicle and they might have an answer for you on that.

MR. R. NGUYEN: Any plans for any other engines besides the 8.9 that's in the works right now?

MR. HODEK: Yes. We have two other products in our -- in our product line. We have the ISB 6.7 that will

launch next April, and that's for the -- the school bus market, small trucks, yard spotters, the lower end of the spectrum. It will -- it will launch at .1 gram. So it's already going to be a low NOx product. That one already has the architecture for near-zero. So it already has the CCV system on it. It has the ISL-G's after-treatment, so it's been handed down. And that one requires some more funding to get it to -- to market sooner. Otherwise, we have to go at our own pace.

And then probably of bigger interest is the 12-liter, the ISX 12G, our Class 8 truck engine. We're working on that one right now, as well. That one is a bigger challenge. We don't have an after-treatment to hand down to the next level. That's a new after-treatment, so we need to develop that one. Cummins Emission Solution is working with us on that and we're trying to make that -- that happen. We're also trying to leapfrog out CCV system and get away from the filter and just for a non-maintainable type that's engine mounted, and all the things that we need to do to do near-zero NOx. But we're kind of hamstrung right now by the resources we have and the 2018 OBD. So we're working with -- I think with ARB on how we manage that, which is a priority. The near-zero NOx is at the OBD.

So for folks that don't know what OBD is, that's onboard diagnostics. And that's in your car. When the --

the little lamp comes on and tells you something is wrong with your emissions system, the same thing applies to natural gas in 2018. So anything that goes wrong that has to do with emissions on the product is going to turn a light on in your dash. And that's -- where you set those thresholds is critical, otherwise the light keeps coming on all the time, or not turning it on enough is a problem to. But that kind of keeps us honest, you know, on how we're doing on emissions and the components that are in the system.

So that's -- that's what we're facing in 2018. And -- but we have it in our scope. It's on the radar screen for both of the other products because we think this is the right direction. And we think having all three platforms at near-zero NOx is probably a good idea.

MR. R. NGUYEN: All right. Thank you.

MR. HODEK: Thank you.

COMMISSIONER SCOTT: Any questions from others at the table for Tom? Okay.

Well, thank you very much, Tom, for your excellent presentation, and reviewers for your thoughtful comments.

I'll remind folks that the engine is out front. So a nice opportunity to go out there and kick the tires and see it in real life.

One of the things that I think the Energy

Commission is really excited about, in addition to this incredible new engine, is the -- the possibility of being able to combine it with renewable natural gas which will bring down emissions even more. So that's -- that's something we're very excited about.

I'll remind folks that we kind of have this going straight through. So if you need to take a little break and use the facilities or whatnot, just feel free to kind of -- kind of wander about as we're talking.

And for folks who are here in the audience, if you would like to make a comment during the public comment period at the end, we've got the blue cards which you see Tim Olson holding up right there. Please feel free to fill one of those out and get it over to Tim.

So now I'll turn it back to Tim for the next presentation.

Thank you again, Tom.

MR. HODEK: Just one comment --

COMMISSIONER SCOTT: Oh, yeah. Of course.

MR. HODEK: -- about the truck outside. They pulled the truck -- it's a refuse truck, so don't smell too hard. But it also is parked right over a sewer. So it's right by the natural gas tank. And when I first walked up this morning I thought I smelled natural gas and I was -- I was in a panic. And then I realized, oh. So there's not a

leak on the truck, if you smell something in that regard. Thanks.

MR. OLSON: Very good. Our next -- next Presenter is Joe Impullitti with the South Coast Air Quality Management District. He's a Program Supervisor in the Technology Advancement Office Demonstration Group and has worked at South Coast for six years in that -- in that capacity. He previously worked for Chrysler and Daimler Chrysler for 24 years as a Product Engineer Supervisor and Manager. And the development of electric, hybrid and fuel cell vehicles. He has a Bachelor's Degree in Engineering Technology and Master's in Business Administration. He's going to talk about the catenary project. And he also has the unique circumstance where his boss is going to be commenting on his work too.

So Joe Impullitti.

MR. IMPULLITTI: Okay. Thank you, Tim. Okay.

I'm going to give you an update on our catenary truck project that we're doing with Siemens and their partner Volvo.

These are some of the project's goals and objectives that we have for this program. First of all, to promote the important of zero-emission technology, and also demonstrate a viable technology that could be used for future zero-emission corridor, like the I-710.

In this project we're going to be proving out several things. First of all, the catenary system itself, the infrastructure. And then also the truck interface with is a pantograph that we'll see later that connects the truck to the overhead catenary lines and, thus, gets its power from the grid.

The trucks will be using various types of system architectures to operate on and off the catenary. We'll be demonstrating vehicle regenerative braking energy through the catenary system. Also, the ability to charge onboard batteries through the catenary.

Another thing that's very important for this project is to identify what the system electrical loads are, the vehicle loads, the loads the power supply, which it's a DC power supply that connects to the AC overhead lines. So we have to know what the loads are for the power supply, as well as what it's going to be for the grid.

Another thing, the very key here is to determine what the costs are, the construction costs per mile, once we get the system up and running, what the operating costs are, integration of the pantographs onto each of the trucks. And then the -- the fuel. What's it going to cost to operate for an operator to connect to the pantograph in terms of kilowatt hours per mile cost?

And then another thing that we want to do is to

determine a possible system owner and operator, if it becomes a viable system. If all the stakeholders agree that this is something that we want to go forward with, we're going to have to find somebody that's going to be able to operate it. And to do that we're going to have to establish some type of business case, identify what the -- the drivers are, what the financial metrics are, what the revenue streams would be. And also analyze what all the costs, the benefits and the risks are for such a system.

In our project, which consists of one mile of overheard catenary line in both directions and supported by poles, this -- in our system, here in the picture you see it's -- it's on the side of the road. Ours is going to be going down the center median, so it would be cantilevers on each side supporting vehicles in both directions. For every mile of catenary a DC power substation is required to power the trucks.

And also on this project what we did is put up a test track that's off the road that we're going to see here. I have some video clips here. Hopefully it works. And we did that so that we could test the software and hardware before we put the car -- the trucks onto the road.

There's going to be four demonstration trucks in total on the catenary, and they're going to be of various types of architectures. First of all, the -- a Volvo will

be doing a diesel hybrid. Now a lot of these trucks, I should mention, is -- are from other projects that we have worked on with the OEMs and integrated, and so we're leveraging projects that we have done in the past.

For instance, on the Volvo, we've developed that with Volva and the Department of Energy to develop the hybrid system on that truck. And now they're going to outfit it with a pantograph, integrate a pantograph into that system and we're going to use it on this project.

TransPower, again, we're developing a lot of projects with TransPower, including a battery-electric. And the CNG will be a new configuration that they're putting together and they'll have a pantograph into that so they can operate on the -- on the catenary system. And then the battery-electric, of course, we've worked with TransPower, as well as the Energy Commission, in funding their work on their battery-electric Class A truck.

And another -- the fourth truck will be from another project that we're doing with the Department of Energy. It's the Zero-Emission Cargo Transport Project. And this will be another CNG hybrid. It will be with -- BAE and Kenworth will be developing this, and we'll be leverage yet another one of our ongoing projects.

The status of the truck portion of the project, TransPower who's building the two -- the two vehicles, CNG

hybrid and battery, they've completed the assembly of those vehicles. They're still doing some commissioning on the vehicles, but they have operated them on the off-the-road test track in Carson along Alameda Street. And there's a couple -- the two trucks, the CNG hybrid and battery truck there with the pantograph. You can see the pantograph behind the cab of each of the trucks.

The status for the Volvo diesel truck, it was manufactured here in the U.S. and with the hybrid system, integrated starter generator system that we have developed with them. Then the vehicle was sent to Sweden where they're going to integrate the pantograph into the Vehicle. And then they will take it from Sweden to Siemens' test track outside of Berlin and they will shake it down there and do the commissioning on that vehicle there. And then once it's ready they will ship it back to the U.S. for our demonstration sometime in June of next year.

The location of our demonstration, it's one mile and it's along Alameda Street in the City of Carson. This is a current route for northbound trucks on Alameda Street. It's heavily traveled with drayage trucks moving cargo from the ports to the warehouses. And it's also a pathway to the 405. But also on here, I don't know if we can -- I can point on this, alongside here is the future sites for the ICTF and the SCIG (phonetic). These will be a rail yard so

that if those things do come about and -- that this system here, if we connect it to the ports, will be able to service those.

The infrastructure status. We started -- or Siemens started the construction back in March of this year. And the first thing that they do, it's an exploratory dig got potholing. And they're on the center median there doing a very small hole, and they drill very carefully because they don't know what's -- what they might find. And sure enough they did find an unidentified pipeline that wasn't on any of the drawings anywhere. And even after an exhaustive search with all the city and the utilities in the area, and we could not find the owner of that pipeline.

So this prevented them from doing an underground foundation which would be 20 feet below grade for each of the poles along the right. And this pipeline runs right down the center of the median, right where we want to put the poles, and so we're unable to do it below ground.

So we had to come up with -- with another solution. And what we did was -- the solution that Siemens and our consultants put together was to do an above ground concrete footing. And this is somewhat a drawing of what it will look like. So the concrete footing will be above ground, totally above ground, and it would support the poles that support the catenary wires along the route. And what

we chose was a precast concrete footing. That would be the best solution in terms of cost and schedule impacts.

The impact to the schedule is that if we -- and we feel pretty confident in this, getting the revised permit from the City of Carson with the new design sometime in December, that we would be able to start the demonstration after the construction, the construction would take about six months, and we would start the demonstration in June of next year, and then complete the demonstration one year later in June of '17.

The off-the-road test tracks, here's what it looks like. You see the poles there that hold the overhead, the catenary lines. And also you'll see the power supply that's right underneath the bridge here. Now this power supply is a DC power supply. It puts out 700 volts to the overhead lines. It's connected to Edison, to the power lines here overhead, to the grid.

TransPower has already taken their trucks out to the test track and had worked out -- did some commissioning on them with Siemens on the track. And let's see if I can get this little video here to show you just what they did.

(Whereupon, a video was played.)

There's -- this is the CNG truck. And you can see the pantograph is moving along and it's going to connect to the wires. Now this is -- you know, it's a very short test

here, actually. We couldn't do this at 55 miles an hour. But they can do this at 55 miles an hour, raise the pantograph, connect to it seamlessly and go from their onboard power system to the grid. Here's both of the trucks there, raising their pantograph, connecting. And there's the battery truck.

Siemens has been requested by some of the state agencies for cost estimates for phase two. Well, that's kind of difficult because we haven't completed phase one. And that won't be completed until '17, but at least the construction of that won't be completed until June. So those -- those costs are still being determined by Siemens, and that is one of their tasks for -- for the project.

In addition to that we had hired one of our consultants, Cordoba Corporation to do an independent cost analysis on the infrastructure.

Also, we employed one of our other consultants, GNA, to investigate possible sites for phase two. And we've already started that, along with Siemens.

Some of the possible sites, of course, the logical thing would be to take the mile that we've already done on Alameda Street and continue it for another approximately four miles and connect to the -- to the ports, or find a new location somewhere around the ports or possibly the Inland Empire.

And then, of course, as I mentioned earlier, the regional solution for the I-710 corridor, one of the things that -- that are being considered is wayside power for their zero-emission corridor along the I-710. There's the schedule for them as far as EIR/EIS is concerned. And they -- they expect to identify what alternative they would do, whether it would be just a zero-emission corridor or whether it would be something with wayside power. That would be identified in mid-2017.

The are just some of the things that I've kind of thought of that -- how we meet the assessment that the -- for this merit review. First of all, the potential for emission reduction is quite large for this type of technology, zero-emission operation in highly impacted areas. And also, in addition to that, near zero-emission operation off the catenary with the architectures that we're looking at developing here.

Our pathway to commercialization, and this is our strategy in this project and other projects, and that is to involve global manufacturers and OEMs. And in this project it's Siemens and Volvo.

The formula that we need to make this successful, well, first of all, this is -- this is a very early stage of the technology. A lot of these components that we saw here on that video, the pantographs are hand-built prototypes.

So they're very expensive right now, as well as the infrastructure. We still haven't quite determined what the -- all those costs are going to be. So there needs to be -- for this to be successful there needs to be cost reduction, not only in the infrastructure, but also the trucks. And then identifying a business case and a system operator that would be interested in operating such a system.

One of the lessons that we learned, of course, that we mentioned, there's the limitation of construction. And the areas where you can employ this system, the areas that are mostly impacted are -- happen to be very industrial areas, highly urban areas that have a lot of infrastructure already in place. And so what we have now, because of this situation what we learned is that, hey, you can't -- one solution doesn't fit all areas. So now we have two solutions for foundations, one is above ground, one is below ground. So now that we can go forward into other areas, and where it's possible to go below, we'll do it. If it needs to be above, we can do that also.

The future success of this kind of technology and any kind of zero-emission technology, I believe, is the -- for us is to -- to leverage our former and ongoing project vehicles, and also and most important is engage national and global manufacturers who want to do this on a large scale.

That's what we believe we have to do as meeting our public policy goals. We believe that there is significant emission reduction in this -- in this project, and also in other planned projects in highly impacted environmental justice communities.

Questions?

COMMISSIONER SCOTT: Thank you very much, Joe. I have a question for you, actually, which kind of goes back to slide four in your presentation. You mentioned that for every one mile of the length that you have to have a DC -- DC substation.

MR. IMPULLITTI: Uh-huh.

COMMISSIONER SCOTT: And -- or slide four in my -- in my deck.

And so I was just wondering, is -- do you need that DC substation for the four trucks, or would that DC substation at some point conceivably support all of the trucks that would be going along that line?

MR. IMPULLITTI: Well, that's -- that's one of the things that we have to determine, what those loads are and how many trucks per mile that you could serve, or we have to up-size the station. This station that we're using is 1.5 megawatts. Of course, we're never going to use nearly all of that for just four trucks. That could support many other trucks. But that's -- that's one of the things that we have

to determine here is what are the load that individual trucks are when they're pulling full load, when they're fully loaded? And what is the maximize that we can take from the power supply? And do we have to up-size that power supply? If so, what's --what's the impact to the grid --

COMMISSIONER SCOTT: Uh-huh.

MR. IMPULLITTI: -- in doing that?

COMMISSIONER SCOTT: Okay. Great. Thank you.

Let's -- let's turn to our reviewers to ask some questions.

Should -- Matt, would you like to start again, or should we start with Bob and work towards you?

MR. MIYASATO: I can start again.

COMMISSIONER SCOTT: Okay. Terrific. Go ahead, Matt.

MR. MIYASATO: It's not appropriate for me to comment critically on this project since we're sponsoring it. But I just want to -- what I want to say is a big thank you to the Energy Commission for their vision in helping support the project. This is one of the most difficult programs that we've undertaken. We have multiple funding partners from both ports, Port of L.A., Long Beach. The Energy Commission is a huge supporter, So Cal Gas. We've got L.A. Metro and the regional planning agency. And so we have a huge group of supporters that are making this happen.

And -- and it's because of the impact to that area.

Joe mentioned two things, the -- the rail yards that are located there. And, in fact, if you look at one of the pictures you can see in the background these trains that are double stacked with the containers. And so we also have an environmental NGO that's helping to sponsor this themself with some funds.

So it is a big undertaking, and it's good to see some of these trucks that Mike is -- and his team are putting on there as one of the first ones to go. So we just appreciate your continued support.

COMMISSIONER SCOTT: Perfect. Thanks.

Margo?

MS. MELENDEZ: So what kind of fleets are going to be doing the demonstration with these four trucks? Do you -- have you picked fleets yet or drivers or operators or --

MR. IMPULLITTI: For this particular demonstration, these will be -- they will be hauling dummy loads --

MS. MELENDEZ: Okay.

MR. IMPULLITTI: -- basically.

MS. MELENDEZ: Okay.

MR. IMPULLITTI: They're not going to be hauling actual cargo, but they would be hauling the same types of

loads that the -- that the trucks would be hauling.

MS. MELENDEZ: So it's all sort of part of -- under a research project, not really turned over to --

MR. IMPULLITTI: No, not -- not on this one mile. Perhaps if we -- of course, if we did extend this to phase two we would -- yes, it would be a commercial.

MS. MELENDEZ: Okay. I don't have any other questions. I just think this is really -- it's really interesting. And it is the perfect type of project for a demonstration because I think you can see how this all works on paper. And what will happen is when you do it you will see, does this really work in real use. And I don't think you could go any other direction, other than to just try a small demonstration like this. I think that's great.

MR. IMPULLITTI: Okay.

COMMISSIONER SCOTT: Thanks.

Kevin?

MR. WALKOWICZ: Yeah. I think this is a really good project. It's -- it's amazing you guys are able to pull this off.

I guess my first -- one question is, is -- have you looked at historical deployment of this elsewhere in the world, other catenary systems, like what are some of the pitfalls? What are the -- you know, you mentioned the -- the pantograph are hand-built, high cost. Are they not

being used anywhere else? You know, what's your knowledge on how to make that piece of it work? Are there any -- any other deployments you can -- you can look at?

MR. IMPULLITTI: The other deployments are fixed pantographs, like on trolleys or light rail, it's a fixed pantograph. This -- this pantograph can connect and disconnect. This is a proprietary piece of equipment for Siemens. And you can do it at 55 miles an hour. I mean, that's -- that's huge. You can connect and disconnect. So that means the system could be discontinuous. We could have it in segments where -- of highly impacted areas, and in between the car could or the truck could run under its own power. So that -- that is a huge advantage to be able to do that.

Where has it been done elsewhere? The only other place -- and we're -- this will be the first that we'll deploy out in the public right of way. The other one that's close behind us is Sweden. They're doing the same -- Siemens is doing the same project in Sweden, but ours will be the first.

MR. WALKOWICZ: Are you going to see a lot of safety hurdles testing that you'd have to do to really deploy this large scale --

MR. IMPULLITTI: Yes.

MR. WALKOWICZ: -- such as --

MR. IMPULLITTI: Absolutely.

MR. WALKOWICZ: -- you know, the one that --

MR. IMPULLITTI: Absolutely.

MR. WALKOWICZ: -- goes up and done?

MR. IMPULLITTI: That is part of the test --

MR. WALKOWICZ: Yeah.

MR. IMPULLITTI: -- the test plan. We do have a test plan in place. They will be doing an FMEA on the -- on the vehicle, the pantograph, the infrastructure, and -- and the safety of connecting and disconnecting and --

MR. WALKOWICZ: My -- my only knowledge of catenary systems are the -- King County had the buses that went through the tunnel up in Seattle, and generally they work really well. But I remember the maintenance issues were -- were a big deal for them and having to keep those operational --

MR. IMPULLITTI: Yeah.

MR. WALKOWICZ: -- albeit those are, I think, hand operated. They weren't automatic and they --

MR. IMPULLITTI: Uh-huh.

MR. WALKOWICZ: -- weren't as advanced as these. But I do remember it was -- it was a maintenance concern for the fleet.

MR. IMPULLITTI: Yeah. And you notice -- and Siemens has addressed that. I don't know if you noticed

that in the video where the pantographs move from side to side. They can move laterally, and also they can, you know, adjust the pressure on the line. So this way they -- they don't cause those problems with maintenance as far as causing grooves in the pantograph. They can wipe so that -- and also, if they move from -- laterally the truck can move a certain distance in each direction and not disconnect from the pantograph and stay connected while they drive down the road. Also, irregularities in the road surface, those are being accounted for by the pressure that they put onto the lines.

So they've -- they've pretty much -- they've thought a lot of this out. So the design I think is really good. But, of course, like I said, getting it to manufacturing ability or capability is going to take a big leap to -- to do that.

MR. WALKOWICZ: I've got a couple more questions.

So the second question is: Why -- why can't you just plug off that pipeline in the middle of the street and see who calls you to figure out whose pipeline is it?

MR. IMPULLITTI: We could, but there would be a lot of liability involved in that, and I wouldn't want to be the one to do that. And I don't think Siemens --

MR. WALKOWICZ: Probably don't want to know --

MR. IMPULLITTI: -- wants to do that --

MR. WALKOWICZ: -- what's in the pipeline either.

MR. IMPULLITTI: -- or anybody wants to do that.

MR. WALKOWICZ: Going back to the other question about the size of the substations and what they can handle, it seems like kind of understanding the traffic flow, the routing and the trucks, but having this setup kind of allows you to do some really intelligent charge control, opportunity charging, opportunity -- you know, how far could you downsize the batteries on the trucks so you don't have to carry around large battery packs --

MR. IMPULLITTI: Uh-huh.

MR. WALKOWICZ: -- to do the routes, you know, when -- could you charge them or not?

And then also how -- how it would be great to be able to look at -- maybe work with So Cal Edison and look at demand charges or peak loads. You know, when should you charge the trucks? When should you -- when should you charge the packs? When should you just -- you just maintain the power requirements of the trucks and not try to opportunity charge also? Or when maybe do you not charge at all, you know --

MR. IMPULLITTI: Uh-huh.

MR. WALKOWICZ: -- based on what the grid is telling you to do?

So I think that's -- that's a huge opportunity.

Once you get the -- you have your hands full with a lot of other things, getting these on the road right now. But I think looking forward the idea of trying to optimize the charging system --

MR. IMPULLITTI: Uh-huh.

MR. WALKOWICZ: -- to minimize the grid effects, and also maybe try to maximize the cost reduction of the trucks by carrying less battery, I think that's the beauty of this --

MR. IMPULLITTI: Yes.

MR. WALKOWICZ: -- is you can put a very small --

MR. IMPULLITTI: Absolutely.

MR. WALKOWICZ: -- battery on eventually.

So is there any plans to kind of dig into that and --

MR. IMPULLITTI: We've --

MR. WALKOWICZ: -- and do some analysis?

MR. IMPULLITTI: I've already had discussion with Mike Simon on that. We've talked about that, bantered about, about some of those things, what -- what the cost savings are by removing some of the batteries and then, you know, doing opportunity charging and so on.

Some of those things we're going to look at through the, you know, the results that we get from this demonstration. And that will give us that hard data that we

need to figure those things out.

MR. WALKOWICZ: You'll have -- you'll have data on how much power the trucks are --

MR. IMPULLITTI: Absolutely.

MR. WALKOWICZ: -- getting in that area?

MR. IMPULLITTI: They'll be -- the trucks will be instrumented --

MR. WALKOWICZ: And then the --

MR. IMPULLITTI: -- as well as the infrastructure.

MR. WALKOWICZ: Very interesting. Thank you.

COMMISSIONER SCOTT: Great. Thank you, Kevin.

Before we turn to Bob, I will note that Kuang Wei is on the WebEx for us. And so what we will do after Bob asks his questions is we'll let Kuang ask his questions of Joe.

And then, Tom, we'll just see if he had any questions that he wanted to ask you. So I just wanted to give you a head's up that we're coming back to you for just a minute. Okay. Great.

Bob, go ahead.

MR. R. NGUYEN: You know, the problem with asking questions after Kevin is that I kept crossing off my list of questions to ask.

Anyways, one of the questions I have is it looks like in your project you have like four different types of

hybrids there that -- that you retrofitted to make use of this catenary system. Are there any issues with the different types of hybrids, like say for series or parallel, or are there any issues that we need to be aware of?

MR. IMPULLITTI: No. As long as it can operate totally electric under -- under power, you know, from their motor, from their electric motor, as long as that can drive the wheels and the loads you could -- it doesn't matter the configuration, whether it's series, parallel, or any combination.

MR. R. NGUYEN: Okay. So even if it's a parallel system, as long as the -- the algorithm can separate the combustion engine from the drive wheels --

MR. IMPULLITTI: Exactly. Yes.

MR. R. NGUYEN: -- you can go and use --

MR. IMPULLITTI: It must be able to do that, yeah, to disconnect the combustion.

MR. R. NGUYEN: Okay. And the other question I had you've already answered in terms of -- because I was wondering whether this system is able to do -- provide opportunity charging for the batteries --

MR. IMPULLITTI: Uh-huh.

MR. R. NGUYEN: -- or whether it's just going to provide them with the power to the wheels?

MR. IMPULLITTI: Yeah. They can do it while

they're driving, take some of that energy and use it for charging batteries, or they can do it while they're just standing idle.

MR. R. NGUYEN: Yeah. One more question. And have you thought about whether this system could be used -- could make use of existing catenary lines, like for the buses and stuff like that, that you can --

MR. IMPULLITTI: Probably not because these lines have a special -- that another thing about the lines, they have a tensioning -- a tensioner built into that, into the poles and the lines so it maintains this tension between the -- the trucks and the lines. I -- they haven't looked at that, whether they could, whether those other catenary lines would be able to handle this or not, so I'm -- I'm not really sure. But that, that would be something to bring up with, you know, down the road with Siemens because Siemens does a lot of these other systems --

MR. R. NGUYEN: That's what I was thinking.

MR. IMPULLITTI: -- as far as the light rail --

MR. R. NGUYEN: Yeah.

MR. IMPULLITTI: -- and stuff.

MR. R. NGUYEN: And that would reduce a lot on the infrastructure costs if were able to make it work.

MR. IMPULLITTI: In fact, the power supply is the same power supply they use for their light rail, for the

metro lines down in L.A. It's the same power supply. They had to modify -- make some modifications for the voltage for this -- for this system, but it's the same -- same supply.

MR. R. NGUYEN: Using this system, is it possible to like synchronize the vehicle speeds? Say you have a whole bunch of trucks that you can just tag along, like trains?

MR. IMPULLITTI: Good point.

MR. R. NGUYEN: Yeah.

MR. IMPULLITTI: Good point. Yes. Yes. You know, Volvo has been working on that -- that type of system, vehicle-to-vehicle and vehicle-to-highway. As a matter of fact, in our -- in our proposal that we made to ARB for our GGRF, we are going to include that for the on-road trucks, that kind of capability where they can platoon --

MR. R. NGUYEN: Right.

MR. IMPULLITTI: -- the trucks.

MR. R. NGUYEN: Yeah.

MR. IMPULLITTI: And, yes, that would be another thing that you could do on the catenary is platooning.

MR. R. NGUYEN: All right. Thank you.

COMMISSIONER SCOTT: Great. Thank you, Bob.

Do we have Kuang available on the WebEx to ask some questions of Joe?

Is he on there?

MR. OLSON: Kuang, your -- your phone is unmuted. You can go ahead and speak if you're on the line.

COMMISSIONER SCOTT: Okay. We will -- we will --

MR. OLSON: We'll try to connect with him.

COMMISSIONER SCOTT: Yeah. We'll -- we'll check back with him.

Tom, I did have one follow-up question for you, though, which was I appreciated, Joe, in your presentation some of the lessons learned and some of the things that -- kind of tips for success. Do you have any lessons learned or tips for success from your project that you could share with us?

MR. HODEK: Well --

COMMISSIONER SCOTT: You have to talk to the mike. Otherwise, the WebEx folks won't be able to hear you.

(Colloquy)

MR. HODEK: But I don't know how to turn these on. How about now?

COMMISSIONER SCOTT: Yes.

MR. HODEK: Okay. All right. Well, the question, are there any lessons learned? We've learned a lot, and there's a lot to learn. Like I said, we -- we came to a point in the program where we thought this was something we could take to market, and so we made that decision. But there is still a lot yet to do, so we're still learning the

lessons. Some of the lessons we learned are proprietary, unfortunately. But it was through the funding, though, that allows us to move forward.

So I guess in a roundabout way, you know, the funding that the -- the Commission and other agencies provide us do allow us to learn some lessons and -- and bring the technology down.

COMMISSIONER SCOTT: Great. Thanks. Okay.

Thank you so very much, Joe, for your presentation.

And we will -- I'll just -- I'll make another reminder of the blue cards. Please be sure, if you'd like to say something, fill them out, get them to Tim. We'll take public comment at the -- at the end of our presentations.

And I will turn it back over to Tim for introductions.

MR. OLSON: Okay. Our next speaker is Ian Wright who is the CEO and -- CEO of Wrightspeed. He's also the cofounder of Tesla Motors and developer of the -- kind of an interesting -- interesting technology, a power train, an electric power train and a micro-turbine technology. And he has some -- some comments on what he's accomplished.

MR. WRIGHT: Thank you very much, Tim.

Okay. Oh look, I have a (inaudible).

Good morning. In case I forget to say it at the end, I wanted to thank the Energy Commission for the vision in leadership in helping us out with this. I'll give you a progress report and you'll see that the funding from the CEC actually made quite a substantial difference to what we've been able to achieve so far.

So we got our first VC funding in September 2010. And, coincidentally, that was the first CEC Grant. It was $1.2 million. And the point of that grant was to get us to build four prototypes and demonstrate them. And that all went pretty much as per plan. It took almost a year longer than we planned for it to do, but it was within the period of the grant so it was okay. But it did work out pretty much as we thought. We got -- we started from nothing in September 2010. We designed the entire power train, and we had the first test truck on the road in November 2011. And we shipped the first trucks to FedEx at the end of 2013. So we've had trucks in the commercial fleet now for two years.

We got a second CEC grant in June 2012, for $5.7 million. And this was to establish a production facility, which we're still in the process of doing. We've moving from San Jose up to Alameda. We have one of the old hanger buildings on the historic naval air station. It's an historic building. It's a wonderful thing. It's 32-foot clear height to the top of the door and the bottom of the

rafters. So we can bring garbage trucks in there and lift them up and not bump into the roof, which is not the case in our current building.

I'll talk about our lessons learned at the end. But we didn't actually set out to do refuse trucks. We started with delivery trucks for FedEx, they were the lead customer. And once we started getting some publicity around that we got a call from a refuse operator up in Santa Rosa and they said, "Can you do this for our trucks?"

And we said, "Well, goodness, they weigh four times as much as the auxiliary trucks we designed the power train. You know, let's go away and sharpen our pencils and see what we can do."

It turns out that we can, in fact, do refuse trucks. We can do them very well. And with the benefit of hindsight, we probably should have started there because the gains in fuel efficiency and emissions are so dramatic relative to the cost of the system that it's a more compelling economic proposition than it is for the lighter trucks.

Somewhere along the way we decided to design and build our own micro-turbine range extended generator, and we announced that in May this year. And we've been getting sort of more and more publicity along the way. And so for the last year or so we haven't sort of been actively out

selling, we've been answering the phone and the emails and we're getting a lot of inquiries. And we've started to get them for buses now.

And so just as with trucks, not all of them are a good target for our technology. You know, school buses aren't. They do, you know, two hours a day, so they don't burn enough fuel. And the city buses are not because -- in the time available I can't walk you through all of this, but the technology where it's best for heavier vehicles and hard stop-go metro drive cycle, and continuous 62 miles an hour on the interstates is not -- not great. We can't save a lot of fuel there. But city buses and airport buses can work very well.

So we've got -- under nondisclosure we've got a couple of orders in process right now. And, in fact, for buses we have our first international sales and process, two -- two different countries.

You know, we complain about fuel prices in California. But there are other places in the world, quite a few places, where they pay $8.00 for diesel. So the value proposition for what we do is even higher in those places. And for things like delivery trucks and garbage trucks, they do use the same kind of vehicles and they do do the same kind of drive cycle, so that works very well.

We haven't moved to Alameda yet. Hopefully that

will be in February next year. We're sitting on a backlog of 42 hard orders and we need to get those out as soon as have the new building working.

If you haven't seen what we do, this is one of the early trucks we did. This is (inaudible) NPR. This is 14-and-a-half thousand pound GVW. This is pretty much the lightest vehicle that would make sense in that we can -- as I said, the heavier the vehicle and the harder the stop go drive cycle, the more fuel we can save. So here the power train has been completed replaced. There's a micro-turbine and range extender up here. This one burns natural gas. We have the same engine that will also burn diesel. There's a battery pack. There's a pair of 200 kilowatt peak inverters and motors and, in this case, two speed gearboxes driving the wheels. We have a patent on how we drive the wheels independently and how we control the tire slip, which gives us better traction control, ABS, and overall stability performance.

There's a video out there somewhere of me drifting this thing around on the salt flats of Bonneville, and you can see the overall stability working very well.

As I said, once we had some stuff out there and we got publicity, then we got approached to do garbage trucks. So the sharpening of the pencils resulted in a few things. We did a slightly heavier duty version of the inverter. We

used the same traction motors but we used four of them, one per drive wheel on a Class 8 garbage truck. And we did a heavy duty version of the gearbox with four speeds. And that resulted in another patent application, and we sort of take that technology backwards so now all the gearboxes we do are four speed. And the final drives are different depending on whether we're doing garbage trucks or delivery trucks or something else.

So this system will put 13,000-foot pounds of torque at the wheel, at each wheel. So you're looking at something like a 45 percent grade, 50 percent grade capability which, you know, is really important. There are hills in San Francisco that are 30-plus percent grade. And there are famous examples of electric garbage trucks that the first time they tried one of those hills with a full load the motor burst into flames and embarrassed everybody. So you really have to do the engineering properly.

We use another -- one of the traction motors to drive the hydraulic pump. It takes about 60 horsepower at peak. So that's easy for that -- that motor and inverter. There's three battery packs in here instead of one in the delivery trucks, but it's the same packs, the same motors, the same inverters, and there's the micro-turbine generator. So that's the layout for a Class 8 garbage truck. It pretty much fits where the existing stuff was. The battery packs

go where the engine and the transmission were. And the differential is removed. And this assembly with a pair of (inaudible) boxes, you know, the traction motor only weighs 76 pounds, and the integral inverter, that all plugs into the rear axle where the this used to be. It aligns itself here behind the cab. So pretty easy installation, either retrofit or -- or new, and that's starting to happen too.

So if people ask us why we do range extension, wouldn't it be better to do straight electric, you know, it's zero emissions, it's a great call and everything? Well, you've got to be very careful with the numbers. So garbage trucks have a really high drive cycle. The national average is 130 miles a day with 1,000 hard stops. Some of our customers tell us that their drivers are actually triggering the ABS on a lot of those stops, so they are driving them very hard. They get maybe three months out of the brakes.

The power train -- the diesel power train that if installed in a long-haul truck would do five or six miles per gallon, in this application does 2.6. And we have some real-world data now from, you know, same trucks, same drive cycle with the natural gas engines, and they go down to 1.6 to 1.9 miles per DG. So they're very, very hard on the power train. They use a lot of energy.

So if you want to do this with straight batteries

you've got to take all that into account. Net energy, you know, net of regen braking, in our system, by the way, one of the things we did differently about this is we run, as you see, 4 200-kilowatt motors. So we can put about 1,000 horsepower of regen braking at the wheels. Generally what we're trying to do is have enough regenerative braking so the driver is not tempted to use the friction brakes. So you just lift your foot, you get enough regen braking that it slows down fast enough that you're not tempted to go over and jump on the friction brakes.

And in the delivery trucks that's working very, very well. And if you want to come down and drive that Isuzu that I showed you, you can drive that and you'll get -- you know, you'll drive all the way around the block, you drive as hard as you can in traffic and everything and might never feel like you need to touch the brakes.

But that takes a lot of power in a delivery truck -- in a garbage truck, so about 730 kilowatts of regen at the wheels. So net of that you're at about two kilowatt hours per mile.

Now it's important to remember that this alone is vastly efficient compared to the conventional power train. If you do -- you work it out the same way, a diesel one of these is burning about 14 kilowatt hours per mile. And the natural gas ones are even worse because natural gas engines

are less efficient. They have a throttle so they have pumping losses. They have lower compression ratios so they are less efficient than diesel. They have lower emissions but they are less efficient.

And if you do rate this (inaudible) temperature, so if it's a pure battery truck and you're in a minus 40c environmental, you've got to heat the batteries. And depending on your battery's chemistry you might have to heat them if you're below freezing. So that's quite a lot of the U.S. in the winter who would have to heat the battery packs.

And if you're out straight electric then the only source of energy you have is the energy stored in the battery pack, so that's going to radically reduce your range.

You've also got to take account of, you know, though 130 miles is an average route, you know, not the longest route. And it's really painful if you get stuck in one of these things. So you've got to have -- you've got to carry some excess battery for that. You've got to take account of the battery capacity fade over time. So typically you define end of life as 80 percent, so you'd need to add 20 percent to account for that. And, of course, you don't want to operate the battery over 100 percent state of charge range because that wears them out. So depending again on your battery chemistry, you might run 0 to 80 or --

or 20 to 100 or some other number, but you don't use 100 percent of it.

So if you do all of that you wind up with this much battery. That's about half the payload of the truck. It takes up about half of the space, and it's about half a million dollars. So you put a range extender in and you get three battery packs. You have no range limitation with refueling. You deliver the same performance as a diesel. And, of course, you can displace the trucks that are doing the longer routes, so they're burning more fuel per year. So you can always kid yourself and say, well, here's this electric thing, but you can only send it out on the -- on the short routes. Well, the trouble with that is you're only displacing the trucks that are using less fuel, and so the economics really don't work. And it's cheaper to put in the range extender than it is to put in all the batteries, so you get the shortest payback time.

So one of things that we have done right from the beginning is optimize every piece of everything we do for the shortest payback time. Because it's one thing to do demonstrators. But if you want this to take off, if you want this to dominate the market, then it's got to be economically compelling. It's got to have a short enough payback time that it's just the CFO at the time -- the customer looks at this and says, yeah, I'll have 1,000,

thank you.

Range extender. So we designed our own micro-turbine. This was not in the plan originally when we got the first grant. It was in the plan by the time I got the second grant. It was in the plan when we applied for some grants that we didn't get, but that's okay.

This is an 80 kilowatt micro-turbine. It's a two-stage compressor, two-stage axial-flow turbine. It runs and intercooler here between the two compressor stages, it runs a recuperator, so it's around 34 percent efficient. It's quite challenging to get small turbines up to that kind of efficiency. I see there's a nice picture of a turbine on the wall there. That looks like a power plant. You know, they run as high as 60 percent efficient with combined-cycle waste heat recovery. The waste heat recovery we do on this is in the recuperator. It's -- it runs up to 100,000 rpm single -- one -- one moving part that the generator is actually on the turbine shaft and runs that turbine speed, so there's an 80-kilowatt generator in there that, you know, is about this big and weighs a few pounds. All the power electronics and controllers are in here, so you put fuel in here and you get DC out here to the batteries. Pretty cool little machine.

Turbines have a lot of advantages and disadvantages. The reason they haven't been used in land

vehicles but they took over aviation completely is that they're only efficient at full power. And cars and a lot of trucks spend a lot of time idling and at low power. So if you try and drive the wheels with them the fuel efficiency is horrible. But we don't drive the wheels with it, we only run a generator. And the generator runs at whatever speed and load gives you the most efficiency. It runs there until the battery is full, then we shut it off. So we don't care anymore that the fuel efficiency at idle is terrible.

We also don't care that it takes a few seconds to ramp up when you ask it for more power. In a car that would be very painful. You know, everyone is already at the next stoplight by the time you start moving. But again, in this case we really don't care if it takes five minutes to get to full power because we're just using it as a generator.

They're expensive in airplanes. But, you know, there's a turbocharger and they make 10 million of those a year for $150. And there's our low pressure compressor which, you know, is a little more complex and it's a little bigger, but it's the same kind of technology. So if you design this engine to use, you know, turbocharger kind of materials and processes you can drive the cost way down, so that's what we've done.

So the advantages for this application are several. The power-to-weight, I mean, that's an 80-kilowatt

generator that weighs about 250 pounds and will do 10,000 hours. So power-to-weight and durability is a big deal.

Emissions is an enormous deal. So this is the difference between a diesel combustion flame and a turbine combustion flame. This is an artist's representation but it's pretty good. This is an actual turbine combustor with a quartz window in it so you can see it. That's not ours. That's someone's lab. And you can see, the first thing you notice is this is bright yellow and this is pale blue. Well, it's bright yellow like a candle flame because that is full of incandescent soot particles. That's what's giving it all the -- the white-yellow-orange light. Over here there aren't any incandescent soot particles so it's powder blue.

So the way this works is you compress the air and sort of get it above the auto ignition temperature for the diesel and then you inject the fine stray of droplets, and then the droplets evaporate and burn at the same time. The nasty thing about that is, A, you get soot particles, and B, a lot of the burning is occurring on the boundary around the droplets. So sort of by definition its stoichiometric. Even though diesels are not stoichiometric engines, the actual combustion around the droplets is. The problem with stoichiometric is that's the highest combustion temperature so you burn the nitrogen, so the NOx is really high.

If you do it like this you can burn almost all of the fuel somewhere down near the lean flammability limit. Turbines have a continuous flame, like -- like a blowtorch. You don't have to light it off every cycle and there's a lot of excess air. So you're feeding more air in as the -- as the flame is traveling down the flame tube. By the time you get to the end there you've burnt everything. There's a lot of excess oxygen. You've burnt all the hydrocarbons. You've burnt all the Co to Co2. And if you do all this combustion or almost all of it down near the lean flammability limits then the combustion temperature is very low, and so the NOx is very low. So the net result of all that is that you can pass the emissions standards without any after-treatment at all.

Now there's an important distinction to make here, I think, the way emissions are measured in cars and the way they're measured in trucks. In cars it's, you know, grams per mile because it's the entire car that's certified. For trucks it's the engine that's certified. So we get all excited about so many grams per horsepower hour. But we actually care about is how many grams of whatever criteria emissions you're worried about is it going to leave lying around our neighborhood while it's picking up the garbage. So it should be grams per mile, but that's not how it's measured.

So if you -- oh, I've got to go back.

Remember I said that those garbage trucks with conventional power trains are burning 14 and higher kilowatt hours per mile? It's two kilowatt hours per mile. You know, we run 100 horsepower turbine engine to do the same job that you do with a 400 horsepower diesel, 390 horsepower or 320 horsepower natural gas engine. So in terms of grams per mile you can do vastly better with this. And you've got to be very careful not to get too excited about that, you know, grams per horsepower out because that's the not the thing that matters, it's the grams per mile.

That's our actual combustor and the actual flame. See, it's nice and powder blue. It's swirling nicely. It's all even. There's a spark plug up at the far end.

This freaks people out. If you do this you can actually make these things cleaner than EVs because a lot of electricity comes from coal, 40-odd percent in the U.S. right now. California is pretty good, it's only about seven percent. New Zealand is even better, mostly hydro down there. That's a Chinese power plant. They've been building those, about one a week. The -- most people don't realize this, but over the last decade the world coal consumption has increased about 50 percent, and almost all of that is for power stations, and almost all of that is in China and India. And there's measurable mercury in the air right

here, and it's coming from Chinese power plants and finding its way all the way across the Pacific.

So if you can make the generator cleaner than the average mix of the power plants, then these vehicles can actually be cleaner than EVs.

Here's a sort of close up -- CAD renderings are easier to do than photographs, surprisingly, of the two motors, two inverters, two four-speed gearboxes, and two final drives for heavy duty axle. This is your 13,000-foot pounds four-speed hydraulically shifted gearbox.

Okay, lessons learned. I think we've done pretty well because we did, right from the beginning, focus relentlessly on payback and scalability. It's fairly easy to make one of anything and get people to buy it and even, you know, get some amount of market share. Does anyone remember Pet Rocks? Some people will buy anything. But, you know, if you want to make a big difference it's got to get across the chasm, it's got to be compelling, it's got to take over some niche such as garbage trucks. There's only about 110,000 Class A garbage trucks in the U.S. But every last one of them has an appropriate drive cycle for this. So, you know, you've got to relentlessly -- you know, we did a payback calculator. And you've got to look at the answer and say, okay, well, that doesn't work, so we won't do those.

And a related thing is that it's very easy to be distracted. We get, I don't know, five calls a week. People want us to do this, that and the other thing. Everybody wants this, but a lot of those applications, it doesn't actually work. I mean, if you -- if somebody's trying to do long-haul trucking we have to say, look, it's not going to save you any fuel, it's not worth it, just don't, sorry. Go to Cummins. If it's garbage trucks, if it's city buses, yeah, that's great. But if the customer has only got ten of them and we have to do all the engineering to adapt it to that particular one, well, that, you know, that will slow us down. We've got very constrained resources.

Another thing that we did that I think is paying off really well is that we built the entire power train, now including the turbine. And so we make our own battery packs. We design the motors, the gearboxes, the inverters, all the control software, vehicle dynamics control, all the (inaudible) instrument cluster, battery management, we did the whole thing, so we own all that IP. But we don't do any casting or forging or machining really in our factory. We -- we have a very diverse supply based across the U.S. of people who do those things. But it does mean we can drive the cost down, so when we go to get gears made, you know, it's our driving, it's our -- it's our 3D CAD model, so

we're paying somebody for materials and machine time. We're not really paying for IP, so we can really drive the cost down.

Another thing that's a mantra for startups, entrepreneurs, and it's easy if you're an established company to forget about this, but it's very risky to rely on new infrastructure appearing. So everything we did doesn't require new infrastructure. You can plug this in, but it will still work if you don't. You can run on natural gas, but if you can't get natural gas it will run quite happily on diesel. You can even set it up as a dual-fuel. That engine can be sent up as dual-fuel. So you can have natural gas tanks, but if you get stuck and in you're in some place where there is no refueling station and you've depleted the battery and you've run out of natural gas, well, you can switch to diesel and keep going, and you can buy diesel anywhere. Okay, it costs twice as much per mile, but it still works.

So we're not depending on fast charging stations. We're not depending on hydrogen. We're not -- really not depending on natural gas refueling infrastructure either. I mean, we can use it when people have it for sure, but we don't rely on it.

It's sometimes tempting when the grant -- grants offered CEC, DOE, whatever, to sort of warp and twist your

business model because there's a grant that -- that you could get. And we try very hard not to do that because the opportunity cost of doing that can be very high. We've got to stay focused on payback, scalability, and listening to the customers.

Now as I said earlier, we didn't set out to do garbage trucks. And it would be very nice to sit there and say, yeah, we had this grand strategy and plan and, of course, we were going to do this, but we weren't. We started with FedEx trucks, and that's all we were trying to do to start with. And this was customers coming to us and saying, hey, you know, we burn so much more fuel. They only burn 4,000 gallons a year. We burn 14,000 gallons a year. How about you do us? And it's obvious now that it's a good idea, but it wasn't. And it was customers coming to us and saying that. Yeah, sell first to end users. I don't know how that went up white. Sorry about that.

So our -- our business model in the beginning was, you know, let's do this as repower kits, go to the existing fleets. FedEx is the biggest truck fleet in the country. They've got thousands and thousands and thousands of freightliner MT-45s (phonetic). Why don't we replace the Cummins engines in those. That's great because there's not a big delay. You can -- you can -- you can get started with that very quickly. And you get -- the earlier you can get

actual customer experience, actually get commercial use experience and find out what works and what doesn't, what they like, what they don't, how they would like it changed. I can't tell you too much about FedEx, but we've had some hard technical lessons.

It's actually surprising that both Tesla and Wrightspeed have had the same biggest problem making these things reliable, and it's actually the least advanced technology we make, it's the gearboxes. It's surprisingly hard to make reliable gearboxes. There's still a bit of black art in that, and the way it's done in general is a long test cycle. It's not so well simulatable.

And then this -- this one is, you know, you've got to match the performance of the diesel. The people that drive these trucks, the people that own these trucks, they have an established performance expectation. If you want them to adopt this new technology it's not only got to pay for itself, but it also has to the job, the same way that they used to. So we've gone to a lot of trouble to try and make these things so that there's not training required. If you can drive the diesel truck, you can drive this one. If it does this level of performance on the hills of San Francisco, well, it will do that good or better with the new one.

And again, if you want to come down and drive the

Isuzu, you'll see what I mean. I'll just toss you the keys, you drive it, it's fun, it's nice. It feels better than a diesel. It accelerates better. It's -- frankly, there's no compromise. It's the same range, same power, same speed, the drivability is better. Even silly little things that we learned from customers like startup time, there's a lot of EVs out there, apparently, that when you turn the key on their booting Windows or something, I don't know. But it's 15 seconds later before you can actually get the thing to move. Now that might not sound like a long time. But if you're doing that 500 times a day you're going to get very tired of it.

So, you know, the target for us was it's got to start up -- start up and move at least as fast as a diesel will. There's no reason why you can't do that. We do do that. You turn the key and a second later it's ready to go, off you go. You just have to decide if you want to do that.

And I think overall the number one best question that filters a lot of these things is what problem are we solving? I don't want to get into engineering arguments. If somebody wants to do something one way, if somebody wants to do something another way, you know, just ask the question, well, what problem are we solving? Which of these ways would be the best solution to that problem or to some other problem. The same thing for all of this. Okay.

That's all I had in the -- in the slide deck. I'm hoping for lots and lots of questions from everybody.

COMMISSIONER SCOTT: Thank you very much, Ian.

MR. WRIGHT: Uh-huh.

COMMISSIONER SCOTT: Let's go to questions from the reviewers. And just to switch it up, why don't we start with Bob this time.

MR. R. NGUYEN: Okay. Thank you for the presentation. I'm interested in your thoughts on how feasible this technology is in the long run for say like the long-haul vehicle?

MR. WRIGHT: Not.

MR. R. NGUYEN: Nothing at all?

MR. WRIGHT: No, not really. So this technology saves fuel in three separate ways. The first way is you plug it into the grid, you charge it, you drive on grid energy that's cheaper than fuel, so that's good. But you can only do the first 30 miles or so that way. So if you're doing 100-mile daily route, that's -- 30 miles is measurable, that's 30 percent of it. If you're doing 600 miles long-haul it doesn't matter.

The second way that we save fuel is regen braking. And garbage trucks would be the best example, 1,000 hard stops a day, heavy trucks. They're putting -- they tear of brakes in three months. They are putting up to 2,000

horsepower into the brakes. That's awesome. We can do that -- recover that energy, put it in the battery, save fuel. It makes a huge difference.

Those guys that are out on I-5 driving down to L.A. at 62 miles an hour all day, they're not using the brakes, so regen isn't going to help you.

Then the third way we save fuel is when we do burn fuel in the turbine engine we only run that engine at the sweet spot, at the speed and the load that gives peak efficiency. Well, that's also what the long-haul trucks do. It's very hard to beat one of those Cummins engines at 62 miles an hour and 80,000 pounds, straight flat road, no wind. But everything is set up for peak performance, peak efficiency. We can't do better than that.

But you put that same engine in a garbage truck and they're -- you know, they pass through the sweet spot 1,000 times a day but it doesn't spend any time there. It's idling or it's full throttle, it's up to full revs, it's just -- you know, then it's hot on the brakes. They're not in the sweet spot. So you can get a two-to-one gain just by going to a range extender and running the engine in the sweet spot all the time. But again, the long-haul trucks do that anyway, so we can't get those gains in long-haul. It doesn't work.

MR. R. NGUYEN: Yeah. The reason I'm thinking

that way is because this long-haul trucks, they burn a lot of fuel.

MR. WRIGHT: Yeah, they do.

MR. R. NGUYEN: And so even if just a one to three percent improvement, it depends on the cost, it may make it worth it.

MR. WRIGHT: Yeah. Yeah. And all I can say about that is, you know, battery-electric is not the way to go, range extender is not the way to go. I would say aerodynamics, tires, you know, the incremental engine improvements, transmission. You see cool things like, I think it was Marithaw (phonetic) did a high-efficiency axle where they just varied the oil supply to the bearings and the gears. And if you have -- if you're cruising, then it has a fairly low oil supply. If you're low speed and high torque, then they increase the oil supply because the hydrodynamic drag of just the oil in the bearings and the gears is enough. And they were getting one percent improvement in fuel efficiency just by changing the loop strategy.

So you're down to -- it's like Formula 1 cars, you're down to all these little incremental improvements that all add up. That's what you're doing in long-haul trucks now, I think. I don't think this kind of technology or any variant of this is going to make a big difference to

long-haul, sorry.

MR. R. NGUYEN: Okay. How much weight does it -- does the whole system add to the conventional vehicle?

MR. WRIGHT: Yeah. It depends what you're replacing. In that -- in those trucks, you know, it depends which engine you're replacing, which transmission and so on, but it's about a wash. It can be up to say 150 pounds lighter than the conventional system. We haven't got a case where it's heavier. In the lighter trucks like the -- the delivery trucks, it can be as much as 500 pounds heavier to put our system in because the engine and transmission we're replacing is a lot lighter. But in these trucks we generally save a bit of weight. GVW doesn't move very far. It may move back a little bit.

MR. R. NGUYEN: Okay. I'm curious why you decided -- well, no. Why have you decided to design and manufacture your own turbines where there are other established players out there that can --

MR. WRIGHT: Well, there aren't really.

MR. R. NGUYEN: Like Capstone Turbine.

MR. WRIGHT: There's Capstone. Yeah. Who else?

MR. R. NGUYEN: And Capstone.

MR. WRIGHT: Yeah. Most people don't know this but William's actually did a 40 kilowatt one for General Motors. And they -- they built -- GM built one prototype of

the EV1 with -- with a 40 kilowatt turbine range extender in it, and then it delivered 60 miles per gallon. But then -- then they killed the whole program and crushed the whole thing and it was over. I think that engine is still out there. It's pretty similar to the Capstone. Those are single-stage machines, single compressor, single turbine, no intercooler, so not a very high pressure ratio, so three- or four-to-one instead of we get eight-to-one with two stages. So just like as in piston engines, if you can get the compression ratio up the efficiency goes up.

So we're something like 30 percent more efficient than the engines we can buy. And we've done an awful lot of work on driving the cost down in volume so we can build these engines in volume a lot cheaper than we can buy them, so that's why.

MR. R. NGUYEN: You, you know, you also stated in your presentation that you initially were going to go with like a FedEx truck for --

MR. WRIGHT: Oh, we still do. We still do.

MR. R. NGUYEN: Oh, you still --

MR. WRIGHT: Oh, we still --

MR. R. NGUYEN: Okay.

MR. WRIGHT: -- do those. Yes.

MR. R. NGUYEN: Okay.

MR. WRIGHT: Yeah. We still do delivery trucks.

We still -- we've got an order from FedEx. They -- they want more. But they're at the lighter end of what makes sense. It's hard to make the economics work down there because they're not burning enough fuel. That's why we don't do cars at all because cars really don't burn enough fuel.

MR. R. NGUYEN: Have you guys had any interest in from the transit industry, shuttle buses?

MR. WRIGHT: Oh, yeah. Yeah.

MR. R. NGUYEN: Because it seems that that would be an ideal application for --

MR. WRIGHT: Yes.

MR. R. NGUYEN: -- your technology.

MR. WRIGHT: Yes. And, you know, they like the fact that they don't have to put in fast charging stations. They don't have to put in natural gas refueling. And if they have it we can use it, but if they don't have it, that's okay. It still works. You still get the gains. You can run diesel. So, yeah, that's -- they seem pretty happy. We're getting quite a lot of interest in that now.

MR. R. NGUYEN: So what kind of volume do you think you would need to get to, to putting the cost down to make it cost effective without incentives money?

MR. WRIGHT: Oh, that's when -- that's -- that should be on my list. We're not actually relying on

incentives at all. That's another thing for entrepreneurs. It's called the stroke of a pen problem. If you -- if you bet your entire business and all your net worth and your, you know, time you're not spending with your kids on this startup company and it depends on subsidies, well, subsidies can go away at the stroke of a pen. So if that destroys your business model then, you know, you lost everything.

So the general rule for entrepreneurs is it's nice to have subsidies but you cannot rely on it. So we -- so we -- no, this -- this works right from the get go. All of the stuff we ship next year is cost effective for the customer and for us without subsidies.

MR. R. NGUYEN: All right. Thank you.

MR. WRIGHT: Uh-huh.

COMMISSIONER SCOTT: Thanks, Bob.

Kevin?

MR. WALKOWICZ: Yeah. Thank you. Great, great presentation. Very interesting technology.

I was glad to hear you talk about the gram per mile --

MR. WRIGHT: Uh-huh.

MR. WALKOWICZ: -- and that, because that was going to be my question.

MR. WRIGHT: Uh-huh.

MR. WALKOWICZ: But what can -- what can you tell

us about the -- the cycle of the generator? Is -- once it's on does it stay on for the rest of the day? Is it turning on and off? And what does that do to the efficiency, overall efficiency of that generator and the emissions of that as your -- your spooling it up? You know, you've got cold starts in there, you're shutting it down. What's actually happening? What does that duty cycle of the -- the generator look like?

And then my follow-on question is going to be -- and you're trying to sell this system in a wide range of applications.

MR. WRIGHT: Uh-huh.

MR. WALKOWICZ: That seems like it's a very dynamic problem to try to calibrate the control of that generator, how many batteries you put on when you're turning the generator on, turning it off. And, you know, have you looked at all that? What -- what can you tell me about how to -- how to calibrate this and how to take into account these -- the cold starts and the intermittent operation of the generator?

MR. WRIGHT: That's a great question. And, yes, we've put a lot of thought into that.

So there are inefficiencies during warm-up and cool-down. One of the things we've done in this engine design is we don't have to run much of a cool-down cycle at

all. So it's an oil-lubricated ball bearing -- hybrid surrounded with ball bearings, and we keep the oil supply on when we cool the shaft. But we can shut the engine down and leave all the heat stored in the recuperator. So the recuperator is the heaviest part of the engine and it takes a while to warm up, it takes a while to cool down. If you're just blowing air through it and cooling it down you're losing that energy.

So with this engine design you don't have to do that. We can shut it off and have a thermal blanket around the recuperator and it can stay hot for quite a long time. You do -- it does take some energy to warm it up in the first place. It takes two or three minutes to warm up.

So for that reason we want not to do that many cycles. We certainly don't want a load follow, and we don't want to start and stop the thing all the time. So if it's something like a package delivery application it might start twice a day. And in a garbage truck it probably only starts once.

The next thing we did was design the engine so that it's efficient over a range of power, and that's quite difficult to do. Generally in turbines they're most efficient at full power. And it's easier to make a bigger one efficient, not a small one. But, you know, the average power demand for a garbage truck is actually only about 30

kilowatts over the -- over the entire workday, it's only about 30 kilowatts. So if you wanted to match the turbine to average power demand you'd want a 30-kilowatt turbine.

You know, but of course, you've got to also cover the case where for some reason they completely deplete the battery and you're driving on the generator. Well, 30 kilowatts doesn't move the needle to much in a garbage truck. So you really want something more like 80 kilowatts for that reason. That will get you to freeway speeds if you need to. So that's an 80-kilowatt engine that's designed to have peak efficiency at somewhere between 40 and 50 kilowatts. So we intend to run around -- at peak efficiency, you know, about 45 kilowatts in that case.

And you're right, there's an interesting control strategy about we can turn the power down, suffer a slight performance hit, but it's better than stopping it and starting it again, so we can do that.

It's designed to cover sort of delivery truck to garbage truck range. It's not designed to give you continuous 300 horsepower for a long-haul truck because we don't do that because we can't save fuel. Yeah.

So is that a good enough answer?

MR. WALKOWICZ: Yeah. That's -- that's a pretty good answer. And is your -- your energy storage size, you said you have three packs --

MR. WRIGHT: Yeah.

MR. WALKOWICZ: -- 30 miles, so I'm guessing they're about 20 kilowatt hours --

MR. WRIGHT: Yeah.

MR. WALKOWICZ: -- a piece.

MR. WRIGHT: Good guess.

MR. WALKOWICZ: Right. Is that configurable? I mean, can you put, depending on the application and how often you want to start and/or stop the generator, can you -- are you planning on putting -- offering different configurations with larger or smaller packs?

MR. WRIGHT: We do. The limits there are you can't really go below two packs and still absorb the regen power. So the minimum pack size is determined by regen power. And we really want to capture all the regen power. So we don't want that limited by the battery, we want it limited by the inverters, the motors, thermal issues there, that should be the limit -- of traction, that should be the limit, not the batteries. So two battery packs minimum for that.

More than three is fairly hard to find room for. And if you do the payback calculation you go backwards. Once you've got enough pack that you're not limiting the regen power, then a bigger pack gives you a longer payback, surprisingly. That's why I said you've -- the payback

calculator is a really, really valuable thing.

MR. WALKOWICZ: Yeah. And along those lines, have you considered battery life versus --

MR. WRIGHT: oh, yeah.

MR. WALKOWICZ: -- the control --

MR. WRIGHT: Yeah.

MR. WALKOWICZ: -- strategy, the charge-discharge cycles on those batteries?

MR. WRIGHT: Yeah. That gets quite complicated. So we do a lot of things to look after the batteries. We're monitoring state of charge and temperature. We have -- since we designed the entire power train the battery management system is talking to a black box called the vehicle dynamics control system, which is talking to the motor controls individual. And in real time it's telling the motors, okay, you can have this much power for driving and have this much power for regen. And depending and temperature, the state of charge and so forth.

So we thermally manage them. The packs are insulated. And then they have a cooling and a heating system. So we try and keep them around 25C. We fed all of this data, including the drive cycle data, to the cell manufacturers, and then they do the live calculations. And so we do tradeoffs there about, you know, we can make a smaller pack that's harder on the cell, per cell they work

harder so it will shorten their life, but the capital cost is lower. So, yes, there's a lot of work that goes into those tradeoffs.

MR. WALKOWICZ: Okay. Thank you.

MR. WRIGHT: By the way, three are -- different chemistries have different characteristics. And so we -- we now have a second source with is a lithium titanate. And that has some nice advantages for this, one of which is they perform pretty well, even high charge power down to minus 30C. So in cold climates you waste less energy heating them.

MR. WALKOWICZ: Do you use -- are there life models that you're using for all the different chemistries you've considered or --

MR. WRIGHT: We generally can't get the life models. The cell manufacturers regard those as proprietary. So the way it works is we feed our data to them and they do the calculation and they give us the answer.

MR. WALKOWICZ: Okay. Great. Thank you.

COMMISSIONER SCOTT: Thank you, Kevin.

Margo?

MS. MELENDEZ: So I guess maybe along Kevin's line, so what I loved most about the presentation and about the project is that it's just such an interesting way to say we have all these cool technologies and how do we combine

these in a vehicle that really then suits what a customer and an end user is going to see the most value from, because there's a lot of cool technologies that maybe don't help a customer.

MR. WRIGHT: Yeah.

MS. MELENDEZ: So what I really appreciate was sort of your focus on this is what's going to help you as a customer.

MR. WRIGHT: Uh-huh.

MS. MELENDEZ: So you talked a lot about understanding what that customer wants. How -- how much variation is there from system to system? Like every garbage truck doesn't need to make a 40 percent grade. Have you sort of just come to a, well, this is generally what we would -- how we would design a refuse truck application, and this is generally how we'd design a package delivery? Or do you talk to a certain customer if they're placing a certain order level of a certain amount and say we're going to make this little modification or that modification?

MR. WRIGHT: Right. Okay. So the trucking industry is quite mature. And there are very well-established ways of doing things. And so, you know, if you were to talk to say the Cummins people or the Allison people, they don't, you know, cut any corners or anything. When they -- when they put an engine on the market that will

work in all of those applications. You know, they've got specs. But -- so if you were a big fleet operator and you operate in a lot of different environments they don't, you know, by -- there isn't a, you know, San Francisco version of the diesel engine and a Phoenix version as far as -- they used to perhaps go to the stage of, well, you have a bigger radiator if you're in a hot climate. Right.

And they do -- at the truck level they do go to -- especially those delivery guys that drive around with the doors open and have this super-duper heater, because they get cold and they, you know, -- so they -- they will put 40 kilowatts or something into an auxiliary heater, and they don't do that in San Francisco or Phoenix.

But generally for the power train stuff, no. The way the trucking industry works is, you know, there's a general spec. It will work anywhere in the Continental U.S. And we try very hard to fit in with the way it's done in the industry. The less -- the less compromise and the less change you ask your customers to make then the easier it is to sell them on the economic benefits.

MS. MELENDEZ: And the other thing I thought was interesting was about regenerative braking.

MR. WRIGHT: Uh-huh.

MS. MELENDEZ: And you said you tried to design it so that the drivers take advantage of that without training.

MR. WRIGHT: Yes.

MS. MELENDEZ: Does that work most of the time?

MR. WRIGHT: It's actually really surprising. So we have this Isuzu that I showed you that's in the shop in San Jose. Anyone that comes by I say, here, take it for a drive, you know, and I -- you know, somebody usually goes out with them. And so you get the entire spectrum of drivers. It's really quite scary sometimes, these people. You have a driver's license? And some of those folks that are not professional drivers and they haven't driven a Tesla, when the lift their foot -- so when they -- when they go to lift their foot off the accelerator their natural thing is just to take it off, right, all the way. And so in that truck that will give you point .3 G, which is a fairly hard stop. It's like, wow. And for some people it takes, you know, a whole lap of the block before they get the hang of that.

So I'm probably not speaking out of school, but when we first started testing with FedEx a bunch of us went out and spent a day with a FedEx driver, and I did that one day. And there's a jump seat in the -- in the thing. Incredibly uncomfortable. I could barely walk at the end of the day. And they load the trucks inside. And this particular day they tossed the keys to this -- this guy and he hadn't driven it before, hadn't had any training. And

they said, "Hey, Frank, take this truck out today."

And he goes, "Okay. No worries."

And so I thought, well, I'll just sit here and not say anything and see how he does; right? And he knew it was electric drive, and he knew that because he turned the key on and there wasn't any noise and it was ready to go and it started to move, so all right. So by the time he got out of the building he had that regen braking calibrated. He had it perfectly controlled. And he never had to think about it again.

And I think that's generally the case with the pro drivers. And to give you a sense of scale, this particular guy has been driving for FedEx for, I don't know, 25 years or something. He's done 3 million miles in those trucks.

So it's just second nature; right? You do anything that much, you get really good at it.

MS. MELENDEZ: Thanks, Margo.

Matt?

MR. MIYASATO: Ian, thank you for that presentation. I found it really interesting because as -- as was mentioned before, we funded, and a lot of agencies have funded turbine companies --

MR. WRIGHT: Uh-huh.

MR. MIYASATO: -- to design series hybrids.

MR. WRIGHT: Uh-huh.

MR. MIYASATO: So you're coming from a different perspective, which I really appreciate.

And I also appreciate -- you know, I looked at your bio. You're an electrical engineer and you're talking about combustion processes. So I loved the -- I love the photos up there. That's my background is combustion engineer. So I really, really appreciated that.

MR. WRIGHT: Well, they're -- they're kind of rare.

MR. MIYASATO: But, you know, I think Kevin mentioned it, one big hurdle that we're seeing is the certification process. I know ARB is going to try to address it with their innovative -- I think it's innovative technologies, a rule making that's coming out. But I'd just like to get more information or maybe you can address it a little bit, discuss it a little bit, how you're approaching the certification process? Because it's really a system that you're trying to --

MR. WRIGHT: Yeah.

MR. MIYASATO: -- certify, not an engine.

MR. WRIGHT: Yeah. So, yeah, we could use a lot of help there. That's not really our forte and we're not very well connected. And we don't have people on staff that know how to do these things, so we kind of babes in the wood.

In general, sort of a general statement is that this -- this system that we make doesn't fit anything. There aren't any regulations that were written with this in mind. So it tends to get shoehorned into the existing ones, and that doesn't work very well. I mean, I would love if we could sit down with the people that make up the rules and say, okay, well, how -- how should this be certified, you know, given, you know, what problem are we trying to solve? What result are we looking for?

So the short answer is they get shoehorned -- if the engine gets certified they get shoehorned into the heavy duty diesel standards and we make up a drive cycle for that and hope that CARB are okay with it. But we could do better.

MR. MIYASATO: Yeah. It's -- it's going to be a nightmare.

MR. WRIGHT: Well, I hope not

MR. MIYASATO: Because you're all -- because, you know, as -- as Tom mentioned, you're going to have to start dealing with OBD2 as it comes into play in the medium and heavy duty space. So --

MR. WRIGHT: Well, most of OBD2 just doesn't apply. Those sensors don't exist on the engine. It doesn't have an emissions control system. There aren't any stuff. Yeah.

MR. MIYASATO: Well, maybe we could talk offline.

And then the -- the final thing is, so what is -- what is your vision for kind of commercialization? Do you -- do you intend to be the manufacturer of record of the vehicle or do you want a sell systems or --

MR. WRIGHT: No, no, no, no. We're a power train company. So sort of Cummins and Allison together, that's -- that's our business model. That's what we do, is we just sell the power trains. Yeah.

MR. MIYASATO: That's a good idea.

MR. WRIGHT: Yeah. And we sell them, you know, as re-packets, but then into -- you know, there's so many NDAs now, there's so many things I can't talk about, but it's starting to happen in new vehicles now too.

MR. MIYASATO: Thank you.

MR. WRIGHT: Uh-huh. Welcome.

COMMISSIONER SCOTT: Thanks, Matt.

Any questions from around the table? And I know that Mike has one, so go ahead, Mike.

MR. SIMON: Thank you. Thank you, Ian. I'm glad to see turbine technologies have come along. It was about 15 years ago, Josh and I were involved in putting Capstone turbines in transit buses.

MR. WRIGHT: Uh-huh.

MR. SIMON: And it was very difficult to make work

with the lead acid batteries --

MR. WRIGHT: Oh, I'm sure.

MR. SIMON: -- and the technologies we had back then, so it's nice to see what you're doing.

Question. You talked about the combustion. And maybe between you and the folks around the table, Matt, maybe you can help educate me. This is -- this is not a gotcha question, so don't take it that way. I'm just trying -- I'm curious.

In terms of carbon emissions, I've been -- from what I've read and the statistics or data that I've seen I've -- my takeaway is that when you burn a gallon of diesel fuel it produces somewhere between 10,000 and 13,000 grams or carbon per -- per gallon.

MR. WRIGHT: Twenty-three point something pounds, yes.

MR. SIMON: Sorry?

MR. WRIGHT: Twenty-three point something pounds, yes.

MR. SIMON: Okay. So somewhere in that range, about, you know, an order of magnitude, 10,000 grams. And then a natural gas engine, my understanding is that the carbon emissions are -- are maybe 30 percent less from a natural gas engine than a diesel engine, or something of that magnitude.

MR. WRIGHT: No. There you've got to involve it with the fuel consumption of the vehicle. So it's -- there's less carbon in natural gas per unit engine than -- than there is in diesel per unit energy, but the natural gas engine is less efficient so it burns more gallons to produce the same amount of --

MR. SIMON: Right. Well, I'm not talking about carbon per mile. I'm talking about per -- just per gallon of fuel. And, obviously, the efficiency would have to factor into --

MR. WRIGHT: Yeah. Okay.

MR. SIMON: -- the per mile.

So my question or you is where -- you know, with your combustion process with the turbine, does that effect the carbon? You mentioned that it really burns up all the nitrogen so you don't have much of a NOx problem as you do with a -- with a combustion engine. Is there any similar reduction or elimination of carbon --

MR. WRIGHT: No.

MR. SIMON: -- or is it still the same -- are you stuck with basically that same number of grams of carbon per gallon --

MR. WRIGHT: Yeah.

MR. SIMON: -- that you would be with a combustion engine?

MR. WRIGHT: Yeah. You asked that -- that's -- it doesn't matter how you burn the fuel, what engine. If you burn all the fuel, and all these engines burn all the fuel, you know, to ten decimal places, pretty much, they burn all the fuel, you'll -- it's a hydrocarbon. When you burn it you're going to combine the hydrogen with oxygen and you'll get water, you're going to combine the carbon with oxygen, you're going to get Co2. That's what happens when you burn fuel. So you burn a gallon of diesel, you'll get 23.19 pounds of Co2 and a certain amount of water, and that's it. It doesn't matter how you burn it, that's what you're going to get.

MR. SIMON: Okay. Great. Thanks. Sorry if that was a dumb question.

MR. WRIGHT: Oh, no. That's fine. That's a very good question.

MR. SIMON: I just wanted to make sure I knew.

MR. WRIGHT: Yeah.

COMMISSIONER SCOTT: All right. Great. Well, thank you so very much, Ian, for your presentation.

MR. WRIGHT: You're welcome.

COMMISSIONER SCOTT: And I will turn it back over to Tim to introduce Mike.

MR. OLSON: Just one other comment before we go. If some of you in the room are trying to use the Wi-Fi, it's

not functioning well because we've exceeded the capacity, which we went through an IT -- IT change apparently this last weekend, and the capacity for Wi-Fi was not upgraded. So it's -- it's just -- bear with us on that.

Our next speaker is Mike Simon who is the President and CEO of TransPower, founded in 2010. And this company is -- has developed one of the first integrated battery-electric systems capable of powering large vehicles. And he's demonstrated that in on-road trucks and yard tractors. Also, they're also working on a bus technology. Mike also, in a previous career, worked at General Atomics and also at -- he was the Chairman and Co-CEO of ISE which made electric and hydrogen buses.

And I want to -- Mike, I hope -- I'm going to -- I want to tell a little story about how I -- I've known you for many years.

But I -- about several years ago I was coming back from a flight from China, and I had no sleep, 24 hours or no sleep. And I agreed to meet with Mike in Ontario. And -- and he wanted -- he was working for General Atomics at that point and he wanted to make a pitch to me about magleve train system. And I -- an interesting concept, but it didn't fit into our investment plan at that time for the -- for the AB 118. And -- and I just -- I was just trying to stay awake.

And finally I just kind of cut him off and said, "What else do you have?"

And he said, "How about an all-electric truck?"

And that's -- that's kind of the lead-in to his discussion today.

MR. SIMON: All right. Well, at least -- thank you. Well, you know, at least my talking kept you awake. Normally I have the opposite problem and I put people to sleep. But I know that you're all -- I'm the only thing standing between you and lunch, so I'll try to not take up too much of your time.

But I wanted to first acknowledge Joshua Goldman who's sitting in the front row over there, our Vice President of Business Development and a close friend of mine, and someone who I worked with at ISE, dating back to the year 2000. He joined us right about when we were building those turbine buses.

And I'd also like to acknowledge a few other people that are managing projects that we have with the Energy Commission, Frank Falcon, Jim Burns, Harry Meyer, a good team, and a very good team. I like to say that I'm the dumbest person in my company. And I think that's great when a CEO can say that because it means you've really hired great people. And so if you ask me any hard questions, I'm probably going to punt it to Joshua.

So moving on to our -- our presentation here, a snapshot of our company is we're developing electric propulsion technology for large vehicles, kind of similar to what Ian is doing. And when I use the term electric propulsion, I use that in a broad sense, not necessarily just battery-electric, but also variants that use electric motors but might be assisted by a turbine or some other type of range extender. I don't know that I necessarily agree with Ian's blanket statement that turbines are cheaper than batteries. I think it really depends. I'll give you an example.

The yard tractor that you see in the third photo on this slide is operating at Ikea at their main California distribution center. And they've got 1.8 megawatts of solar power on their roof, and so they are operating that tractor at less than 3 cents a mile. And so I think it would be difficult for any vehicle using any kind of fuel-burning system, whether it be a micro-turbine or anything, to be cheaper than operating that vehicle, even if you do factor in the life cycle cost of the batteries. But again, I'm not that smart, so I'm not smart enough to know for certain whether batteries are cheaper than turbines or vice versa. I don't think necessarily Ian's statement was right in all cases, but it may not -- but it's probably right at least in some cases.

So to hedge our bets we've developed a versatile system that can be configured in different ways so if it turns out that, you know, turbines are always cheaper than batteries, then we can always put turbines on our vehicles. And if it turns out that sometimes it's cheaper just to run with batteries, we can just keep them as batteries and so on, so -- and we can add fuel cells to them and so forth.

But one of the principles of our company was to start with a battery-only system because throughout the 20 years that I've been in this business I've seen a lot of companies try to develop integrated power trains that use fuel cells or that are hybrids, and they're just juggling too many different challenges and they don't succeed. Now Ian had this background from -- from Tesla and probably has a great team, and so he -- he's probably in a unique situation where he can tackle the entire integrated hybrid system using a turbine. But for -- for most startup companies it's difficult. I think most startup companies who have tried to go directly to a hybrid or a fuel cell solution have found difficulty making everything work.

So we wanted to start with -- and I put myself in that situation with my last company, ISE, where we started off -- you know, rather than us trying to do hybrids, it took us ten years to come up with a vehicle that actually worked. So we decided that we would start with a pure based

battery-electric platform. And then as we perfected that, branch into other variants.

Our model through 2016, through next year is to basically do the whole job ourselves in most, if not all cases, which means we -- we take a vehicle, a diesel vehicle, and we do a turnkey conversion of the vehicle to an electric or a hybrid variant.

However, just -- just like is similar to what Ian's business model is in the long term, we see ourselves primarily as a power train supplier. And I will talk about that in a little more detail. I'm not saying exclusively because I think there will always be a role for a vehicle integrater because technologies will always change, and there will always be new vehicle models that want your technology. So I think we'll always be involved in vehicle integration, vehicle conversion at some small scale.

But to get into large scale adoption of any technology, I think the more logical way is, as Ian put it, to follow the Cummins, Allison, or you know, in our case, Cummins-Eaton model which is to be the power train supplier, let the OEMs install the systems on their own assembly lines because they're already set up to do that very efficiently.

So having said that, we've set up our business to follow that logic. The first of the -- on the far left you see some snapshots of work that is very R&D related. We

obviously have some technology focus, so we do a lot of engineering and design work, experimentation, testing. You see the truck on the upper left photo is one of the electric trucks we built on the chassis dynamometer down at UC Riverside. I'll talk a lot more about that later in my presentation.

We then have what we call a vertically integrated manufacturing process which -- in which we sequentially build up to the point where we can convert an entire vehicle. And we start with the very base component manufacturing. What you see there in the top photo in center column is a control component that we -- that we designed and we build that -- that has most of the master control hardware and embedded software for our overall vehicle control system. We then build up subsystems that control a plate, you see there, that's actually mounted on top of what we call our power control and accessory subsystem which is the -- the package you see in the lower photo in the center column.

Once we've built up all the subsystems, another one of which, incidentally, is the energy storage system you see in the lower right corner, we then do the vehicle conversion. So that's what we mean by a vertically integrated model. And, well, I'll talk more about that in a minute, as well.

We're targeting the largest vehicles on the road. We, you know, we did conclude early on, you know, at the start of our company that there, as Ian put it, there is a greater payback per dollar invested for the vehicles that are larger and heavier and use more fuel. They're also typically -- when they're operated locally they -- they are least -- they're less efficient, so there's a greater social benefit in terms of emissions reduction. So we, like Ian, we're not pursuing long-haul trucks. We think our technologies may someday in some incarnation find their way into long-haul trucks.

But for the foreseeable future we see our market as exclusively being vehicles that are operated in the same general area, local vicinity day in and day out, return to the same location at the end of each duty cycle. That includes about 20 percent of the on-road truck market, refuse trucks being a big portion of that, as well as port drayage trucks. Yard tractors, such as the one that Ikea is operating and that also are prevalent at most ports. Buses of all types. Right now our focus is on school buses, although we believe that the technologies we're developing could be adapted someday to transit buses, as well, and then a variety of other types of vehicles such as cargo handling equipment.

One point I'd like to make is that all four of the

vehicles you see on this slide are actually working vehicles that we've converted to run on electric power.

We owe a lot to the California Energy Commission. And I want to thank Commissioner Scott and the rest of the Energy Commission for the -- the tremendous vote of confidence that they -- or votes of confidence that they've -- they've placed in us over the years.

We were founded in 2010 and we -- we -- our very first funding, in fact, came from the Energy Commission. It was a contract that started in early 2011 and kicked us off. And that was the Vertically Integrated Manufacturing Contract in which we proposed this basic concept of a vertically integrated manufacturing facility and proposed to do some basic testing and develop some basic components and build them up in a vertically integrated way to validate that. It was, you know, a $1 million contract and it was our -- you know, it gave us our start.

I'd like to say a story I've told at a couple of events involving the Energy Commission that Commissioner Peterman liked was that when I -- when I wrote that first proposal I was actually working in -- at home in a little office, home office right next door to my bedroom. And I told her -- I publicly said that I was actually working in pajamas when I wrote that proposal, which is maybe partially true.

But the energy -- the point of that story, though, is that the Energy Commission took a chance on -- on me and the idea of TransPower before it was anything, before it even had -- before the company even owned a screwdriver and had built anything. And I think that there's very few -- you know, no venture capitalist would have done that. In fact, we tried raising venture capital, or I tried raising venture capital and really got nowhere. And so there are very few types of entities in our -- in our society who will take a chance on a very embryonic idea and a very embryonic concept and help support it.

So I think that's a very important niche that I think the Energy Commission fills. And I hope the Energy Commission continues to -- to be receptive to new ideas and new people. You know, I'd love to see some younger people in this room. You know, I think this is -- these technologies are -- are very important to the long-term survival of our species. And so I hope that that continues.

Anyway, enough editorializing.

We succeeded in securing some additional funding for the Energy Commission. The orange bars there show four different projects that were awarded to us, roughly along the timelines. The -- the horizontal positioning of each bar shows you approximate duration of each -- of each of these projects. The Electric Drayage Demonstration Project

provided funding, a little over $2 million, to build seven drayage trucks.

And I'd also like to acknowledge Matt Miyasato and the AQMD and the -- you know, Kevin and the Department of Energy for supporting that project. You've heard about the catenary project. That was a project that, actually the AQMD funded us to build those two trucks you heard about earlier from -- from Joe. But the Energy Commission, indirectly at least, is supporting us on that project.

We also are involved in developing an electric school bus. And the very -- six of those, the first of which will be completed in the next few days under -- with Energy Commission funding.

So -- and what you see are just the thumbnails of the different vehicle projects. And a battery -- the battery pack that you see there is the -- the latest version of our lithium iron phosphate battery pack that's going to go in the school buses.

There -- I'm also highlighting four closely related projects that we've acquired, a high-power terminal tractor which was our first yard tractor project actually funded from the Texas Commission on Environmental Quality. And a couple of projects funded by the ARB, and Economical Electric School Bus Project that resulted in the Type D electric school bus you see below, and two yard tractor

projects, one funded by the San Joaquin Valley Air Pollution Control District for the Ikea tractor, and one funded by the ARB for the Port of L.A.

I'm showing these projects because we could not have won any of those -- these other awards, we could not have done any of these other projects without the foundational projects that the CEC funded first. So -- so I give the Energy Commission, you know, partial credit for helping us acquire these other grants, as well. And that's only some of the -- the projects that we've gotten funding for. So we've been able to leverage Energy Commission investments and it really has provided a huge, you know, amount of benefit to our company. And I'll talk about what we've done with that investment a little later on.

So I just showed you kind of what the last five years looked like. Looking forward to the next five years, we were fortunate enough to be selected for four additional Energy Commission projects at the very beginning of this year. And, you know, those are listed here. I don't have photos yet representing those projects because they're still in the early design phases. I actually could have included some CAD drawings and so forth. Had I had a little more time to work on this presentation, I probably would have.

But we have a Manufacturing Grant, and then we have three different Vehicle Demonstration Grants that we

were awarded that we're working on. One will allow us to experiment with some new battery technologies in port vehicles. Another will allow us to expand the use of electric yard tractors around the State of California. And the third one will allow us to integrate our electric drive system into refuse trucks for the first time.

And again, we also have some parallel projects that I'll give credit to the -- the AQMD for the two that are shown here, helping us develop range extenders using a natural gas hybrid engine which could be a turbine, but of now we're using a small -- a small Ford engine that runs on -- that has been converted to run natural gas in those vehicles. In fact, the -- the catenary hybrid truck that you already saw is the very first of those vehicles. It has -- the CNG hybrid system on that is based on a Ford, I believe it's a V6 engine that -- that was developed for an F150 type vehicle and a Mustang, I think, and we're using it, as -- as Ian mentioned, in a micro-turbine you only need 80 kilowatts. You know, you don't need a 300 horsepower engine as a range extender. So we've -- we went -- we've -- we're experimenting to see how small of an engine we can use.

And similarly, we're working with Rob and Hydrogenics on -- to develop a couple of -- two -- two trucks of the CNG hybrid and two trucks of the hydrogen fuel

cell type using Hydrogenics fuel cells. And with two fuel cells on each truck, again, that's going to be about 66 kilowatts, I think, of fuel cell power, augmented by a battery pack.

We have proposed already through the -- the, you know, current solicitations for -- out of the ARB, we've been involved -- we're fortunate enough to be on a few teams proposing to expand our fleets. And we're anxiously awaiting the results of those competitions, as well as hoping that we can take advantage of some of the Proposition 1B money to help fund expansion of our vehicle use.

The photos you see there again are the photo of the Ikea tractor. And then the photo below that is the first of the seen drayage trucks that we built, hauling a large pile of steel to show the robustness and the large load carrying capability of these vehicles.

This is an engineering drawing, artist concept that shows you generally how our drive system is configured in the heaviest duty vehicles that we convert, which are the large on-road trucks. We made a couple of interesting choices that worked out for us in our design. The electric motors, for example, which are the green disks that you can see right in the dead center of the photo, those are the electric motors that were actually designed and developed for the Fisker Karma hybrid automobile, very high-power

motors for a car -- for a vehicle of that size, and the Karma has two of them. We can power an 80,000 pound truck with two of those motors. They don't produce the torque that we need.

But we've solved that problem by developing what we call an automated manual transmission which basically is an automated manual transmission that Eaton already developed for diesel -- to work with diesel engines, but by developing our own software that controls that transmission in harmony with the Fisker motors instead. And it's fully integrated with our inverter which actually is an inverter charger unit, which you can see the big boxes at the front of the -- the vehicle. Those are vehicle -- those are inverters that also recharge the batteries. So we use the same power electronics to -- same IGBTs, insulated gate bipolar transistors, to recharge the batteries for the switching of the batteries, we do to control the drive motors, the high frequency drive motors. So -- so that was an innovation. And it's a very high-power charger, 70 kilowatts that's -- that help minimize the infrastructure you need outside of the vehicle.

And we do have a lot of batteries, a very, very heavy battery subsystem. We hope to reduce -- I hope we can reduce the weight of this subsystem over time. Right now a full battery truck like this, that battery subsystem as a

whole weighs almost 7,000 pounds. And that's only enough to get you about 100 miles range with today's battery technologies. So -- so, yeah, I mean, there will be a lot of users who just won't use that for whatever reason, because they either need more range or because they need every bit of weight that they can get, and those users will use a micro-turbine, you know, they -- hands down. You know, on that time application for that user, the -- the micro-turbine or some kind of hybrid is a better option. But that's we designed the system to allow us to offer hybrid, as well.

But we also do think there's room under the tentative for some battery solutions. There are -- there will be those users who are already hauling very heavy weight, so the extra couple thousand pounds of weight won't matter to them and -- and who don't need very high range. We have users that do round trips between their facility and the Port of Los Angeles and the Port of Long Beach do -- you know, it's 14-mile round trips and haul, you know, 100,000 pound loads on a heavy-weight corridor. So for someone like that, a couple thousand pounds of battery -- extra battery weight and the limitation to 100 miles a day, it doesn't matter, and it may be a great solution for those users.

So that's one of the -- the strategies we're employing is not to try to be all things to all people but

to, you know, to capture niche markets with different configurations, but use common component across all those configurations so the hybrid vehicle is not totally different than the battery-electric. It uses -- you know, it's 80 percent the same components. It's just an add-on hybrid kit or a fuel cell kit that gives you that differentiation and allows you to achieve some economies of scale while still differentiating your product across multiple niche markets.

So as I mentioned earlier, our strategy is to move what we call kit sales. A kit would be the complete set of subsystems needed to convert a vehicle to run on electric power. And our long-term goal is to package these kits, test them at our facility using a test stand, and shrink-wrap them and send them to large truck and bus manufacturers and let them install them on their own assembly lines, the same way they receive an engine and transmission today. And that will clearly result in a lower-cost product than if we're doing it at a much lower volume, especially if, you know, if there are differences in labor costs between, you know, our costs of operating in Southern California and maybe a truck manufacturer that might have a plant in the Midwest, or even down in Mexico.

So, however, as I mentioned earlier, we do see ourselves continuing to convert vehicles on our own in

special cases where -- because an OEM is only going to take over, you know, that -- that role is there's enough vehicles coming off their assembly line to justify them changing how they do business. You're -- if you go to a big truck manufacturer and say will you install these systems on your trucks and you're only ordering five a year, they're not going to do that.

But if you have a customer that wants five, you know, if you have a customer that really wants the -- our system in a certain truck model and that -- we're not yet at that volume with that truck and we can do it ourselves, it may not -- it may cost us more. But if the operator is willing to pay -- if the vehicle operator, the buyer is willing to pay the extra cost for a custom aftermarket job, we'll always be available to do that, as well as the continuation of the R&D process, adapting these technologies to new truck models as new -- as new OEMs do become interested. And also experimenting with new components as -- you know, we see battery technologies continuing to evolve. We see turbine technologies like Ian's continuing to become -- you know, becoming available. We want to be able to adapt to those technologies.

So here's just sort of, you know, a pictorial representation of how we do that. Again, we have -- the basic subsystems that we would delivery to an OEM fall into

three basic categories. We -- and we call them the motive drive subsystem which is basically your -- you can see your two Fisker motors there connected to an Eaton 10-speed transmission. And the -- the energy storage subsystem which is the batteries integrated into enclosures with battery management systems and monitoring.

And -- and then finally, a power control and accessories subsystem, or PCAS is what we call it, that has those inverter charger units, the overall vehicle controls, electrically driven accessories for power steering, braking, air conditioning and so on, all packaged onto one skid that is similar in size to an engine. So if you look at the way that that PCAS assembly in the lower left-hand corner is shaped, it's rectangular shape and its size are designed to basically emulate sort of the dimensions of a large, you know, Cummins engine that would be in a -- in a Class 8 truck. And, in fact, the attach points that attach to the frame are the same as -- as the engine would have. So the idea being to make it as simple as possible for an OEM, an original equipment manufacturer, to install this in their trucks when they -- when we do get to that point.

In the meantime, as shown on the upper right-hand corner where show one of our trucks being integrated at our facility, it also makes it easier for us to integrate them and give us more flexibility if we can build up a lot of

these subsystems assembly-line fashion and put them in the trucks ourselves that's -- we found that's a major lesson learned. As opposed to just taking all the base components and putting them directly onto the vehicle first, doing -- having that interim stage is -- we've learned that that's a lot easier to handle.

If you look, for example, at that PCAS assembly in the lower left corner, clearly, if we had to make an adjustment to one of those components it's much easier to do so if it's sitting on a test stand out there on our floor than if it's already integrated into the vehicle in the engine compartment, which forces you to climb onto the -- you know, on top of the engine compartment to get to it.

So -- so not only does this packaging, this vertically integrated approach of building subsystems first position us for our longer-term business model of selling kits to OEMs, it also makes our near-term job easier.

One of our goals for next year is to get to a process where for this coming year we want to produce one vehicle every two weeks. So our goal is to produce about 25 vehicles next year, all -- but using this -- you know, building all the kits at once. For example, the PCAS assemblies, which is really the most complicated of all the subsystems, we want to build all 20 or 25 of those in one batch, probably at a rate of maybe one a week. And the ones

that -- and then stockpile the extra ones and put them right into the vehicles. So when the vehicles show up we hope to only have a vehicle in our facility for a few weeks, and eventually be able to convert a vehicle in a few days.

I've mentioned some of the innovations. We -- you know, each one of our subsystems has its own unique features that we think give us some competitive advantages. I mentioned the automated manual transmission; that has a lot of benefits over other ways. There are only two other ways, really, to make an electric vehicle work. Most electric vehicles use the direct drive method which is where you -- you just have a motor that can do -- you know, generate the torque, as well as the speed range you need. The problem with that is that most motors that are capable of doing -- giving you -- for these very heavy vehicles you need a very, very large heavy motor to do that, and those motors get very expensive.

And they're generally not able to achieve high efficiency, both at the low speed-high torque range and at the high-speed range that you want where you don't need as much torque, you know, just to sustain freeway speed. It's -- it's virtually impossible to get, you know, optimal efficiency at both ends of the speed range. So you sacrifice that if you go with a direct drive, as well as you have a very big heavy motor.

The other approach that's commonly used in electric vehicles, the only other approach, really, that I'm aware of is to use essentially an automatic transmission to give you that -- that gearing. The problem with automated -- automatic transmissions is they have these things called torque converters that are always spinning, and they're always sapping energy from the vehicle. In a diesel vehicle using an automatic transmission you don't really notice the -- the losses from the torque converter because you have so much energy content in a gallon of diesel fuel. But in an electric vehicle where you have precious, you know, few kilowatt hours of -- of energy storage, that torque converter has a significant effect. It can reduce your operating range by a couple three miles each day easily, maybe even more, maybe five or ten miles.

And that's generally true of the electrically driven accessories as a whole, the -- the accessories. We use very efficient on-demand accessories that turn on your braking, you know, your air system for your braking and your power steering pumps only when they're needed as opposed to running them all the time, and that saves energy, as well.

And all those little things, as well as the -- the efficiency, mapping the efficiency of the automated manual transmission exactly to your motor speed range and having a very efficient inverter, 98-and-a-half percent efficient

inverter, all those things combine to give our vehicles a higher efficiency and a longer operating range than previous generation electric vehicles. And we have -- we have dynamometer test data to prove that, which I'll show you in a couple minutes.

We also have an advanced energy management -- or battery management system that we recently started using on all of our vehicles. That's the lower photo. The green squares or rectangles you see there the main sensor balancing boards of the battery management system we developed with EPC Power which is a sister company located across the street from us which actually developed the inverter charger unit for us.

They're actually friends of mine that came up -- that left General Atomics around the same time I did, they had previously developed megawatt inverters for the Navy with General Atomics. And I convinced them or helped convince them to leave General Atomics and develop their own company, and they've become very successful, developing super-advanced inverters for commercial applications, including ours.

And sort of as a side favor for us, they developed this battery management system board for us which is spectacular. It not only monitors each individual cell's voltage and temperature to about ten time as high an

accuracy of any commercially available BMS we were able to find, but it also does active charge balancing at up to a 6 amp rate, which is unheard of. And it basically lets you -- instead of just shunting power from your highest voltage cells, which is what most passive BMSs do, what all passive BMSs do which most BMSs are, it actually takes a charge from the high voltage cells and routes it to low voltage cells, and that makes the -- the vehicle more efficient. It -- it -- you're not rejecting as much heat and it makes the -- you're not wasting as much battery energy, so that also helps.

And none of these -- none of these innovations in itself is a huge game changer. But when you add up all these little teeny features it really has a significant impact on the vehicle's overall efficiency.

COMMISSIONER SCOTT: Hey, Mike, just a quick time check. You've got until 12:00, 12:05, so --

MR. SIMON: Okay. Great.

COMMISSIONER SCOTT: Sure.

MR. SIMON: Thank you for that.

COMMISSIONER SCOTT: Yeah.

MR. SIMON: So I'll speed up here.

The -- the next few slides, which you can -- you can read at your leisure, basically just talk in a little more detail, drill down into each of the vehicle programs.

We have an On-Road Truck Program where we have about 20 trucks funded to date and of which we've completed about half of those trucks, including the two catenary trucks, including six drayage trucks, three of which are in service and -- and three of which are just being completed as we speak and are being commissioned as we speak, and will be in service by the end of the year.

And we have built five yard tractors to date. The -- the first one to go into service, the one -- the Ikea tractor as accumulated over 15,000 miles and operates three shifts a day. These are very reliable vehicles. We've had almost no service calls for any of these vehicles for the past year. You know, we basically have one Maytag repairman up in L.A. who goes out and -- and fixes -- does little software tweaks or fixes a small part here and there. But we've had, you know, no major propulsion system failures really to speak of. And so we're -- we're now moving into the mode of expanding these.

We have one transit bus. This was more of a learning bus -- I'm sorry, one school bus. It did actually operate in day-to-day service out of San Diego at two San Diego School Districts last year for a couple of months. But we -- after we learned we took it out of service and we're now upgrading the drive system on that, as well as building six buses using a more -- you know, the more

evolved systems that we've -- that we've gravitated towards over the last two or three years that will be in service permanently later this -- starting next year.

And we are hoping to jump into a significantly higher volume school bus build next year with a target of building about 35 school buses for a demonstration that would take -- that would take place between 2016 and 2017.

I mentioned the dynamometer testing. Here are just some conclusions of the UC Riverside. This is independent test results and direct quotations from UC Riverside from their report on their independent testing of our latest generation electric -- on-road electric truck, which you see here. This is one of the three trucks that is in service today. Before it went into service it was tested at their dynamometer in Riverside. You can see that it had -- it's -- they've concluded that it has, you know, significant improvements in emissions, as well as fuel economy, and significant potential of cost savings estimated at $350,000 over a ten-year operating life. The same exact type of conclusion from testing of -- of the Ikea electric yard tractor before it went into service.

And, you know, without naming names we saw the data side by side with previous electric trucks and previous hybrid tractors that had been tested and there was no comparison. Compared to the previous electric truck, our

electric used half as -- it was almost a full 50 percent lower energy consumption per mile as a previous electric truck that had been tested.

The impact on this -- the impact of this on a bottom-line basis is pretty substantial. Here you see basically the UC Riverside data translated into dollars and cents. And you can see that on the left-hand side the cost per mile of operating an electric truck using our system is shown to be, again, about half the cost because of that twice the efficiency of the competing electric truck that was tested two years earlier, and a sixth as much as a diesel truck based on the fuel pricing assumptions at that UC Riverside assumed.

And similarly, electric tractors, same basic thing. And as I mentioned, the -- the electric tractor is Ikea is average about 3 cents a mile versus a 31 cents a mile here, because 90 percent of its energy come from the solar panels they have.

The -- because of the accomplishments we've been achieving, getting fleet operator interest has -- has improved. It was, frankly, quite slow the first few years while we were in the prototyping phases and we just had, you know, earlier-stage demonstration vehicles to show. We only had a few very -- very, you know, advanced-minded earlier adopter customers willing to work with us, and those are

shown in the left-hand column. But within the last year we've -- we've engaged a much larger, broader use of fleet operators. So on the right-hand side, every one of those fleet operators has agreed to operate our vehicles in their fleets and either has them or will have them within the next year. And the distribution of those fleet operators, you can see, is statewide, from the Sacramento area all the way down to San Diego, with a lot of operation in disadvantaged communities.

In terms of just numbers, what we show here is a summary of, at year end, the number of vehicles that we have in operational service. You can see as of the end of last year we had six. At the end -- at the end of this year, with the three drayage trucks about to enter service, we'll have 13. That does not include the two catenary trucks which we consider to be prototype vehicles in testing. By the end of next year we project that number to go to 50. And our goal is to get to 125 by the end of 2017, in two years, and to continue exponential growth after that. Especially if we can start supplying kits to OEMs, we see those numbers potentially doubling every year. And if you do the math we could be in the range of -- of providing 1,000 drive systems a year by the year 2020.

The -- some of the metrics -- and again, I don't know -- I have no idea how we compare to other recipients in

this regard, but these are numbers that you can crunch here at the Energy Commission to kind of, you know, compare, you know, how much bang for the buck you're getting with the -- with what we're doing with the money that you've been giving us. I'm kind of open kimono here, just, you know, it's public information anyway. But I'm showing how much Medium and Heavy Duty Program funding we received each year the past couple of years, and how much we project to receive next year and in 2017. You can see it's a substantial amount of support, and we definitely appreciate that.

And based on the reduction of carbon and petroleum shown on this slide we're kind of showing -- I'm kind of showing here in rough numbers the dollars per -- you know, investment per Co2 eliminated or, you know, per ton of Co2, dollars per gallon of petroleum reduced. And I would say I've used fairly conservative numbers here. I haven't assumed any -- you know, this is just for the next couple of years. This is based on vehicles that are already funded. If there were some major change to our company and major infusion of capital or major ramp-up in production, the -- the carbon reduction and petroleum reduction could -- could be greater than what's shown in this slide. And I do expect those numbers to (inaudible).

So you can see the basic trend is that dollars per gallon of petroleum eliminated. Gallons per -- or dollars

per ton of Co2 eliminated are fairly high today and were fairly high last year, but are shown to go to down substantially over the next few years as the vehicle population and vehicle miles increases. So again, I don't have time to go into that slide in more detail, but you have it for your use. And I'm available to answer questions about it.

Here's just our estimates of the addressable market for the types of vehicles we're targeting. In summary, we see it as about an $11 billion market.

And I should mention that the Energy Commission, not the Medium and Heavy Duty Program but the PIER at the Energy Commission has supported us in adapting our battery (inaudible) to stationary energy storage and which is one of our goals. Just as Elon Musk is taking his batteries and developed a power wall, we have our -- he's got the consumer version and we've got the -- the larger wholesale version of a power wall which we call Grid Saver, which is basically taking a lot of the same battery technologies and adapting them to stationary applications, such as shown here.

The -- the $2 million Energy Commission contract allowed us to build a proof of concept version which we then sent to Sandia National Laboratory and they tested it, the largest battery they've ever tested. And they'll be publishing data on that.

We also have a contract to develop -- to build a system that's going to be deployed in midtown Manhattan that's going to capture energy from the New York City Subway system starting in early to middle of next year.

And more recently, we've received a contract from the Navy to -- to deploy a battery system on one of their bases on one of their islands off the coast of California.

So combined, all told, you know, you won't normally see companies disclose this kind of information but, you know, what the heck, this is where we -- where we think we can take the company. We think we can make this is a $200 million to $300 million a year company within the next five years. This is the same story we're telling investors. We haven't had any private investors yet, but we are in discussions with an entity that is excited about our prospects. And -- and we may be working with them to raise a substantial capital round very early next year.

So in summary, hats off to the Energy Commission. We're -- we have -- we're very indebted for our first funding coming from the Energy Commission. And it's definitely played a key role, not only, we think, in our success but in just demonstrating the basic feasibility of -- that we can make -- I think before we got this funding and before we entered the picture I think there were serious doubts about whether electric propulsion actually could be

used reliably with these large vehicles, and I think we've show that it can be.

Our vehicles aren't perfect but they are working day in and day out with minimal intervention. So that's not something that you could have said five years ago for vehicles that are in the 80,000 pound class. I think that's a significant achievement and I'm proud of it. And I'm grateful to the Energy Commission for that support that enabled that -- us to do that.

And based on that we do believe that exponential growth in using these vehicles is possible and that continued public support will certainly help us achieve that goal. So thank you for your attention.

COMMISSIONER SCOTT: Thank you very much, Mike, for your excellent presentation.

Let's go to our reviewers for questions. And we'll start with Matt again.

MR. MIYASATO: Thanks, Mike. We're intimately familiar with TransPower, and also the previous incarnation at ISE. So it's good to see you expanding.

I only have a couple questions. One is the Fisker electric motors, I mean, what's the cost and supply of those? What's the forecast for those since it's unclear what Fisker is going to be doing; right?

MR. SIMON: Okay. Well, those motors are now

presently manufactured in China by a company called JJE, and they are our motor supplier. And I'd prefer not to disclose what we pay for the motors. But I would say -- I would say that we, you know, when we -- after we buy the motor, two motors, and we integrate them with a transmission, the combined total package there, propulsion package is something that is, you know, less than $20,000. And if you were to compare that with a large Siemens motor that ISE was using to do similar type work, it's about half the cost and -- and has, actually, better performance across the total speed range.

I think in higher -- as we go to higher quantities the combined cost of the -- couple those motors and the gear -- and the gear reduction system in higher volumes we can get down to say the $10,000 range, and that's for a dual motor solution for a very heavy vehicle.

Does that answer your question?

MR. MIYASATO: It does.

MR. SIMON: -- sufficiently?

MR. MIYASATO: Yeah.

MR. SIMON: Okay.

MR. MIYASATO: You had mentioned the goal is to produce about a vehicle a week; is that right?

MR. SIMON: Well, for next year, one vehicle every two weeks --

MR. MIYASATO: One every two weeks. Okay.

MR. SIMON: -- with the ability by, frankly, by the end of the next year we may very well need to be in a position where we can produce a vehicle every week. But the goals is to get there in steps. So the next step, I would say, in our evolution is to go to consistently a vehicle being completed every two weeks.

MR. MIYASATO: Got it. And then, finally, and we've -- we've chatted about this before, is you did mention you're looking at niche markets, although you're -- you're doing a lot; right? You're doing truck integrations, your power saver. You're doing stuff with the New York Subway system and whatnot. So what is -- and you had mentioned in your presentation, you're really looking at being a power -- power train supplier.

So what's your vision in the next five years? Is it really focusing on trucks or is it really energy storage, or can you comment on that?

MR. SIMON: Well, yeah. I showed a slide. You know, this is basically the vision right here, it's to do all of the above. And again, that -- that kind of violates the conventional wisdom of you have to be focused, focused, focused. But what hedges us, you know, or gives us that ability is the fact that we're using the same basic core subsystem. So he subsystems, for example, the PCAS assembly

that we would be selling in a kit form for school buses and yard tractors would be essentially identical. And for the Class 8 truck system the main different is adding a second inverter. Otherwise, it's basically the same exact thing. So why not go after all those markets if you can use the same and sell the same product, all the -- the same thing, basically, that we're -- we're striving to get to a standardized battery module where we can use a very, very similar, if not identical, battery for all the vehicle applications.

MR. MIYASATO: But does that -- does that slide depend on any type of incentive?

MR. SIMON: Well, the unit costs, you know, basically have different -- different assumptions built in. If you look at the, you know, converting the full turnkey conversion at a cost of $300,000, you know, that going to probably require some time for the setup. There aren't too many truck operators that will pay that much.

But if you look at a drive system kit at $150,000, $100,000 to $150,000, there may be ways -- I think initially subsidies will certainly make that -- help, you know, drive adoption. But long term, I don't think so figures are too far off from what could be commercially viable because, again, these are vehicles that are going to save $100,000 to $200,000 to $300,000 in fuel over the course of their --

their use. So it's really more a matter of monetizing that.

And one concept that we're talking about with one OEM in particular is a battery lease. So, for example, with a school bus kit shown there at $100,000, if you take the batteries out of that, that becomes a $50,000 kit. And the school bus manufacturer can potentially sell that bus for very close to what a diesel bus would cost, maybe a $20,000, $30,000, $40,000 incremental cost. And then separately we might be able to lease the batteries to the -- to the school district over an eight-year or ten-year period.

So while subsidies, I think, undeniably will remain very important to getting up to scale, I think once you get into scale and can get to these lower numbers there are possibilities through creative financing to reduce the dependence on the -- on the subsidies and, hopefully, eventually eliminate dependence on them altogether.

A lot has to do, also, with fuel costs. Well, if fuel costs go to $8.00 a gallon like they are in Europe, or if we end up with a carbon tax, you know, all bets are off.

MS. MELENDEZ: That was going to basically be my question about $100,000 school bus kit, and how many would you really sell? Would you really sell 500? But I guess if it's the same as the yard tractor kit, you might as well just offer it all up if you're building it anyway. So I think that answered that question.

Out of all those applications that you're sort of looking at now, which ones do you think are going to be the most robust from a business case standpoint? Which ones are you most excited about?

MR. SIMON: You know, I'm an excitable person. I get excited about just about anything, so I'm excited about all of them. You know, again, I'm not smart enough to really pick. Are hybrids going to be better than fuel cells? Are fuel cells going to be better than battery-electric? Are yard tractors going to sell better than school buses?

Actually, I just changed this slide, and it bumped up to school bus number substantially. That was really the least -- if you'd asked me the same question six months ago I would have put -- I would have said I don't know, but I will say the one thing I do know is I'm -- I would put the school buses at the bottom of the list. But based on recent conversations with OEMs and recent developments, now I'd put school buses at the top of the list. So it's a very dynamic -- you know, it's really unpredictable how OEMs and customers are going to react, as well as how technology is going to change. So again, we're trying to cover our bases.

Now, frankly TransPower will be a successful company if we just nailed one of these, you know, you know, much, you know, much less at 270 million. But even -- even

if we only did school bus and yard tractors and became a $50 million company, that wouldn't be a bad thing for a company that this year is only going to do about $6 million in revenue, so that would still be huge growth.

So this is -- granted, this is a home-run scenario. This is we -- this is we succeed spectacularly in everything. But if we can do one or two of these we'll be doing just fine, or all of the above at ten percent of what we're showing there. So it's not -- there's a lot of different paths to success here.

COMMISSIONER SCOTT: Great. Kevin?

MR. WALKOWICZ: Great presentation. Good -- great product. I've had the chance to drive in it. I think Joshua took me for a ride in one of your trucks at South Coast, maybe a year ago. I think he was able to demonstrate the wheel spinning capability through at least the first two gears, maybe third gear, too. But it's -- it's a pretty impressive technology.

And I was going to ask the same question as Margo, kind of what's the -- what do you think the sweet spot is? But it -- it sounds like your answer is you're -- you're kind of covering all the bases and seeing, you know, what the medium and heavy duty market is. It's very diverse, and every customer needs a little bit different solution, whether it's a range extender, the catenary system, or I've

seen the work you're doing with South Coast there. We're looking forward to getting your school bus out to NREL here in the next six months to look at the V-to-G (phonetic) bidirectional capability and some of the -- the grid power management capabilities of that -- that system.

So just very impressive system. And I think, yeah, it's -- you kind of having everything on the menu to choose from is an interesting approach if you can -- if you can, you know, adapt to the market and make money on, like I say, at least a couple of those it would be -- a good success for you.

I was going to ask you just a real quick question. I think I read somewhere that part of the -- the funding from CEC was going to go towards developing a new battery chemistry from a new supplier. I think it's called Candu Energy (phonetic). Is that still on the --

MR. SIMON: Yeah.

MR. WALKOWICZ: -- (inaudible)?

MR. SIMON: Thank you for asking that. First, of all, thank you for the testimonial. I was upset that we couldn't put a little video clip of -- we have some -- Joshua has some nice video clips, if you want to see, at lunchtime, on his iPhone of different fleet operators, you know, excitedly talking about our vehicles. But I couldn't get one incorporated, so thank you for that, providing that.

As far as the battery, yes, on the -- on the Advanced Battery-Electric Port Vehicle Project, we have purchased about $100,000 worth of batteries from a new company in China that has developed what we think is a very promising new battery. It's a lithium iron phosphate battery, which is the same chemistry we've been using in all of our vehicles to date. The main difference is we're -- the batteries we've been using are prismatic batteries, basically rectangular shaped batteries which are the type most commonly used in heavy duty vehicles by companies like BYD and others, whereas the batteries that this new company has developed take the lithium iron phosphate technology and wind it into a cylindrical cell where it's more tightly wound.

And so you basically get about a 50 to 60 percent higher energy density out of those cells. And they start to approach the nickel cobalt energy density that, you know, the LG cam has been using and that, you know, Tesla has taken advantage of in the passenger car and the passenger car companies like Tesla and Nissan have taken advantage of. So that would give us the best of both worlds.

The -- the disadvantage of the higher-energy batteries that are being used in passenger cars is they don't have as high a cycle life if you deeply discharge them, you know, all the -- all the way down to 20 or 30

percent state of charge, which is not a bad -- which is not a deal killer in a passenger car because most users don't drive down their battery all the way, most consumers when they -- by passenger cars. So you can use the nickel cobalt technologies for those types of vehicles.

But for commercial vehicles like ours where the average yard tractor or truck driver is going to use every bit as much battery as he can every day, the nickel cobalt is not a good choice because it would have a much shorter cycle life. So that's why we went lithium iron phosphate. Plus, it's a very stable, safe chemistry. It requires less monitoring and less thermal -- active thermal control and all that.

So this new cylindrical cell preserves all those benefits of lithium iron phosphate technology but gives you the opportunity to get a higher density packaging like you get with the nickel cobalt. So we're very eager to see it. If it works out and we find it as safe and reliable and long life as the prismatic cells the impact would be that it would reduce the weight of one of our big trucks by about 2,000 pounds, or for the same weight we have today it would increase the range from 100 miles to about 150 miles. So it's a pretty -- it would be a significant improvement.

MR. WALKOWICZ: And I think I read somewhere, too, you -- you were paying a little extra on the prismatic cells

to bend them to help kind of with the cell, the pack balancing.

MR. SIMON: Yeah. I'm not going to --

MR. WALKOWICZ: Are you going to have to do that with the new cells?

MR. SIMON: With the cylindrical cells, I don't think so. Well, no. They -- you know, but -- but the surgical cells are a little more expensive, at least today on a cost per kilowatt hour basis. So you're basically paying the same price for those that you are for bending the -- the prismatic.

And this gets to another benefit of the cylindrical cells. It's easier to manufacture cylindrical cells with the same -- with the same manufacturing consistency. Part of the problem with the prismatic cells is just due to aspects of the manufacturing process that I'm not smart enough to tell you about. They -- they have a high -- first of all, they have a high outright rejection rate for those cells. And then secondly, the -- of the cells that do have acceptable characteristics, the energy storage capacity can still vary fairly significantly.

So if you don't have somebody there handpicking the batteries at the factory you're not going to -- you know, if you buy a 300 amp-hour cell, you're not going to have a guarantee that it really has 300 amp-hours of

capacity. So that's why we have -- you know, we sometimes work with intermediaries to, you know, make sure the batteries we're buying do have the advertised energy capacity.

MR. WALKOWICZ: Okay. Thank you.

MR. SIMON: One thing about the cylindrical battery that's also attractive to us is because it's a newer, smaller manufacturer, they're a little more flexible. And they are willing to license the technology to us for manufacturing here in the U.S.

So one of our -- one of the other paths we're investigating, at the risk of making you all think we're totally unfocused, is possibly getting into battery manufacturing. But hell, if Elon Musk can do it, you know --

MR. WALKOWICZ: Yeah. There's room in the desert for another plant, battery plant; right?

MR. SIMON: Yeah. There's another -- another battery. We'll hire -- hire some more people, here, go build batteries. But, you know, the goal there would be to get the cost down to about $200 a kilowatt hour, which is about half what we're paying for the batteries today.

MR. WALKOWICZ: Switching gears a little bit, you know, the good thing is you've -- you've developed a lot of different vocations here. And I guess I just wanted to get

your -- your opinion or outlook on what are you seeing as far as the -- the fleets that you're working with? And are you seeing any -- do see any concern on their sides if you -- if you did switch over their fleet to full EVs with these very large packs that would need to be recharged overnight on a daily basis, are you seeing any concerns as far as what kind of infrastructure, installation costs, burdens are going to happen at the fleets?

And then just the charge management, if you've -- if you've got 50 trucks with 250-kilowatt packs each per truck on there all trying to plug in and recharge during the same 8-, 10-hour, 12-hour period, what are you -- are you seeing any issues, concerns there? How are you going to handle some of the -- the facility EV infrastructure issues that might come up?

MR. SIMON: There are, Kevin, very significant issues there. And I'm sorry I didn't have the time to get into them in my presentation. But, you know, the good news is that we mitigate those issues somewhat by the fact that our charger is onboard the vehicle. So that solves part of your challenge of having infrastructure. But one of the lessons learned, and I'm sorry I'd didn't have a lessons learned chart, one of the lessons learned was that even though we have the charger on the vehicle, to comply with SAE standards and provide total safety you have to have an

off-board separate EVSE box that's capable of providing fault detection, isolation, and so on. So we had to design a special box. I's not nearly as expensive an off-board charger, but it's a piece of -- added piece of equipment. And also we have to -- because we have -- we're -- we have a 208 three-phase interface, anybody with a 480 volt, which is more common, has to have a transformer.

So one lesson learned is even though the transformer and our EVSE box combined cost may be a quarter as much as an off-board charger but can provide the same power, it still is a hassle getting the fleet operator to agree to pay for it, and figuring out where to put it, and scheduling electricians to, you know, to do all that. And -- and if it's too far from where their power source is you could have a very expensive cable run. So then you can -- you get into a debate over where -- where you should charge the vehicles. So there are complications that have to be addressed, definitely.

But the good news, again, is that with the high-power charger it can recharge one of these vehicles in three to four hours. It doesn't need to be overnight. And you can get a pretty good amount of power back -- or energy back into the batteries in just an hour. So we're seeing a lot of fleet operators, like Ikea, for example, they just keep doing opportunity charging all day long. You know, they

stop for breaks, they -- they, you know, they stop for lunch, they recharge, and they can operate almost around the clock by doing it that way. So the --

MR. WALKOWICZ: Have you heard any concerns over demand-charge issues, you know, adding -- doing too much charging at once?

MR. SIMON: It's definitely going to be a concern at some point. It hasn't been yet. With Ikea they have solar. And most of the other fleet operators that we're working with are just, at this point, operating one of our vehicles. And they can either operate at off-peak periods and they can stretch out the charging. But certainly, clearly, to get a point where a fleet is going to have a significant number of vehicles and that load from charging a lot of vehicles at once, that's going to put these fleets in demand-charge territory and we're going to need some help from the CPUC and the utilities and others to soften that blow if we really want this technology to get adopted.

But the real short answer to your question is every fleet is a little bit different. And there will be fleets for which just any battery solution is just going to be a deal killer. And they're the ones that are going to buy hybrids and turbine hybrid and things like that and we're not -- and we're just not going to be able to convince them because it just won't work for them.

And then there will be fleets that have tons of solar and for whom a battery-electric is just -- it's just a no-brainer. An they're the ones we're obviously going to go -- the low hanging fruit that we're going to after first. And then there's everyone in between.

COMMISSIONER SCOTT: We're very close to 12:30, so I'm going to let Bob ask a couple of questions. And then maybe if you'd like to continue to follow up with Mike, you guys could have lunch with him.

Go ahead, Bob.

MR. SIMON: Or take me out to dinner. I'll be here.

COMMISSIONER SCOTT: Or take him out to dinner.

MR. SIMON: My flight doesn't leave until 7:15.

MR. R. NGUYEN: Yeah. Well, yeah, I got four -- it looks like I've got about four minutes here. Well, my questions will probably take you less than four minutes to -- to answer, so -- so that's good.

To kind of tack onto what Kevin was talking about in terms of the batteries and the costs, and you had also mentioned target goals of going down to $200 per kilowatt hours, do you project -- are we going to get there in the next five to ten years or it's going to be a longer term?

MR. SIMON: You know, I don't have a crystal ball, so it's really hard for me to -- to say anything like that

with certainty. What I can tell you is that the battery company we're working with right now is, you know, they're not yet at full capacity, but they've projected that the cells can be produced at $200, you know, a kilowatt hour. And once we transport that to -- if we do that in the U.S. with certain costs being higher here, we may find that there's challenges getting down to that level. But we're also reading projections that, you know, other cells are now down to $165 kilowatt hour. And when we started TransPower five years ago the conventional wisdom was that lithium batteries were all about $1,700 a kilowatt. So they've already come down, at least by a factor of five just in the last five years.

We know we can buy -- if we -- if we go with -- you know, if we're less discriminating about cells we buy from China today, and some of the cells that are actually manufactured here, we can get them for closer to $300 a kilowatt hour; $400 is sort of the maximum we'll pay today for a cell. So we're already buying them for, in some cases, $300 a kilowatt hour, maybe even a little -- a hair less. So we know that those people must be manufacturing them for close to 200 a kilowatt hour today.

So -- so I think it's entirely possible that we can get to $200 a kilowatt hour within the next five years. And, you know, with the ingenuity of all the people working

on new battery technologies, who knows how much lower it can get. I used to believe you'd never get below $200 because that's about what lead acid batteries cost in today's dollars, or $150. And now I'm hearing -- I'm reading claims that we might be able to even get below that.

MR. R. NGUYEN: Right. Just one more question on the -- the way that you guys approach your manufacturing process. You guys are still pretty small manufacturer, especially when you think in terms of the truck market. And looking at the number -- the number of vehicles that you have available that could make sure of your product, and thinking longer term there's quite a bit more platforms that you could build your -- your electric driver out, what are you thinking in terms -- or have you been thinking in terms of how can you manufacture those components to attain a certain level of modularity so that you can -- a certain number of components can just transfer to a number of different platforms just to reduce the cost?

MR. SIMON: Yeah. Absolutely. The whole philosophy of the company is that these subsystems you see here, the same basic subsystems could be installed in many different vehicles. So the most complicated one, again, is that power control and accessory subsystem. That has all of power electronics, all of our accessories, our inverters. That's the most labor intensive and has the most parts and

is the most challenging to manufacture of all the subsystems we build. And we believe it's possible to build -- well, all the major components are the same. The -- the geometry may differ slightly from vehicle to vehicle depending on the space claim, what the engine compartment size and shape is. But all the inverter charge units are the same, so we can produce just hundreds of inverter charger units assembly-line fashion and then route them to different inverters, to different power conversion -- PCAS geometries.

The electric accessory components, the scroll compressors, all the other things are identical from vehicle to vehicle to vehicle. So, you know, 90 percent of what we put in the vehicle -- 90 percent of the build material will -- is going to be identical no matter what vehicle we're talking about. And so we can just go and we can use our buying power and buy all those components and just stockpile them and get the economies of scale there. And a lot of the subassemblies, same thing, we can build the same exact subassembly. And then the differentiation will occur as late in the process as possible.

So you build as much commonality as you can, you know, and you keep everybody in the same room doing the same exact thing. And then you route -- at the last possible minute you route, you know, the things that have to be a little different for the school bus, you have a separate

team doing that -- that last stage of assembly. And for the ones that -- and then for the yard tractors you have another -- you know, at the tail end of the assembly process you customize all those items for the -- for the yard tractor. So it's -- it's a challenge.

But I think that, you know, there -- there are analogies, you know, today in the manufacturing arena for how that's done. You have companies -- well, you know, transit bus manufacturers, you know, it's not a commonly known fact, but every single transit bus is custom designed for that transit agency. They all have their own color, their own seat patterns. They're -- they're not identical. Transit buses are mass producers. You know, New Flyer builds thousands of buses a year, but -- but they're not all the same. And they will -- they're built in batches of 5 and 10 and 40 and 50, and maybe a few hundred bus batches for big cities. And they have to preplan each production run and they're all a little bit different, sometimes very different. We have to basically emulate that kind of production model.

COMMISSIONER SCOTT: Great. Well, thank you so much, Mike, for your excellent presentation. I think we've all had a really informative morning.

Just remind folks, if you'd like to make a comment the blue cards are our front. And make sure you get those

over to Tim. And we will -- and I'll also remind folks to go visit the truck, if you have some time during lunch. It will be, I think, very neat to take a look at it and see.

And please come back right at 1:30 sharp because we've got three more really interesting projects that we'll dig into this afternoon. So we'll get started after lunch at 1:30.

Tim, anything else?

MR. OLSON: No.

COMMISSIONER SCOTT: Okay. Terrific. See you guys at 1:30.

(Off the record at 12:34 p.m.)

(On the record at 1:31 p.m.)

COMMISSIONER SCOTT: With our afternoon, we've got three additional projects that we will do a deep dive into and have a chance to hear and learn more about.

So I'm going to turn it over to Tim Olson to introduce our next speaker.

You ready?

MR. OLSON: Yeah, I'm ready.

COMMISSIONER SCOTT: Okay.

MR. OLSON: Okay. Thank you, Commissioner.

So we're going to go into, as the Commissioner mentioned, the last three presentations and use the same kind of round robin kind of questioning.

The next speaker is Jim Castelaz of Motiv Power Systems. And this company has been in operation for about six years, I think, something like that, for -- and is developing an electric power train for lots of different applications. We're familiar with shuttle buses and -- but they have some -- some interesting things that they're looking at, maintenance trucks, delivery trucks, shuttles, school buses. And Jim has a -- has a degree in -- Master's in Electrical Engineering from Stanford University, and an BS in Engineering Economics from Harvey Mudd College.

So, Jim, you're welcome to give your presentation.

MR. CASTELAZ: All right. Thank you very much, Tim. I appreciate that introduction.

And thank you to Commissioner Scott and the rest of this Commission for hosting this event. I think there are probably not enough opportunities for the industry to get together. And looking around this room and the people that I have the privilege of presenting, before and after, I think is -- is cutting edge for -- for vehicle electrification. There's nowhere -- nowhere in -- in the country where there's this much horsepower into changing an industry, into changing this industry. And so that's awesome to be a part of it, so thank you all.

So Motiv has been around, as Tim said, about six years. It started in my living room back before I was

married and had two kids. And so it's been quite the ride, a lot of fun. I don't -- I'll say that, yeah, sure, I was in my pajamas, yeah. That makes the story better.

So you can see some Motiv-powered vehicles here. These are all in service with customers. You'll notice one of them is a garbage truck, a little like the one sitting outside except it's a rear loader. And it is on snow and it has operated in snow through winters in the City of Chicago minus 30-degree weather. It's operated through snowstorms, and without any real significant range degradations there.

So what these vehicles all have in common is what's under the hood and the electric power train. So Motiv develops controls and software. We pair that with batteries and motors and we install it onto truck chassis at the time of manufacturing. And that's our technology, that's our product, it's this kind of operating system for the truck, the software and controls to make that plug and play. And we manufacture all those controllers in California. And then we have different truck builders and bus builders install them.

So looking at ARFVTP objectives, our first grant was in early 2010. And at that point in time I was kind of referencing that scope of work from our more recent ones. And our ARFVTP objectives have changed a little bit, but generally they're -- they're about the same and they fall

into a couple of buckets that I just created from my own thought. And what we really focus on are these vehicle technology, and that's -- that's how we fit into the scope of this great program. Kind of ancillary to that is training and outreach. We do end up doing that. But really our focus is developing this technology, and not even all of those objectives.

Really, we just tackle one of those objectives which is improving the efficiency, performance and market viability of alternative medium and heavy duty vehicle technologies. We only do this for one type of technology. This is focused. We only do electric drive. We only do all-electric vehicles. So a little bit of maybe a break from what you've heard earlier. These are all zero emission, all electric vehicles. None of them burn any type of fossil fuel or anything else or have any other emissions. And kind of the corollary of developing the technology is that we promote it and we -- we get to train people to build it.

And so kind of our method of doing this, our method of supporting this objective is to become the Cummins of electric, which is cool that I've heard a lot of people talk about -- about that today, and I think it's great; right? We all love Cummins' business model. So bravo to Cummins. You're doing something right in that regard.

We're just going to do it without the emissions part. And so --

UNIDENTIFIED MALE: Booyah.

MR. CASTELAZ: Yeah. So I guess we're racing. You know, you guys have a lot more resources, but we have more batteries.

So -- so when we look at kind of Motiv's journey over six years, you know, we've got a long way to go. We've come a long way. Starting core technology development, that was really the first four years of our existence. And that's the operating system. We want to be able to plug in different batteries and motors, install it onto a truck chassis and go.

Our very first grant was to demonstrate that. And that was a grant that CEC took a chance on us. And, you know, similar to Mike's story, I don't think that Motiv had a great track record at that point. We certainly had some smart people. And I guess we put together a good application and you guys took a chance on us, and we get to be here today because of that, so thank you.

And what emerged from that project was a successful demonstration of a prototype shuttle that used two different types of batteries side by side. We rotated different batteries through that shuttle. At one point it had sodium nickel and lithium ion batteries running side by

side. We did demonstrations, put it in use for a short amount of time, then upgraded the technology, moved forward.

So looking at that first project, I wanted to talk a little bit about that because it's completed. It actually completed a couple years ago, and we learned a lot from it. And I think the -- the number one key ingredient is also echoing a point that's already been made, a good alignment between project and business strategy. We had a business strategy, become the Cummins of electric drive. And this project just fit in really well. And we knew nothing about the Energy Commission at the time. So I think there was a bit of luck. And, you know, the Commission was just really smart in writing a great solicitation that matched exactly what I thought it should. So -- so that worked out well and we -- we applied.

And -- but I think it's important to not try and, you know, create knots in your business to get a CEC project. Really, that alignment is what's going to ultimately drive success. Otherwise, you're just struggling to check the boxes.

And then I think, you know, when I look at Motiv's business strategy and the project, the -- the things that made them successful were being aligned, and then also being focused. So from day one we only wanted to do the power train. We kind of knew, hey, we're never going to have to

become experts in axles or transmissions or braking systems, or the door locks on parcel delivery vehicles, or regulations for school bus catch laws for backpack straps and all that kind of stuff, so really focusing on one piece of the value chain, one piece of the supply chain, one part and then -- but still remaining flexible.

The initial battery supplier we went into for this project ended up becoming insolvent during the project, and so we switched to a different one. And I think that those levels of flexibility are important. So I think focused on what you're doing but flexible on how you're going to accomplish it leads to success, it did in this project.

And then capital efficiency, which I think is really important when you have an unknown market like electric heavy vehicles. And we can all have projections of how many we're going to sell next year and how big the market is going to be next year and the year after. And we have to do that. We have to set some expectations. But at the same time, if we're wrong we can't let that sink our companies. And -- and I think that that's, you know, maybe been -- been part of contributions to some of the fallout that we've seen in the last few years in the electric truck and bus space. It's just we don't know exactly what's going to happen to the price of fuel and all these other things. And so being robust to those types of market projection

errors I think is -- is important, and to do that from the beginning.

And so looking at lessons learned in this first project, our timelines were too optimistic. I went back and read our grant. And by 2015 we were going to have 108 employees. We have 41 people so, you know, it's not like an order of magnitude, it's only 2X. But still, I mean, I think that was -- I think it's okay to set optimistic timelines, you know, via the point earlier, capital efficiency and be robust to error.

I think we also didn't understand the work that exists between a snowflake vehicle and a commercial production, aka OEM-caliber vehicle. So a snowflake is like it sounds, everyone is a little bit different. Every bracket fits a little bit different on one vehicle versus the next. The cable lengths are all a little bit different. Everything is kind of formed in place or made in place after you look at the vehicle and you get a very skilled technician to decide how long to make the cable and then that's what happens.

Going from that to a robust 100 percent complete bills of materials where you're accounting for every nutrient and bolt on the vehicle, every zip tie, the location of every zip tie, you know, how tight do you tighten every screw, full FMEA on critical fasteners, I

mean, we've received an education working with the automotive industry. I could give credit to Roush Industries and Ford Motor Company and some of the outreach Ford does in their QVM program for helping us understand what an OEM-caliber vehicle and OEM-caliber parts for that vehicle look like.

And I think the other lesson learned is the supply chain is weak for electric trucks; right? There are not -- there are some places where we would like to have more suppliers. We may have a critical supplier or the choice between only two and neither one is exactly what we want. And key parts of the system, key accessories, the supply chain isn't quite there yet.

So coming back to Motiv's kind of grand timeline here, ARV-09-015 was that prototype shuttle. From there we were awarded a few other projects, 11-014 was a pile of three shuttle buses and one work truck, and that was in partnership with CALSTART. And those vehicles are all on the road driving around. Those shuttles have logged about 65,000 or 70,000 miles total to date. And the work truck is with the City of Santa Ana, being used in Parks and Rec kind of applications. It's a dump bed utility truck.

A repower project which is for delivery vans, and basically reusing the body of the delivery van and putting that whole new power train underneath it, that one is

underway. I'll talk more about that in a minute.

The manufacturing line. All right. Thank you. The manufacturing line. So Motiv manufactures its electronics. This is not vehicle manufacturing, this is electronics boxes. We do all that in Hayward, California. We got to have the grand opening. And we were lucky enough to have a few guests from the Energy Commission and from CARB attend. That facility which is up and running, manufacturing electronics controllers for trucks and buses, we pack them up and ship them to truck builders for installation on their electric trucks.

And two new projects we're working on are doing some all-electric refuse trucks similar to the picture I showed you, but in the -- in California. And then looking at a school bus that leverages some of the platforms that we've already worked on.

This is a little bit of summary of all those. It's in your notes, so I'll skip over that.

One thing that we've been very impressed with is the partnership between CEC and CARB on holding our hands from pilot vehicles through kind of early stage commercial success and providing support along different steps of the way. In the case of two different grants, one for a shuttle bus and one for a walk-in van, we were able to pilot the vehicles through grants from the CEC, and then able to sell

more of them under the HFIP (phonetic) Program that CARB runs. And we think that this is a great system for seeing CEC and CARB work together and kind of walk this product that -- that, you know, that was kind of brought into being with help with the CEC grant into now being commercially -- commercially viable and using HFIP to -- to bring the volumes up to where it really is -- can be quite economical for fleets.

And to see that in two different applications, walk-in vans which is like your delivery style truck, and then shuttle buses, we thought was just awesome, so we're excited about that.

In the first grant where we did that first shuttle, the black shuttle that I showed you, there's a picture of some of our technology. Now you can see it looks better. It's all painted black and orange, so decided on a color scheme. But more importantly than that is, you know, I got 70,000 miles on the road. We have three different ways to install it into chassis. We call that a configuration kit or an outfit package which is just all of our controllers, plus batteries and motors and cables and nuts and bolts and hoses, all specified for a particular chassis.

So looking at those three chassis, this is our product lineup. So we have one control system. We install

it on three different chassis. We have two to three configurations on each of those chassis. And -- and then those different chassis configurations are used in about eight different end-use applications, seven end-use applications. So -- so when you look at that our goal is to leverage one product into lots of applications, learning from Cummins on that one.

And so in the Class 4 we have a Ford E450 available as a cutaway and strip chassis from Ford. We take that and install our electric power train, 80 to 100 miles range driving. And then that incomplete vehicle is used by vehicle OEMs who are experts at building their school buses, shuttle buses, parcel delivery vehicles and flatbeds. The Ford F59 commercial strip chassis is a somewhat newer product from Ford. And it does not have a cab, so it's designed primarily for walk-in van applications, parcel, linen, other types of deliveries. And we supply that electrified chassis to Morgan Olson to building their -- their vehicle on it. And then the Class 8 chassis used primarily for refuse collection. We have one of those on the road right now in the City of Chicago.

So the way that we work, just to explain this and make sure -- so the truck ecosystem, most of the time it's not one company that builds a complete vocational vehicle. In most cases in -- in the U.S. one company builds the

chassis, they give it to someone else who finishes that particular type of vocational vehicle. So think of your delivery trucks, your cutaway shuttles, maintenance trucks, box trucks, they all work that way.

So what happens when we electrify, when our -- our components is are use and these, is the chassis OEM, someone like Ford, produces an incomplete vehicle chassis. They are the chassis owner --

(WebEx feedback.)

MR. CASTELAZ: -- (inaudible).

COMMISSIONER SCOTT: Let me just --

MR. CASTELAZ: Yeah.

COMMISSIONER SCOTT: Can you guys make sure that the phone lines are muted so we don't get the feedback through the phone?

Or if you can hear me and you're not at mute at your home or office on your phone, if you could please mute it, that would be terrific. Okay.

Sorry to interrupt you. Go ahead, Jim.

MR. CASTELAZ: Or you can help me present, too, that would be fine.

So reiterating that, Ford or another OEM will make an incomplete vehicle. They provide that vehicle with a VIN and with a set of documentation that basically says here's what you need to turn this into a complete vehicle. They

send that to an upfitter who installs our power train. So the bottom of our -- the ribbon cutting at our manufacturing facility. And then what we make there, which is this nice pelletized set of controllers, and those all get shipped. And other components get drop-shipped straight into that upfitter, and that upfitter takes the chassis from the Ford and they output a chassis that looks similar but runs on electricity. So they remove the engine and transmission, drop in batteries and motors.

Other manufacturers that are lower volume, we get the chassis without an engine and transmission. That's nice. That is obviously something we would like in the future from Ford, but it's a question of volume.

So -- so right now that chassis then leaves -- leaves our upfit station as an electric incomplete vehicle. We provide additional documentation that explains what we changed and any other requirements that we might impose upon the final vehicle builder. The vehicle and all of its documentation gets delivered to the final vehicle builder. They're the expert in their application, whether it's school buses or, in the case of this slide, delivery vans. And they put -- they complete the vehicle. They're responsible for certifying the vehicle under FMVSS and other applicable standards. And they do that using Ford's documentation, using Motiv's documentation, plus their own testing and

whatever they think is appropriate. And at the end of the day it's their product. They're the OEM.

They typically have dealer networks. They might sell direct. And the fleet gets to buy a vehicle from the body builder, from the same company they're used to buying vehicles from.

This is an Ameritrans Eco-Charge shuttle. Ameritrans is a small shuttle bus builder based out of Elkhart, Indiana. They build mostly gasoline shuttles, a few diesel shuttles, and some all-electric shuttles using Motiv's technology. So they order that Ford E450 cutaway chassis with Motiv's electric power train installed. They build it into a shuttle bus. They've built six of these to date for the City of Mountain View in a program funded by Google. It's a community shuttle. If any of you happen to be in Mountain View sometime, hop on the free community shuttle, ask the drivers and the passengers what they think about the electric -- the electric vehicles. And those are all powered by Motiv under the hood. And they're running with full HVAC and running pretty well. Each of them has -- so there were four. And then Google actually -- so there were four, three of which were CEC funded, the fourth was an HFIP vehicle. And then Google and Mountain View ordered two more shuttles, and those were HFIP-funded shuttles. They're all in service now. The four that have been on the road the

longest are about 11 months on the road and have logged something around 15,000 miles each. And then the two new ones just went into service about a month ago.

Trans Tech Bus based in upstate New York builds school buses, Type A school buses for the whole country. They build the buses they call their SST. And they build an electric version of that. Most of them are gasoline, but they build an electric version of that using the Ford E450 chassis as well. And two of those are in service with Kings Canyon Unified. Two more are on order and being built right now. And then one is in service in Long Island.

Excuse me.

Product number three that uses Motiv's technology under the hood is the Cargo Port E (phonetic) from Rockport Commercial Vehicles, also in the Elkhart, Indiana area. They build these box trucks for bakery delivery and other parcel delivery, also on that E450 chassis. And this one right now is, I believe, being shipped from Chicago where it did a bunch of demonstrations with various fleets to the Bay Area where it's going to do more demonstrations with fleets. And so come by Motiv and you can go for a spin in that.

The all-electric flatbed funded by the -- one of the CEC projects is in service with the City of Santa Ana. And that's like a stake bed with a hydraulic dump and a utility chest, built by California Truck Equipment Company.

They are the vehicle OEM on that particular product, also on the E450 chassis.

And our newest vehicle, this is the -- a walk-in van from Morgan Olson, delivered to AmeriPride Linen and Uniform Services. And this was delivered a few weeks back, three of four weeks back, and it's -- it's gone very well. And we are building nine more for these guys, five of which are re-powers under a CEC Grant, in addition to this first one, and then the four on top of that are HFIP funded vehicles.

And then finally, our garbage truck. This one had no funding from California directly, although obviously the technology was developed through many of our grants, but was actually awarded from the City of Chicago. And this garbage truck is on some of the hardest routes in Chicago. They have 600 garbage trucks in the City of Chicago. And this truck can do every single one of those 600 routes. And it's all electric and it has a lot of batteries. But, I mean, you know, it still can handle all the payloads. It can handle all the requirements. City of Chicago has 130-page specification that every single one of its garbage trucks has to comply with, and this electric one complies with all of them, same as the diesel ones, except the brakes last ten times as long. And the -- the drivers tell us -- well, we had one driver tell us that this truck changed his life,

which is cool to hear about a garbage truck. I don't know how much you guys hear that about garbage trucks. We were surprised.

We kind of figured, well, I mean, every Tuesday morning, I live in Alameda and garbage collection comes Tuesday morning. And every Tuesday morning I wish we had an electric garbage truck, because I get to hear that idling diesel engine outside. And it's natural gas so it's a little bit quieter than a diesel engine. But, you know, if we had an electric truck, you wouldn't hear anything. You'd still hear the can getting, you know, picked up, but you wouldn't have that engine idling right outside your window.

So the residents like it, but the driver -- you know, if you think it's annoying to have the truck sit outside, imagine sitting on top of that engine, like one foot away from it, all day, for eight hours. And, you know, this is his life. This is work environment. But with the electric truck, it's not noisy. It doesn't smell bad, at least it doesn't smell like diesel. And actually in the cab it doesn't smell bad. And it doesn't shake, and it's not hot. And he said his back wasn't hurting as much because he's not using the brake as much because of regenerative braking. So it's eased his back pain, which we thought was great.

So since 2012, which is really when we ended our

first project, we've -- we've made the 500 fastest growing private companies in America. We've raised a number of money in grants, most of that from the CEC. We've grown to about 40 employees. We've leveraged our grants with about 12 million in private investment from a few different investors, one large investor group out of Colorado. And we've increased our office space considerably. We are in Foster City, our headquarters, and then we manufacture in Hayward. And we've done the three chassis applications that I've shown you. And a list of all the different applications we're in. And we're something over 70,000 vehicle miles traveled to date. And over the last few months I think we've doubled the number of vehicles we have in service with customers.

So this re-powered linen truck has been a huge success. A few quotes from the fleet manager or, you know,

"I've heard nothing but good things about how the truck has been running, about the responsiveness of and interaction with the Motiv team. We really appreciate all the extra efforts and testing Motiv did to ensure the truck worked well when it got to us. And we're going to get rid of our spare truck that we thought we'd keep around just in case the EV truck wasn't working."

They decided that two or three weeks in, so we were very happy with that. And I think it's -- I think it's

a good, you know, good foreshadowing to things to come in that -- in that application. I think these -- these kind of business -- business delivery applications are -- are awesome. And I think they also don't require a lot of accessory power. Other applications, you know, school buses, garbage trucks, those accessory drives, the supply chain there isn't as robust. I mean, we have solutions, but a lot of time it's sole-source solutions and they're kind of shoehorned in from other applications. And I think that having a more robust supply chain around those accessories would -- would definitely strengthen where electric could go today.

So the conclusion is, you know, project business strategy alignment key, and focused on exactly what we're doing but flexible in how we -- how we do it. So, you know, keeping our eye on the target but being able to be flexible if, you know, a key partner like a battery supplier isn't going to be around in a year because we just don't always know. And then capital efficiency because none of our projects are perfect.

And I already mentioned my favorite quote there, so I'll leave you guys with that.

COMMISSIONER SCOTT: Thank you very much, Jim. I love it, "Changing lives one vehicle at a time."

MR. CASTELAZ: That's the goal.

COMMISSIONER SCOTT: Let us go to our reviewers and see if they have questions. I think it's time for me to start with Bob and work towards Matt.

So, Bob, go ahead.

MR. R. NGUYEN: Thank you. Thank you. Looking at your slide 13, when you were showing the -- the process in which a glider (phonetic) kit becomes a final vehicle. And it looks like you guys entered into that stream pretty earlier on, right after the glider kit was delivered from the OEM. And based on what you've described as far as your company, it seems to me, and correct me if my understanding is kind of off -- off kilter here, are you guys mainly involved with building and designing and building the control for the electric vehicles or are you involved with any other components?

MR. CASTELAZ: Yes. I think maybe another commonality here is with the immature market there's not this clear designation between product companies and integraters; right? And so you see a lot of us, Motiv included, maybe we want to ultimately become a product company but we're kind of forced to do some integration work. And I would say that that's a good way to characterize it. Our core product, our controller, it's like the brain, so like the ECU equivalent --

MR. R. NGUYEN: Uh-huh.

MR. CASTELAZ: -- for the power rain, the vehicle control unit, if you want. And that's the thing that decides how to arbitrate power between the different battery packs and the traction motor and accessory motors and charging, and the remote telemetry associated with, you know, doing remote configurations and remote diagnostics and getting data off the vehicle.

And so all that software infrastructure and the controls, that's our core product, and we -- we manufacture that. It's a printed circuit board with a bunch of parts on it. And it goes into a box, and we have about five of these -- well, I guess we have three of these boxes now that we manufacture with a couple different configurations each. And we manufacture those in Hayward. A lot of our work there goes into automated testing. So, you know, you plug the box in, you scan the serial number. It runs the test, stores all the data and, you know, just good manufacturing process kind of stuff. And so that's -- that's really our core business.

We do bundle our controllers with batteries and with traction motors and with accessories, and with brackets and cables, that are all designed to fit on exactly one chassis. And so we have a kit that goes onto each one of these chassis. That is our core system, bundled with batteries and motors and brackets and cables that all just

plug in, and a very thick assembly manual. And so we work with installers, like Roush Industries in the Detroit area. And they actually then get our installation manual and a big box full of parts, and then they install it all onto the vehicle.

MR. R. NGUYEN: So if -- so if -- if a customer wants one -- one of your vehicles, do they just walk into your office and order one, or do they go through their regular dealer to do -- to order?

MR. CASTELAZ: So my presumption as customer, you mean fleet, someone --

MR. R. NGUYEN: Yeah. Right

MR. CASTELAZ: -- that wants to use the vehicle?

MR. R. NGUYEN: Right.

MR. CASTELAZ: Yeah. So we don't sell to fleets. We would sell to someone like Ameritrans of Transtech or Lockport or Seatec (phonetic). And so if someone comes to us saying, hey, I saw a Motiv-powered vehicle out there, I what one of those, or you know, we could use those in our fleet, we will typically show them this portfolio of, hey, these are all the guys using Motiv's technology. Can you order from one of them? And -- and if there answer is yes, then we'll connect them, they place their order, and we kind of get pulled into the supply chain. If their answer is no, we'll explore, does it make sense to add kind of another OEM

to our portfolio.

And if it's a big customer, maybe we can go knock on, you know, Morgan Olson's door and say, hey, AmeriPride wants some linen delivery trucks. Would you build them for AmeriPride, you know, electric linen deliveries. And by the way, after you do that you can sell it to your other customers too.

And that was -- this -- this garbage truck, that was how that worked. When City of Chicago said they wanted a garbage truck, once we kind of had that information and we went to the garbage truck OEM, Crane Carrier, they said, "Oh, for City of Chicago, sure, we'll be willing to do that." They would never do it for just us. But when we bring that customer to them, then -- then they do it, they expand their product portfolio. They get an electric version of their vehicle that now they can offer to anyone, and we become kind of part of that supply chain.

MR. R. NGUYEN: How -- how would you handle the warranty claims? And let's say because you are sourcing out your electric motors, your batteries, and you sell them together as a package. So you're the sole provider of warranty for that particular -- for those components together?

MR. CASTELAZ: Yes. So typically what happens is the final vehicle -- the final vehicle builder, Transtech or

Ameritrans, they own the full vehicle warranty. So if something goes wrong the fleet goes back to those guys; right? And if turns out that it's a power train issue, then they'll come back to us and we're responsible for administering the warranty the whole power train. And granted, for batteries and motors, that's kind of a pass through. But we do administer the whole power train warranty, but not the chassis warranty and not the body warranty, and not the overall warranty. Yeah.

MR. R. NGUYEN: So of the vehicles that you have built so far, are there any warranty claims that come through due to the power train, that's attributable to the power train?

MR. CASTELAZ: Yeah. Yeah. I mean, yeah. We've had -- I mean, putting that many -- you know, 70,000 miles, yeah, we've had things come up. We had -- we've had some battery issues like early, kind of infant mortality battery issues that our battery supplier kind of owned and replaced and fixed. And then we've had -- I think we had some problems with infant mortality of -- of a water pump that we bought from a supplier, and so we need to fix those. And we had a few other things come up. We've had a lot of software upgrades that we've made over the time.

So the nice thing is one fleet finds some software bug in some, you know, weird state where they charge and,

you know, for a short period of -- or whatever the case may be, we can push that software update, the remote -- we can actually remotely push firmware updates to all of our vehicles in the field securely at once. So everybody benefits from the learnings of -- of one fleet.

MR. R. NGUYEN: All right. Thank you.

COMMISSIONER SCOTT: Great.

Kevin?

MR. WALKOWICZ: Thank you for the presentation. It looks like really good technology. I'm just drawing some parallels between what you guys do and TransPower as far as the different markets that you're getting into. And I'm kind of noticing, you have -- I didn't really see you talk about the flexibility of the architecture of your system and, you know, how does that work? You know, is it a one size fits all? Are you going to change battery sizes, motor sizes? Or how do you feel that, you know, the system you've designed with will for all the various vocations that you're going to build onto those -- those platforms with?

MR. CASTELAZ: Yeah. So as I mentioned, one core system, right now it's installed on three different chassis. And then in each one of those chassis there are a couple different configurations offered. So on the Ford E450 we offer a 158-inch, 176-inch, and 212-inch wheel base, and we offer 4, 5 or 6 batteries. So 4 batteries gets you 80

miles, 5 gets you 100, 6 gets you 120 miles range.

On the F59 we have 190 or 208 wheel base and 5 or 5 batteries. And on the Class 8s we do 8, 9 or 10 batteries, I believe, for corresponding range, and there's big accessory loads there, too.

So I think that these will not work for every single use of these chassis; right? Because some people build vehicles on these chassis that need to do 300 miles a day, and we can't put enough batteries on there to get there.

So I think we would work with the OEM that wants to build an electric version of their vehicle. So if they're -- if they're a box truck builder and they want to build an electric box truck, we'll say these are kind of our -- our options; right? And, you know, I can -- I can easily say, yeah, we're flexible, we'll do whatever you want, right, but it's going to be, you know, however many hundred thousand or million dollar engineering to -- I mean, just designing brackets, right, anybody can design a bracket, but you've got to produce them in volume, you've got to do FEA, you've got to do crash testing. And so to say that we have -- I mean, we have as many configuration options as we've seen needs for in the market, and we don't want any more than we have to have.

MR. WALKOWICZ: As far as like motor, propulsion,

motor, power, you know, is it kind of middle of the road? It's overpowered for some applications, underpowered for others, are you seeing that at all?

MR. CASTELAZ: So that sized to the chassis; right? So in the same way that a Class 4 chassis at 14-5 GVWR is going to need -- basically, we just -- we just size the motor that we use in each of these to match the performance of the gas equivalent.

MR. WALKOWICZ: Well, it's a different -- do you have different motor sizes?

MR. CASTELAZ: Oh, yeah. Yeah.

MR. WALKOWICZ: Oh. Okay.

MR. CASTELAZ: Yeah. Sorry if that wasn't -- wasn't clear. So different motors on these. Obviously, we can't use the same motor across the spectrum, so --

MR. WALKOWICZ: You might have said that. Maybe I just --

MR. CASTELAZ: Yeah.

MR. WALKOWICZ: -- didn't catch it.

MR. CASTELAZ: Yeah. So each one of these chassis has a motor appropriately sized for the vehicle weight rating, you know, because we need the gradability and the top speed and the -- that doesn't necessarily mean that this chassis is going to work for -- for everyone that uses the gasoline version of that chassis, like our top speeds are a

little lower than the gasoline top speeds.

MR. WALKOWICZ: Are you looking at range extending technologies, opportunity charging technologies such as catenary, or wireless charging? I wanted to ask you that. And then also -- well, I guess those two things are mainly what I wanted -- and maybe V-to-G, also. You know, what are -- what are your thoughts on those kind of accessory --

MR. CASTELAZ: Yeah.

MR. WALKOWICZ: -- technologies?

MR. CASTELAZ: V-to-G is in our product pipeline. I think it gets really important when you want to install a lot of vehicles at one location. I think you can lower the cost a lot by doing V-to-G. So that's -- we have, actually through -- is it PIER or EPIC? There is a program at the CEC that funded lab development of a -- of our V-to-G converter that we did in-house. And we're moving that into -- it's kind of in our -- in our product lineup for late next year, early 2017. And that will be very useful in certain applications.

Range extenders we've looked a little bit but it's -- you know, we would -- we would consider doing that, but only if someone else took most of those responsibilities, like when it comes to compliance of range extenders and dealing with that on just the core technology of working with fuels. These are really not our areas of

expertise. And, you know, I guess Mike said it pretty well, we're -- we're focusing all our smarts on electric drive. And the hybrid systems I think are great but -- and are needed in some applications. But we see enough applications for all electric that we can -- we can sell lots of these things just going all electric.

Catenaries are interesting. We like that a lot. That was fascinating to see the presentation. And, you know, we'd certainly love to learn more about integrating catenaries. The -- the operating system architecture I think is perfectly applicable for putting -- you know, dropping in a range extender.

MR. WALKOWICZ: Okay. And then last question. I was going to ask you the same question I asked TransPower, is what are you seeing from your -- your fleet customers? Are they concerned at all about looking to the future? And if you had large numbers of vehicles in one location all charging up at the same time, are you seeing concerns over infrastructure, installation or demand charges, all those types of things? Are you -- what kind of feedback are you getting from fleets about -- if you're talking large numbers? I know one or two is not a big deal. But if you're talking 40 to 50 vehicles at one location, what are you -- what are your concerns that you're hearing?

MR. CASTELAZ: Yeah. It does become -- it becomes

highly variable. So like AmeriPride, we're doing ten vehicles at their Vernon, California facility. And so when we look at infrastructure there it's not a lot. It's not as big of a concern because they kind of have the -- the backbone power already coming into the facility. Same with Chicago for that electric garbage truck. They're running it at a facility where they store 60 garbage trucks, and they could run a feed to every single one of those 60 if they were all electric with no building upgrades.

But then AmeriPride is looking at other facilities in areas that don't have as great a power infrastructure, and they're seeing really, really large quotes for putting in 10, 20 charging stations. And I think -- I think there's some actual -- there's room for core technology development around vehicle to grid and vehicle coordination of charging. And I think doing that intelligently and working with the utility, you can turn a large fleet of vehicles at one location from a liability into an asset if you do it right from a utility perspective. And so I think vehicle to grid and vehicle coordination are going to help there.

But I think that's -- that's going to be a big question in the next couple years, yeah.

MR. WALKOWICZ: Demand charges, any talk of that from your fleet customers?

MR. CASTELAZ: We haven't seen that -- that yet.

I think the vehicle coordination can help there, too, and make sure that you're -- you're running these at the time when the facility is using very little power. Yeah.

MR. WALKOWICZ: Okay. Thank you.

MR. CASTELAZ: You're welcome.

COMMISSIONER SCOTT: Thank you, Kevin.

Margo?

MS. MELENDEZ: Oh.

COMMISSIONER SCOTT: Go ahead, Bob, one more.

MR. R. NGUYEN: I forgot to ask. Sorry, Margo.

You know, I'm a little surprised with the trash trucks that you've built. I've always thought that the battery weight is going to be a hindrance for that type of application because it's weight sensitive. So what kind of weight penalty is that truck seeing?

MR. CASTELAZ: That's a very good question. I don't have the exact number off the top of my head. It's -- it does weigh -- the curb weight is higher than a diesel equivalent, in the same way that a hydraulic hybrid curb weight is heavier. And I think that for some applications that's problematic. We have a little bit more flexibility. Like front loaders, you worry more about front axle loading. Side loader is like rear axle loading. So because we can, you know, put the batteries in different places we get some flexibility there to make sure we're not exceeding axle

weights.

But generally what we've found is that you just have to talk to the customers; right? Like at the end of the day Chicago said, yeah, well, this works for us; right? Yeah, it's a little bit heavier of a truck, but we're going to save so much money in fuel, and we have all these other benefits, you know, that we want to go electric. And we've heard that from other cities, too. So if you have like a long drive to a landfill, you know, if you're not using a transfer station model for refuse collection, then electric refuse trucks are going to be tough because you're not going to get that much mileage on -- on the highway.

So I don't think it's like a complete drop-in replacement for all diesel garbage trucks. But I think that there are a lot of applications where you can stand a little bit higher, curb weights and, you know, kind of -- kind of move that around to keep you under the gowers (phonetic) of the front rear axle. And then it -- it works pretty well, I think, for a lot of customers, at least that's what we found.

MR. R. NGUYEN: Yeah. The reason I ask is I'm aware of this, you know, the hydraulic trash trucks weigh quite a bit more than -- than the regular trucks. And one way that a fleet has -- has found a way to work around that is to change the route. And so instead of collecting

regular garbage, if they turn around and use that truck to collect recyclables, it would tend to be less weight. And they still can do one loop without having to return -- no, without having to do more than one -- one time, the regular ones.

MR. CASTELAZ: Yeah. I mean, I think honestly the jury is still a little bit out. We just have the one truck in Chicago. They put it on their hardest route; right? They have 600 garbage trucks. They say this one, we're going to try it out on the hardest route and it worked, and it met all their requirements. So could they use it for recycling? Yes. Could they use it anywhere else they wanted? Yes. So for them it wasn't an issue.

Now we're going to come to other fleets. And, you know, in our new project we're -- we're starting with the CEC, there's going to be other concerns, you know? And so like residential front loaders, I know you really have -- have an issue with the -- with the front axle, and so maybe that would be limited to recycling, maybe there will be other limits. But kind of we believe from the customers we've talked with that, you know, these limitations are going to be things that we've going to find ways to work around for a lot of these fleets.

MR. R. NGUYEN: All right. Thank you.

COMMISSIONER SCOTT: Margo?

MS. MELENDEZ: So you talked about the transition from a snowflake to more mass market --

MR. CASTELAZ: Yes.

MS. MELENDEZ: -- and how that was harder than you thought. Do you have a couple examples of some of the things that sort of surprised you about that? And I think in particular, is there anything that, you know, government or regulations or anything could do that would help make that -- or training or something that could be done to help you with that, other than a technical barrier which I would assume you could overcome?

MR. CASTELAZ: Yeah. That's a good question. So the first example that comes to mind is when we first designed some brackets for a Ford chassis, you know, they fit. And then we got the next Ford chassis and they didn't fit. And when we tried to figure out why, we noticed that Ford allows a certain amount of torsion in their frame rail positioning relative to the other frame rail. And so they're not perfectly parallel; right? They're like slightly twisted a little bit. And if you want to know how twisted they are statistically speaking, you either need to measure a heck of a lot of Ford chassis or you've got to talk to Ford. And they actually know and they'll tell you the normal distribution of how twisted they're going to be.

But that's just like -- that's something that we

wouldn't have -- like on a snowflake you would never --

MS. MELENDEZ: No. Right.

MR. CASTELAZ: You'd design your brackets --

MS. MELENDEZ: Right. Right.

MR. CASTELAZ: -- and you'd think you were there.

MS. MELENDEZ: (Inaudible) is always fun.

MR. CASTELAZ: You know, and --

MS. MELENDEZ: They all look the same on the outside.

MR. CASTELAZ: Yeah. Yeah. Exactly. But when you're trying to line up the bolt holes it really matters; right? And if -- and if you've got to drill a bolt hole every time you do this, it's a different job; right? You don't have the $20 an hour guy drilling the bolt holes, that's a $40 an hour guy, and it changes the economics.

And so I think we've gotten a lot of education working with -- with Ford. And they've -- they've established this QVM program. And so I think looking at these types of collaborative programs, like what Ford has set up, and seeing if there's a way to like support those kind of efforts.

And then I think the other big thing that takes you from snowflake to validated product is thorough testing. And so like the Altoona Test for Transit Buses is great. But have like some sort of thorough testing and support for

that testing, why don't -- you know, there are -- there are two reasons why truck and bus companies don't crash test their vehicles. The first is because it's really expensive, and the second is because they don't have to; right? But that doesn't mean crash testing is a bad idea.

So, I mean, if there were support to allow for -- and crash testing is only one example, but crash durability testing where it didn't cost, you know, a small scrappy company quite as much and, you know, there was some incentive to do it, I think, you know, I think that those would be things that would lead people to -- to commercial grade products, yeah.

COMMISSIONER SCOTT: Thanks.

Matt?

MR. MIYASATO: Hey, Jim. I just have a couple questions.

Do you -- do you see a sweet spot for your application? You're showing, you know, a pretty wide product lineup. Do you see one vocation or one application that's winning out in terms of your product line?

MR. CASTELAZ: I would say -- so my somewhat political answer there would be --

MR. MIYASATO: Hey, now, that's fine.

MR. CASTELAZ: -- would be -- the sweet spot are trucks that have a high monthly fuel bill and don't ever go

more than 100 miles a day; right? If you get those two things, I don't care what the application is. This is great for electric.

Within applications, I mean, we like applications that use the chassis we already have; right? So if you can use one of those chassis and do whatever you want with the truck, accessories, like really trucks that need very high powered accessories and other specialized accessories, sometimes that can be a good fit, but it can be high NRE to get there. And you're, you know, you're developing a whole supply chain to try and get there, and that can be tough, you know?

But I think -- I think it's more about not necessarily what the vocation of the truck is but kind of, you know, how much mileage it's doing and, you know, how much stop and go it's doing. And that's not necessarily vocation dependent always.

MR. MIYASATO: Yeah. I mean, because historically it's very hard to get payback with school buses, right, for example. And then I noticed that you have the Kings Canyon. I thought that was a Smith Electric bus, so --

MR. CASTELAZ: So that -- that project was originally proposed as -- as a partnership with Smith, and Motiv was not part of that project. Some of the project applicants or partners came to Motiv as that was ongoing and

said --

MR. MIYASATO: Fix it.

MR. CASTELAZ: -- we'd like to go a different direction.

MR. MIYASATO: Right.

MR. CASTELAZ: And we were -- we were happy to help out and help -- help bring a product, which we feel really great about, to market there.

School buses are interesting. I think you can get a midday charge. School buses become great when you can incorporate vehicle to grid and maybe some emergency response. Your power goes out at a school, you can bring the buses there and get to the full day so that you get your funding for that day and you don't have to send the kids home early. And, you know, 90 percent of school buses go 60 miles per day or less. So I think when you combine that with the energy resilience aspect you can get a pretty strong value proposition.

MR. MIYASATO: Pretty interesting. Yeah, it's an interesting model that we're actually investigating.

But I would just offer that the next year's Carl Moyer Program will allow re-powers of school buses and provide funding for that, so you should keep your -- keep your eyes open for that.

And then finally, we'd love to follow up with you

on the catenary application.

MR. CASTELAZ: Okay. Yeah. Great. Just kind of a word on re-powers, so we -- most of the time we don't do re-powers; right? We're a supplier to an OEM. They're releasing an OEM product. With re-powers we just, you know, if -- if we get involved there we just want to make sure that the -- the chain of who's responsible for what, everybody -- everybody knows what's -- what's going on there. I think that there might be good applications for re-powers. Our trouble with doing them is it's tough to get the original OEM to -- to buy into, you know, assuming any responsibility for that vehicle after we repower it. They're kind of like washing their hands of it and walking away. And that doesn't really work for us because then all of a sudden we've got whole vehicle responsibility. And are not school bus experts, and so that's a scary proposition.

So, you know, getting an OEM to have an old vehicle that's going to be changed and still have them be responsible for it, I think, you know, you guys, I guess, maybe could like twist their arm into -- into doing that, that would be helpful, but we haven't had any luck with it. So I wish that we could figure out how to get that to happen though.

COMMISSIONER SCOTT: Thank you so much, Jim, for your excellent presentation.

I'm going to turn it back over to Tim to introduce our next Presenter.

MR. OLSON: Okay. Our next presentation will be done by Kent Peacock who is the Director of Government Relations at Proterra, Inc., which is an electric bus manufacturer. And he previously worked at Acorn Energy and has degrees from Brown University and Georgetown University. Please welcome Kent Peacock.

MR. LEACOCK: Thank you, and welcome everybody.

I'm going to start with the fact that we're actually kind of unique in this position. And I'm not a scientist like everybody else. And our grant is strictly for a manufacturing facility. We were in California. We started off in Southern California. We were founded in 2004. And unlike a lot of the other companies here, we're new to the grant world, shall we say. We were primarily funded by the venture capital world. Kleiner Perkins, GM Ventures, Southern California Edison Ventures Group, Constellation Energy, we have a very, very strong financial backing. We've raised almost over $150 million. And we currently have about 14 customers out there. We've reached the point of about 1.6 million miles of revenue service, and that's all out of our manufacturing facility in South Carolina.

Interestingly enough, this time last year we had

no physical presence in California. We had about three or four guys working out of the basement of our venture capital firm, Kleiner Perkins, as our California presence. Now we have over almost 200,000 square feet of -- of two different facilities here in California with I'd say about 20 open positions and growing rapidly.

Our -- our leadership team is pretty diverse, as you'll see, and it makes sense for the -- for what we make, because we make an all-battery electric composite body bus. And when I say composite body I think offshore power boat, racing, race cars. We have -- we have people from Roush -- Roush Racing as employees, Ford. Our CEO came from Tesla. We have -- we've managed to lure away a couple of Tesla battery geniuses that had been working there for a number of years. Our Chief Technology Officer came for DENSO, before that, GM. And what's missing in here is that he also worked at Fisker. He was a Chief Engineer at Fisker down in Southern California in Anaheim for a little while.

And so -- and why are we now coming to California? And why are we having success in this battery-electric bus world? And a lot of it is driven by the fact that we are solely focused on a market that has been using the same technology for the last 50 years. And the diesel bus, you know, unlike California, that's kind of in certain areas like in South Coast where they're -- you're not allowed to

have a diesel bus, you know, the vast majority of the U.S. use diesel buses. They get five or six miles to the gallon. And our bus recently, at the Altoona Testing which was previously mentioned, got the equivalent of over 22 miles to the gallon. So there's a huge efficiency gain when you switch over to our -- our vehicle.

Now what make the economics work? Well, one of the things that's also previously been mentioned is the cost of batteries.

We actually deploy -- oh, I didn't mean to do that. Sorry about that. We're having little technical difficulties. Okay.

When we started this process we were -- the lithium ion batteries were $1,200 a kilowatt hour, and now that's -- we're down to about $300. Previously it was mentioned, we buy -- we source our battery modules from Toshiba and LG Chem, Toshiba on the lithium titanate side and LG Chem on the nickel manganese cobalt side, because we have two different versions of our bus. We have an extended range and a fast charge. As has been previously mentioned, the lithium titanate batteries have the ability to accept a high rate of charge. And they -- at a high speed we can charge our fast charge bus in under seven minutes on average, which allows that bus to then go roughly 30 to 45 miles. And on a fixed circuit transit route or say a fixed

route at an airport or those type of situations it's -- it's ideal.

Now our extended range bus does the nickel manganese cobalt. It takes about two hours to fully charge. And then, once again, it's not fully depleted. But it accepts 2 50-kilowatt hour charging ports, so it charges at about 100 kilowatt. It takes a couple hours to charge. And what we do is we're taking advantage of the growth in the passenger vehicle sales which has -- which has driven the price down. And we -- we foresee that that price reduction will continue. Our bus started off at over $1 million. And we've now reached a point of roughly around $750,000 for the 40-foot, you know, 70-passenger transit bus. And the vast majority of those costs have been as a result of the battery price reduction in the last five to six years.

Now interestingly enough, as I said, we're new to the incentive game. And around the U.S. there are -- is a movement for funding transit buses in the zero-emission category. As you can see, there's about six states or so that have done that. But what is really interesting is the fact that our customers are currently spread across the U.S. in many areas where you wouldn't think they would be going to a zero-emission electric bus, including Louisville, Lexington, Kentucky, Dallas, San Antonio, Texas, Massachusetts, Duluth, Minnesota. And we've operated now

for a number of years in Massachusetts through some of the harsh winters they've had. And we have seen no issues with the lithium titanate chemistry on the batteries in terms of their ability to function in the fixed route that they -- the same route that they run in the summer.

The interesting thing that we found is that they love the fact that our buses don't rust because they're a composite material. They've been on the road now three or four years and have, you know, zero rust. And as I said before, we've reached roughly 1.6 million revenue miles.

And, in fact, there's a number of other cities where we are -- where we have some orders or we are working on closing out the orders that I can't reveal now. But we are, you know, soon with -- I'd say sometime early next year we'll be up in the 17 or 18 range for the cities.

And this is just some of the kind of press that we've received. And especially touting our move and our opening of our office here in California, but a lot of this stuff was received prior to coming to California.

So then why, if we're doing so well, why would we come to California? Well, there's a number of reasons. And the CEC is one of the reasons why we're here so quickly. We would have ultimately probably come to California because one of the other Presenters mentioned that if you want to be in transportation electrification and battery technology,

this is the place to be. And our CEO from Tesla felt that very strongly, that California was the place to be.

And -- but then you have to take into account, and this is the -- the meat of the CEC grant is, okay, it's all well and good to have your corporate headquarters and a small R&D facility anywhere in California, but where are you going to be able to find 150,000 square feet to be able to do heavy duty manufacturing in California when the economy is booming, real estate is wildly expensive, and you're under the gun to get your facility, under the guides of the grant, get a facility and -- and get going basically.

One of the things we did, we took advantage of existing, shall we say, governmental support. And we reached out to GO-Biz who was able to, since we didn't really have a California presence, they were able to help us in choosing a location. They advised us that based on what we were looking for and the kind of employee stock that we would need ranging from hourly, line to, you know, kind of assembly workers, to engineering and software people, the full gamut in building this bus, we -- they identified, you know, an area in Southern California called the City of Industry which was semi-close to a lot of the former aerospace manufacturing groups and a lot of, you know, kind of technology. And the -- let's just say that the City of Industry is extremely friendly for business.

And as a result we also were able to come across -- we found a facility. And once again, this is just using some internal resources. Once we identified City of Industry, one of our members of our board was on the board of another company that did real estate. And we were able to find this existing 140,000 square foot facility that had already gone through a CEQA review, had all the electrical infrastructure that we needed in place, and was going to require minimal modifications to make it work.

Now as everybody else -- as many people have said, you know, you can't try to squeeze yourself as -- as a square peg into a round hole. And so why did we apply for the CEC grant and how did it match up with what we were trying to do? Well, this particular grant was strictly for producing zero-emission vehicles or vehicle components in California. They wanted to expand alternate vehicle -- fuel vehicle manufacturing, reduce GHG emissions, reduce petroleum usage, and provided economic and job benefits. Well, that's exactly what we were going to do. That's exactly what we wanted to do. So this grant was perfectly suited for us, and it was going to allow us to do what we wanted to do in a faster manner than we had previously anticipated.

So this is just to give you an idea of the scale of what we were going to be trying to accomplish in

California. These are some photos from our plant in Greenfield where it shows you just the scale and the size that you need to build and have an assembly line for buses. This facility puts out roughly a bus a week. And that means there are nine buses on a continuous basis in various stations, if you will. This -- the forward most station that you see onto the far right of the screen being the closest to finish. And on the backside of this photo that you can't see, there are another couple stations that get it even closer and closer.

Somebody mentioned about transit bus configuration. Well, that's exactly right. The buses have to go through an extensive process of choice by the individual transit agency. For example, you would think that, you know, nobody wants like the pull-down emergency stop. Well, we have a line that we did for Nashville called their -- their Motor City Express. It runs through some of their, you know, their downtown kind of club, night club music area. And they wanted to go kind of a little bit retro. A lot of our buses mostly just have, you know, a push button, an electronic push button for the emergency stop, but they wanted to go old school with the pool. So we had to -- we had to put that into the design of the bus.

So this is an aerial shot of the new location in the City of Industry. We were able to -- because of the

nature of the facility and the kind of readiness, we were able to get a lease signed and the necessary tenant improvements laid out by May of 2015 after -- I guess we officially got the grant in April, sometime around there. And I actually flew down in August and then -- for the first walk around. And then in September I went down and got the keys to this massive facility.

That just shows you the interior there. There's some scale. The only thing we -- it was already mostly in the format that we needed. We had to do some widening of the garage doors because our buses, you know, we wanted to be able to have our buses be able to drive out once they're finished being assembled, obviously. And the shells have to be brought in.

Now that's the interior of the office, the layout. The office was already pretty much in a configuration that we were willing to accept. We were trying to maximize the usage of dollars and spend as little as possible. So we -- we even cobbled together some, you know, what I would call discount furniture, for lack of a better way of saying it, but it still looks -- it still looks pretty -- reasonably nice.

So now here's an interesting thing that was an unintended consequence of us reaching this grant. Our composite body bus is sourced from a company in Rhode

Island. They make the shell. And then the shells are shipped down to our South Carolina location. Well, as a result of this additional facility in Southern California, we started thinking about, well, we need -- we need a more -- we need a more robust supply chain.

Well, once again through the good fortune of having a gentleman from GM on our board, in fact, it's their Chief Technology Officer, we learned about a company in California just 60 or 70 miles north of the City of Industry facility in Adelanto called MFG which is -- stands for Molded Fiberglass. They, back in the late '50s, early '60s, they were the company that produced a lot of the Corvette parts. And that's how our GM guy new about him.

So we were able to, through -- through his knowledge of senior management get them onboard to build from scratch the Proterra composite body mold to source our body shells. And, in fact, they will be sourcing body shells as needed for both locations, including our South Carolina plant.

As a result of this interaction with us, they had to add, right out of the box, thousands of man hours that were completed unbudgeted for them, which was great, they thought, you know, because they're an existing facility, to -- to do this. This is -- shows you the scale with the people inside. This is them building from scratch the mold

for our composite body. That's -- this is -- this just took place, you know, I'd say a month ago or so.

Here's the first kind of prototype of the -- the top half of the shell of the bus, because we get it in two pieces, a top and a bottom, and then -- and join those with -- together with carbon fiber and Kevlar. This is the top half of the bus. And you can see a version, a more complete version right on the other side of it in white. And that is what it looks like when it first comes out of that mold that you saw them building earlier.

So as we stand now we really haven't -- we haven't -- our goal is to create roughly, I'd say 70 to 80 jobs by the end of this project in Southern California. But as a result of what's going on in Southern California we have added, you know, I'd say 15, 20 jobs in the Bay Area by locating our corporate headquarters there to help support Southern California. And already MFG has had to add additional jobs and man hours to support what we're going to be sourcing from them.

So I guess some of the key lessons that we learned from this project -- because, you know, we hadn't done business in California. And everybody said, oh, what, are you guys crazy? You're going to start a manufacturing facility in California when you're already manufacturing in South Carolina where you might guess that it's considerably

less expensive to do business, and you'd be right. The choice of your location and your facility is very important in getting -- in getting your project off the ground. We, like I said, we made use of GO-Biz that gave us really good advice. And then we were fortunate to have kind of an extensive network that we were willing to reach out and ask.

Now one thing that we are fortunate is that when we -- the production facility in South Carolina I showed you guys, we are basically just going to duplicate that. And so we have a very high comfort level that we will be able to duplicate what we're building in South Carolina here. What we're also doing is we're going to embed some of our more experienced, long-term employees in the -- in the Southern California facility. And we'll be ending out new hires from Southern California to South Carolina.

The other lesson learned is you take advantage of all the available resources, internal and external. Don't hesitate to ask for help. Don't ask -- don't hesitate to ask for advice. And I think somebody else referenced this, is that your timelines are generally going to be off. It's good to set ambitious timelines, but everything that you do will take longer than you originally planned. Even with finding an almost ideal facility, it took longer to complete some of the improvements that we needed. It took longer because of the economy booming.

It took us longer to find, for example, a contractor that could design a pneumatic air system for building the buses. You know, most of the -- if you're not in the kind of auto world of tools and everything, you need a heavy extensive pneumatic system to build a lot of the buses the way we do. And just finding the appropriate person to design a pneumatic system to support, you know, 130,000 square foot facility took a lot longer. I'm still waiting for the plans, as a matter of fact.

Make sure you have more funding than you original projected. It seems like everything always costs a little bit more than what you plan. We've been fortunate that we raised a fair amount of money and we hang onto it like it's gold. Our matching portion for the CEC grant is -- is considerable. And fortunately our investors have seen how we've been very judicious in the -- in the use of money, and the fact that we, you know, we landed this grant. And to do business here in California, it made it very doable.

When possible, remove barriers to product acceptance. This is something I didn't touch on too much, but I think somebody was talking about how quickly professional drivers, I think it was the UPS drivers, how quickly professional drivers pick up a completely different kind of technology. Well, our buses have amazing regen capability. And the first -- I've ridden in -- with bus

drivers that drove it for the first time. One of the things that we did was -- our bus looks and feels like any other transit bus you might see, except it's dead quiet and it is -- it's faster, it's smoother, and you don't have to hit the brakes. Our customers have seen two years of service without brake replacement, whereas they were replacing brakes every three months.

So the -- the fact that when we take our buses to these bus facilities, put them up on a lift -- I went -- we were at Tri Valley in North Contra Costa County. They put it up on a lift and the mechanics looked underneath. And they -- everything they recognized, except for the motor. And, you know, and frequently -- frequently they're excited to learn about a new technology, something other than diesel, you know? I mean, I've had -- I say that their wives are ecstatic, they don't come home covered in diesel fumes, grease, gunk because we don't have the same level of grease in our buses either. It's just -- it's just a different experience for the mechanics. And they're -- the buses are much more reliable.

There have been a number -- there was a couple of slides. I don't have the -- I don't -- I don't have the details. But I will echo the point that was made a couple of times in that the total cost of ownership model works very, very well, especially for transit buses that do a lot

of miles. We have seen on average that -- and the other thing that I'll mention is that the -- every bus is subsidized by the federal government. They have to have -- a transit bus, that is. They have to have a 12-year life span. And over that 12-year life span, we haven't reached that yet, but we, being roughly $300,000 to $400,000 more than a traditional diesel bus, we've seen our six- and seven-year customers reach equilibrium. And now they're putting almost $100,000 a year in their pocket.

We've -- based on them we've been -- we've previously been estimating a $400,000 or $500,000 overall savings per bus over its 12-year lifespan. We -- we're finding that we may be low on that number in the diesel world. Natural gas buses are a little bit closer, but we are still seeing that we can offer savings in the natural gas world. And one of the ways we overcome our higher up-front cost is we are offering leasing programs for batteries.

And the -- it's interesting because one of the first concerns was what are you going to do -- what do we -- what do we do with the batteries that wear out? Well, it's funny, we don't have to solve that problem because there are -- there are so many companies that have sprung up already. We've been contacted by at least a half-dozen companies asking us, who are you going to sell your

batteries to when they have to be swapped out? Because our second life batteries at 80 percent are still a fantastic proposition for somebody that's going to maybe do energy storage or any other number of options.

One of the other things we've learned about the lithium titanate batteries is that we got -- we had a projection curve from Toshiba on the life of those. And we are looking at, after over 10,000 cycles, those batteries are still operating at a little bit over 90 percent. And that's roughly six or seven years -- or six years into service. So we are already beyond where we thought the batteries would live. We offer a six-year warranty on the batteries, and they're already proving themselves to outlive that. And we are getting better and better batteries than what we had originally already.

And last and most important is keep your grant partner informed and communicate often and early. When we had our first initial meeting with the CEC, and I think I saw Darren earlier, he made the comment that -- you know, because I asked him, "Well, how do people screw this up?"

And he said, "Well, you know, sometimes they try to hide stuff. And if you just talk to us, you know, it's -- we'll be -- you'll be fine. You know, explain things. If you really have a true path to success that the timeline is a little bit off, just let us know."

And so even though what concerned me as a potential delay didn't even raise a blip when I communicated it with Darren because he made the comment, he said -- he said, "Kent, we often have people drop out. They can't even get a building, okay? You guys have gone -- you guys have made a lot of progress right out of the box."

So I'll conclude now, and I'll be happy to take any questions.

COMMISSIONER SCOTT: Thank you so much, Kent.

Thank you, Darren, he's over -- he's back there, for your great project management.

I actually had a question for you. When you were talking a little bit about MFG and them being able to put those composite bodies together for you all, I mean, were they able to scale up fast enough for what you're -- you're looking to do, and do they have enough space to -- to get done what you need?

MR. LEACOCK: Well, in keeping with things take a little bit longer, they have enough space.

COMMISSIONER SCOTT: Uh-huh.

MR. LEACOCK: But it took them a little bit longer to build. They have experience building huge things. They build nose -- noses for -- for trains. So they -- and they built these crazy big observation high roller enclosures that hang off the sides of some of the casinos in Vegas.

They -- they're used to building big, big things. But they weren't used to building with the level of, let's just add-ons and everything that we need for a full length, you know, 40-foot transit bus.

COMMISSIONER SCOTT: Uh-huh.

MR. LEACOCK: So it's taken a little bit longer. They've taken a little bit longer, and there was a couple of missteps. But we feel like -- it's interesting. We feel that by this time next year the facility will be able to consistently churn out a bus a week, just like our plant in South Carolina does. Now we had thought, you know, really ambitious, we thought we'd be doing that by the second quarter of 2016. But it's -- it's clear that everything is going to take a little bit longer. And we want to, you know, kind of do everything in a manner that allows for success versus failure. So we don't want to get too far ahead of ourselves. And so the -- and the key, you know, we can't get anywhere without the bus shell. So we had to get that aspect of things nailed down and get those to a point where we consistently can get those to our facility before we start ramping up everything else.

COMMISSIONER SCOTT: Great.

Let me turn to Matt.

MR. MIYASATO: Thank you. Thanks, Ken.

Appreciate the Energy Commission funding their

City of Industry facility which is three miles away from our headquarters. So we're looking -- looking forward to seeing a lot of progress and -- and more modular furniture going in there.

I guess I'm going to steal Kevin's question, because I know he's got it written down, about demand charges; right? So -- so I guess a precursor to that, are the 14 cities that you showed on the slide for the deployments, are those all the lithium titanate fast charge buses?

MR. LEACOCK: Yes, they are.

MR. MIYASATO: So I know in California I think the PUC rate structure was experimental, one that only lasted for a year; is that my understanding? And are you seeing other --

MR. LEACOCK: We're seeing panic. It's going to expire at the end of this year the ability to, just through advice letter, get the exemption through demand charges. And so our biggest customer, Foothill Transit, is nervous. But we've been very proactive. I've -- we've had meetings with Southern California Edison. We've had meeting with PG&E and with San Diego Gas and Electric. And, in fact, I -- if I weren't here I would be at a CPUC hearing that's taking place because under SB 350 they have been -- the PUC is charged to remove barriers to acceptance. And so one of

the things that we're going to be doing -- and also to promote deals and -- and rates that also promote electrification.

So one of the things that we've done at Proterra that we're going to be doing proactively is we are going to be forming a little coalition, shall we say, because we want to try to work on establishing a transit rate that eliminates the demand charges much the way the waiver advice letter, and just get that as a permanent rate. And while we're at it we want to have the conversation, much the way they're doing in the passenger vehicle world, about the service equipment. Fortunately, we don't think there's going to be as much of a brouhaha because the way we are hoping to get everybody onboard to do it is basically that the transit agency would request the PUC to -- not the PUC, the -- their investor-owned utility or privately owned utility if they didn't feel they had the expertise to install and own the -- the infrastructure, the service equipment of their choice. They choose which one they want. The utility installs it and owns it and operates it under the rate that is agreed upon.

It's interesting, though, because some of the -- for example, we are currently in conversations with a number of Central Valley municipalities or transit agencies. And their publicly owned rate is such that they wouldn't even

have to worry about demand charges because our fast charger through software modifications can -- we can -- we could temperate the charge anywhere from to 2 to 350 kilowatts, and their demand charges don't kick in until they hit 500 in any one -- on any one meter.

So some people think it's a moot point, but it's not a moot point for Foothill and adjacent customers. So it's something that we're very actively concerned about and are going to be working on.

COMMISSIONER SCOTT: Margo?

MS. MELENDEZ: You talked about the leasing programs for batteries. And for the transit buses that get like federal funding, how does that work? Is that -- has that worked out okay?

MR. LEACOCK: Well, it's interesting because --

MS. MELENDEZ: To me that seems like (inaudible) nightmare.

MR. LEACOCK: Yeah. It's --

MS. MELENDEZ: But how did it work?

MR. LEACOCK: You know, we have -- put it this way, it is. And I don't have to know it because we hired a guy that has worked on public financing for rail, etcetera, from Zion Bank in Utah. He is our kind of business development funding guy. And he's already interacted with the different programs with the FTA to get kind of an

approval letter ahead of time so that when we go to the transit agencies they -- they don't feel a level of discomfort.

Now, once again, here's an interesting thing of making use of your resources, I don't know if people in the audience are aware but, you know GO-Biz has what they call the iBank (phonetic). And we are now in conversations. He's done the same thing with the iBank about financing batteries for transit agencies here in California. And so far it's moving along very smoothly, the conversations, and we are very optimistic. He's already got a little -- Porterville, it's amazing, these transit agencies and cities have good ratings. We've already gotten approval for Porterville through Wells Fargo to finance batteries for transit bus purchases.

And then when you do the financing of the batteries, the amount you save on your diesel pays for the financing. And so you're at a wash on your up-front capital.

MS. MELENDEZ: That's very cool. Thanks.

COMMISSIONER SCOTT: Great.

Kevin?

MR. WALKOWICZ: Kent, I think you weren't telling just the truth. You said you weren't an engineer or a scientist, but you know an awful lot about all the

technologies on the bus. So I don't know. I'm going to have to check into that.

MR. LEACOCK: No. I realize, sitting in the audience, from hearing everybody, I realize I've gotten to the point where I know enough to be dangerous.

MR. WALKOWICZ: Thinking back to your slide on where you've deployed -- and this has nothing to do with the plant that you're -- the facility that you're building. I don't really have any questions about that. That's not my area of expertise. But the -- the map where you deployed, borrowing a phrase from our friends at Idaho National Lab who have done a lot of EV deployment tracking on the light duty side, they call the -- the shape of the deployment from the -- the west coast through the south up to the east, that's the EV smile. That's what they call it. That's where everyone seems to deploy EV vehicles. So I was surprised to see one in Duluth, Minnesota. It's like how -- what -- what was the pull there and how -- do you know anything about how that's working out? I've been to Duluth. There's not a lot there and it's very -- very cold and --

MS. MELENDEZ: With one eyeball.

MR. LEACOCK: Yeah. That's -- that's a lone eyeball.

In fact, that -- that location, I believe it was a result of our -- our sales guy knew somebody and convinced

them, you know, it was a relationship -- that was a relationship sell, quite frankly, but it's working out well for us. The people there love the bus and it's become the bus of choice in that -- in that small area where -- where it's deployed. And I'm not sure how many they have, but I think that they've already applied for a second purchase round through the -- the federal LoNo grants.

MR. WALKOWICZ: Yeah. That would be interesting to see some battery data, if you guys have that kind of data.

MR. LEACOCK: I'm not going to say exactly where, but somebody in this area has ordered some buses, as well. And I'll be able to put them on the map soon. Soon we're hoping to -- we're hoping to eliminate that EV smile and make it a big smile for Proterra across -- across the U.S.

MR. WALKOWICZ: So, all right, since your – your -- is it your CEO is a former Tesla --

MR. LEACOCK: Yeah. Senior Director of Finance.

MR. WALKOWICZ: So, all right, I'll ask a question that we haven't -- I haven't asked yet today. So since all the other good questions have been taken.

Proterra, you guys are doing a good job putting together buses. The system is looking really good. It's a good EV system. Are you -- and Tesla has been all over this autonomous vehicle, connected, automated vehicle. I know

there's a lot of traction getting going around smart mobility, connected vehicles, autonomous vehicles. Is that something you guys are looking at? Like how could you incorporate that into the bus --

MR. LEACOCK: We think it will --

MR. WALKOWICZ: -- systems?

MR. LEACOCK: We think it will happen first in buses before it happens anywhere else.

MR. WALKOWICZ: Right. That's why, yeah, I was asking that for that reason. Are you --

MR. LEACOCK: Absolutely.

MR. WALKOWICZ: Are you seeing a lot of interest from municipalities as far as opening up data from the infrastructure and traffic signals in order to work with the bus controls?

MR. LEACOCK: Honestly, no. The first -- we're still getting over the hurdle of just getting an electric bus. But we have a couple of our really smart guys that are already looking at scenarios where the 100 percent hands-free kind of electric bus works.

Because I didn't -- you know, because this was about the manufacturing facility, we have available on our website videos that shows our charging mechanism. And the charging mechanism for that last two or three feet takes over the bus from the driver. The driver can seize control,

but it takes control of the bus, brings it in. The overhead charger comes down, chargers the bus, all automated. And then when it's charged up, you know, this is an opportunity charge, it charges it up and then it releases the bus. It's all automated. And then it gives the bus driver a signal that it's time to go.

And from my perspective, on a fixed route especially that's -- you're not that far away from, you know, putting some sort of guide wire, drive-by wire technology or something that it has, you know, infrared sensors for passengers or camera or whatever, and you could go driverless. And we think it will happen in buses before anywhere else.

MR. WALKOWICZ: Or even just driver or -- I'll be the first one to talk about drive cycles and the importance of knowing the variability and, you know, the difference between a urban cycle and a highway cycle. I mean, when you start getting into that there's huge energy savings possible. And we need to talk about knowing when lights are going to change and timing the traffic coming through the lights, and eliminating traffic, you know --

MR. LEACOCK: Right.

MR. WALKOWICZ: -- smoothing out traffic, that's a huge --

MR. LEACOCK: Right.

MR. WALKOWICZ: -- national opportunity.

MR. LEACOCK: Our -- and our buses are pretty smart. We think that we have -- we have the room for the level of technology that would be necessary for all those things that you're talking about, but we've got to sell buses.

MR. WALKOWICZ: Right. Right. You've got to get them on the road first. Okay. Thank you.

COMMISSIONER SCOTT: Thanks, Kevin.

Bob?

MR. R. NGUYEN: Thank you for a very nice presentation. I guess you have a total of 22 slides, and my questions are going to be focused on 1 slide.

MR. LEACOCK: Sure.

MR. R. NGUYEN: Just the slide -- well, generally, just -- just kind of derived from that slide, on slide five where you project some -- some of the costs. And you also mentioned that the -- the bus cost has increased significantly from the beginning of $1 million down to $750,000, now to $750,000. And then -- and then later on you also mentioned about the fact about the possibility for leasing -- leasing the batteries. Now the -- the $750,000 case, is that considering the purchase of the batteries, too, or is that just --

MR. LEACOCK: Yeah, that's batteries included at

$750,000.

MR. R. NGUYEN: That's included?

MR. LEACOCK: Yeah. That's why I say leasing the batteries eliminates, depending on your configuration of how many battery packs, you know, for how much energy storage you want, that puts you at a parity with a fully outfitted diesel bus and/or natural gas. And then you lease the batteries off of your savings on the -- on the fuel.

MR. R. NGUYEN: Okay. And -- and you said that the -- roughly the $750,000 is roughly $300,000, $400,000 more than the -- you know, an equivalent diesel bus?

MR. LEACOCK: I think those numbers -- that number is roughly accurate. You know, and once again, that is kind of a onesies and twosies number. For a larger order I'm sure you could get diesel buses cheaper, and for a larger order you could get our bus cheaper, as well. And when I say a larger order I mean we are -- we are at the state now where we've had multiple orders in the five to ten range.

You know, the next phase, and that's why we felt now was the right time to come up with the second manufacturing facility is the next phase is to get a 50 to 100 bus order. And then the price will come down -- will come down some amount that would be noticeable for an order of that size.

MR. R. NGUYEN: Have you had any interest in the

leasing concept for the batteries?

MR. LEACOCK: Yes. We had a number of agencies get themselves approved as part of doing their due diligence in terms of running their numbers.

MR. R. NGUYEN: Okay. One more question on the costs, and then it has to do with infrastructure.

How do you -- are you involved with any part of it to finance the -- the costs or the transit agency has to come up with the money for the infrastructure?

MR. LEACOCK: Any?

MR. R. NGUYEN: How -- how much of it?

MR. LEACOCK: Yeah. In terms of the -- the fast charger, the fast chargers are expensive. They are roughly, I'd say in -- in California I'd say it's a safe number of about $350,000 to purchase and install one of the overhead fast chargers. That's presuming that you're going to be able to site it at an existing location that the transit agency owns, or if they've worked with the utility on the right-of-way and the -- and the infrastructure there.

Now as for the -- the power necessary there, we don't do that. That's, you know, that's one of the things that -- that we've been told by the utilities that that's, you know, at the very least that's what we can do at this point in time is get the level of -- of electricity to the location that you need. And that's where they're, at this

point in time, they're hands off. But we're going to try to get them to get more involved to the -- to the very end of the, you know, kind of charging connection, so to speak.

And then for the extended range that just uses a shop charger, we use off-the-shelf Eaton, one of the -- a company here in California called ChargePoint makes a 50-kilowatt shop charger, as well. And those -- it's -- it depends on what the shop has in terms of existing power capability to -- to run those shop charges. But those are 50-kilowatt chargers that are -- are pretty standard out there right now.

MR. R. NGUYEN: And you said that you provide six years warranty on the batteries?

MR. LEACOCK: Correct.

MR. R. NGUYEN: And if the -- the FTA bus cycle is 12 years, how -- how are the fleets handling that remaining six years that is without a warranty?

MR. LEACOCK: Well, one of the things that we -- on the lease it just -- you just lease it for that amount of time, and then you get -- you get new batteries and you embark on a new lease.

The people that have -- that have purchased the buses, nobody knows yet. We don't know what's going to happen. And in many cases it may be just like when a transit bus has to get a rebuilt diesel motor prior to their

12-year life expectancy, they have to rebuild a motor. We don't know yet what's going to happen with the batteries because none of the battery packs -- well, we've had some premature, somebody mentioned, premature failures. We just swapped those out on our own dime. You know, but the batteries that are in service now and still at 90 percent after 6 years, we don't know how long they're going to last.

So I really don't have a firm answer for you on that. We don't know what is going to happen. But we -- we haven't had -- we haven't -- we've had -- every one of our customers is a repeat customer, I'll put it that way. And that's as a result of our willingness to go the extra mile in terms of customer service.

MR. R. NGUYEN: Because barely -- that's a large chunk of the cost of --

MR. LEACOCK: Oh, yeah.

MR. R. NGUYEN: -- of the vehicle. And if a fleet manager is faced with that situation, let's say hypothetically seven years down the road the battery fails and they have to put on a whole -- a big chunk of change to replace the battery, that would change the, you know, the economics of -- of the whole purchase; right?

MR. LEACOCK: Absolutely it would. And so that's why we think that the battery leasing option is very attractive. And as we proceed forward, you know, every year

we get under our belt is -- is year seven, eight, nine, ten of the life of these batteries that are lesser technology than what we're putting in to buses now. So we're putting better buses in now that are -- you know, at year one, two or three. So, you know, it's an unknown at this point in time.

MR. R. NGUYEN: But you still -- you foresee that you're still going to be focusing on just all-electric technology, or are you looking into maybe in the future going to fuel cells or --

MR. LEACOCK: Interestingly enough, Proterra actually has made two fuel cell buses. One is in -- I think it's in Texas somewhere, something like that. But the company made a conscious decision to strictly go for battery-electric. And the main reason was, as they saw the hydrogen fueling infrastructure cost versus the already ubiquitous electric infrastructure, it was -- it was almost a no-brainer.

And with the way batteries have been coming down -- I was at a recent meeting of a transit agency in California. They're still paying over $1 million for fuel cell buses, or close to $1 million, and that's what they were -- that's what they paid, you know, eight, nine years ago. So the price hasn't come down, and our price has come down because of what's happened in the battery world.

MR. R. NGUYEN: Thank you.

COMMISSIONER SCOTT: Thank you very much, Kent, for your excellent presentation.

I will turn it back to Tim to introduce our -- our final Presenter.

MR. OLSON: And speaking of fuel cell vehicles, our next speaker is Rob Del Coro who is the director of Fuel Cell Power Group with Hydrogenics Corporation where he's designed fuel cell power systems and directs work to develop hydrogen heavy duty markets in the U.S. He has led the development of 20 zero-emission drive systems for hydrogen-electric vehicles, including a transit bus and drayage truck at Hydrogenics.

MR. DEL CORE: Thank you, Tim. Okay.

How is everyone doing? I'm the last guy up at the end of the day here.

So thanks for the introduction, Tim.

And -- and I'd also like to just thank everyone for -- for being here and, of course, the opportunity to present. And I'd like to thank the CEC for -- for funding our projects to put Celerity Plus into a drayage truck and a fuel cell bus. You know, these projects directly contribute to the goals of commercialization of vehicles and ultimately reducing greenhouse gas emissions and reducing petroleum consumption. So I'll talk a little about what Celerity is.

But just for -- for those who are not all that familiar with Hydrogenics, we are a hydrogen technology and fuel cell company. So we are total zero-emission solution. We make fuel cell products for powering fleets. And we also make hydrogen generation technology using water electrolysis. So providing fuel for fleets through water electrolysis and fuel cell power modules is -- is what our core business is -- is all about.

Just here's a snapshot of our two projects here that -- that have been graciously funded again by the CEC. And again, thank you for -- for the support. On the left-hand side is the fuel cell drayage truck project. The partners we're working with, Daimler, to integrate Celerity Plus which is bundled with a Siemens ELFA drive into the chassis. This truck will be demonstrated in the Port of Long Beach and the L.A. area of the Alameda Corridor. DTSI is the operator for the project. The -- the project funds are there for your reference. A very, very tight and strong team here.

Hydrogenics, we are the lead integrater on this project. We're also the project managers and providing a fuel cell technology. Daimler Freightliner is providing the chassis through EVG which is their -- their dealer in the South Coast Basin. Siemens is providing the electric drive, and also technology support. And Actaea (phonetic) is a

battery integrater with a lot of experience with projects in Europe and North America that deliver some 400 systems working with Siemens and Vanwool (phonetic) and some other large names, as well, too. And you can see from the banners that we have a very, very strong team here, big players in the -- in the space. That's the drayage truck project.

And on the -- the right-hand side is our other project with New Flyer. So this is actually one project to delivery Celerity Plus integrated into a New Flyer battery-electric plus platform. This will be -- this bus will be operated in the Alameda -- sorry, in SunLine Transit in Coachella Valley for your demonstration. And again, a very, very strong project team. We have New Flyer who will be doing the lead integration. Hydrogenics is providing the Celerity Plus fuel cell system, bundled with -- with the ELFA drive and providing all the support, and with Siemens being the electric drive supplier, SunLine Transit being the operator. Again, an excellent example of strong key players here on this particular prom with SunLine, Hydrogenics, New Flyer and Siemens working closely together on this -- on this particular project.

So what are the -- some of the key elements here to the project's success? This is some of the -- kind of more of the technical element. But, of course, number one is the Energy Commission's support, you know, to make these

projects. You know, because of these projects we were able to contribute to the goals of commercializing vehicles and reducing the greenhouse gas emissions, which is very, very key.

Another key element is Celerity Plus. And Celerity Plus is -- it's a fuel cell system. It's designed for commercialization. It's -- it's an all-in system. It's -- it's intense. It's really to make integration of fuel cell bus platforms a lot easier by reducing the total cost of ownership, by taking out a lot of the NRE that's required to make a fuel cell system work. And by doing this we substantially reduce the cost of building a fuel cell electric platform, and it enables adoption and it enables commercialization by -- by taking care of the integration. So by doing this we're -- we're designing it so it's easy to integrate and service. And servicing and maintenance are very important for total cost of ownership, as well, too. It's a key thing.

But also importantly is that it's an innovative fuel cell technology. Celerity is based on our state-of-the-art stack technology. So Hydrogenics has invested heavily in stack technology. We're into our sixth generation of stack which is based on a lower pressures, which means we use blowers, not compressors, low humidification, so simpler architecture. And it's also

bundled with -- with the state-of-the-art Siemens ELFA drive, as well, too. So two solid, very proven technologies coupled together in this particular project. And -- and by doing this it allows us to accelerate commercialization, reducing total cost of ownership and -- and getting us there -- there quickly.

Another element here of successful projects and going forward here is working with strong players and great technology. We're working with reputable OEMs. We're working with Daimler Trucks. Daimler is involved in the process, and also New Flyer. These are the biggest players in their field. They have the largest market share for their respective markets. And they're involved in the -- in the development cycle.

Also, having a small focused and capable team where we have communication, being very, very direct, and it's very, very important as we know it's a managed risk, communication is something that's key to -- to making sure that issues are addressed and discussed. So by having a small, tight, focused team with everybody an expert in their leading area, communicating is really a driver for -- for success.

The other key thing here, too, is that, you know, Hydrogenics has a dedicated long-term commitment to California. We have a plan and vision to deploy fuel cell

technology here with the infrastructure. The infrastructure is also an enable, as well, too, in providing the hydrogen with that. So by combining this fueling infrastructure with the fuel cell technology, that allows you to help to grow fleets, get the scale, which is really a key thing that needs to happen in order to get cost of overall fuel down, cost of the structure down, and to get the scale in general. So a strong commitment. Everything is aligned and aligning here in -- in California.

So just a little bit of a summary on the projects. I'll get into some detail here. So looking at the drayage truck that we're doing with -- with Daimler on their freightliner chassis, so the scope of the project and deliverable year as to develop and demonstrate the fuel cell drayage truck with the Celerity Plus fuel cell power system bundled with the Siemens ELFA drive and to demonstrate the technical viability and -- and show how we can get to commercialization with that, have a performance measure, go 200 miles of zero-emission hydrogen fuel range. We'll be operating the truck for 12 months with 6 months of that data collection up the Alameda Corridor and in the South Coast Basin, and demonstrate that we can achieve the goals of achieving -- of reducing emissions significantly and offsetting the petroleum consumption, as well.

So kind of a project summary. We're, you know,

we're just getting started here. We sort of one of the last ones to get kicked off in the process, so we're very much in the early stages of the project.

But we've already had -- you know, this project kicked off in October. We submitted our first progress report. And one of the milestones that we have is to set up a facility in Southern California. We have identified several sites. We've been going through the process of working with real estate folks, as well, and waiting on information to come back so we can review it with management. But in doing so we have made contact with GO-Biz and -- and the City of Poway for those initial discussions sometime back to get that process going, so that's moving forward and that's -- that's under review, and we recognize the importance of that.

And on the -- the technical side, we're very much into our design process. We're gearing up activities associated with -- with designing, collecting and reviewing duty cycle information. We have a functional specification that we're designing, too, and detailing that out, getting right down to the fine details of what the truck performance needs to be. We're finalizing chassis specifications. We're laying out details like high voltage system architecture, and doing all the traditional mechanical, electric and control design development as part of -- as

part of that process, so that's underway. We see no major concerns at this point. And we're -- we're getting all the information that we need from our partners.

And sort of high level schedule here. And again, we've submitted the report. And we're working on the -- on the invoicing of -- if you look at the high level schedule as per -- per contract, so we see everything is on -- on track. We don't see any schedule risks at this point in time. And -- and you'll know that the security and technology integration site is something that we plan to have completed by -- by Q-1 2016, but we -- we anticipate an earlier date than that. And -- and everything is moving -- moving along per plan on the drayage truck project here.

So what is the -- the significance here? And this is -- this is very important. You know, with the drayage project, and we understand that port trucks and drayage trucks are operating in very, very polluted areas of -- of the state. And by successfully demonstrating a zero-emission truck like that we can show that we can achieve these goals of improving air quality, especially for the disadvantaged communities. And somebody earlier had a graphic showing, I think it was -- it was Mike, where the -- basically a lot of the transit routes, the routes for the cargo under drayage pass through many disadvantaged communities as part of their service road. So it's a

critical thing to be able to do this technology.

And the learnings that will come from this, as well, too, is that the data that we gather from doing this initial deployment will help us enroll into other deployments going forward. So, for example, if we're looking at longer than -- typical drayage-type cycles are longer over the road-type operations, how to optimize the drive system configuration, the fuel cells, the batteries so that we can actually have a longer than normal distance route fueled by hydrogen. And then in doing so it will help us to understand planning for infrastructure. So if we want to carry container as cargo over greater distances we know where to strategically locate fueling infrastructure to make that happen.

And -- and, of course, the important thing, too, is that everything we develop is transferrable. So this project will also show that we can develop a drive system technology that is transferrable to other applications, as well. And this is also being illustrated by -- by doing this in the drayage truck, as well as the transit bus application. And -- and really by completing a successful demonstration and achieving these goals it will allow deployment of more trucks and increasing the -- the selection of technology offerings that can be used to mitigate air quality in respective areas.

And on the -- the New Flyer transit bus that -- with Celerity Plus, again, we're demonstrating the Celerity Plus technology into the New Flyer transit bus. So in this particular model, New Flyer is the lead integrater. We are providing the fuel cell technology with the engineering support. It's a 12-month demonstration. And really one of the goals here, too, is to increase adoption by basically increasing the supply of the -- of selections of offerings here in order to achieve greenhouse gas goals. And I'll talk a little bit more about that in a second here.

But just to give you a sense of technical progress, the bus is a little bit ahead of the truck project in terms of a timeline and -- and delivery. We kicked this off a little sooner. But right now we're going through the design processes with New Flyer. We started with handing over technical information. We've been working. We have our technical reviews scheduled on a regular basis where we have constant communication, and following up on, you know, meetings, and action items are being taken. So on Monday we had our first preliminary design review of the packaging of the Celerity Plus system into the -- the New Flyer platform. And things are moving along quite nicely. So as -- as per plans, we don't see any -- any schedule issue. It's -- it's great to see that a lot of the dialogue is taking place and -- and the progress is progressing quite nicely there.

And just a similar sort of a milestone summary here. So we've submitted our first report. And just kind of high level scheduling. You know, we're looking at having the bus built Q-1 2017, although we anticipate Q-4 2016. And we will test, validate and ship the bus in Q-3 of 2017, around that time. And then we'll have the demonstration testing with Altoona. We will take the bus to Altoona for testing as part of the program here, which is a very important step for commercialization and validation going forward. And so it's very much a part of what we're doing.

And also the demonstration of SunLine, as well. And SunLine is a great partner to have on this project, as well, too, given their -- their sophistication and experience in operating hydrogen fuel cell buses. So they're very enthusiastic, very supportive, as are all of our partners working together. Everyone is really, really excited about these projects. So it's great -- it's great to have the momentum keeping things moving forward here.

So on the -- on the bus project, what is the -- the significance here. And these things are really, really key. By -- by having a fuel cell bus project here, what we're essentially doing is increasing the supply of offering of technology.

And -- and by doing that we're -- we're encouraging competition in the marketplace, so competition

is great. We welcome competition. It keeps everyone on their -- on their toes. But by having competition in the -- in the space, as well, too, that leads to massive options and ultimately commercialization of fuel cell bus. So if you had only one type of fuel cell technology provider at any one time providing that technology, and let's just say it didn't work, very quickly I think operators would be turned off fuel cell technology. But by increasing supply and having that competition you're giving another option to help develop commercialization of the technology going forward.

And I mentioned Altoona Testing. So -- so New Flyer is very excited about offering their product with -- with the Celerity Plus as a configuration. And by having - going through Altoona Testing they can offer it as a standard product in their portfolio and -- and offer it to their customers. And, of course, it will make it eligible for other funding opportunities, as well, too, and hence it helps us get to that path of commercialization.

And really where -- where it's all really -- what we're also very excited about here is by having mass deployment of fuel cell buses and trucks we're enabling economies to help bring that -- that cost down. And -- and by doing that we can actually collocate large fleets with centralized hydrogen fueling infrastructure. By having

large fleets of vehicles like trucks and buses that are high utilization, so we've talked about how the TCO is helped by vehicles that are -- that are used and they're doing longer range and moving forward, these high utilization vehicles. They're consuming a lot more fuel. And for technology providers that provide fueling infrastructure, if there is an understanding as to how much fuel can be consumed it gives confidence to those technology providers to lower their price, lower the cost for a longer term if they understand exactly what the fleet and what the infrastructure is going to look like.

So you see economies of scale kicking in with -- with hydrogen supply, with that cost reduction of fuel, and that's important, and all these factors together enable commercialization.

And with that, I look forward to coming back and talking about more lessons learned as we're starting -- as we're starting off here. But I will take some questions.

COMMISSIONER SCOTT: Great. Thank you so very much for your excellent presentation, Rob. I have a question for you on that last slide.

So you mentioned that the mass deployment of them together can get you some economies of scale in the fueling infrastructure. Are you also anticipating that you'll have developed a fuel cell that can fit into both the bus

platform and into various truck platforms, such that you get economies of scale there too?

MR. DEL CORE: Absolutely. So as -- I should have had a slide on Celerity. But here's what Celerity looks like. It's -- so Celerity is -- it's an optimal configuration. It's a very market-facing product. So when we developed Celerity we looked to the market to see what is the technical configuration that would fit most of the needs. And we're looking at the Class 6 to 8 space. And this involved forming a factor package, voltage current, you know, all the things that basically if you can optimize and cover off as many of the market needs as possible, and then you would close the gaps with special treatment like engineering services on that part.

So Celerity being 60 kilowatts, it's a 60-kilowatt fuel cell. That's net power out. All the parasitic are inside that box. Everything you need to run the fuel cell is actually in there. As a matter of fact, everything you need to interface the fuel cell is in that box, as well. So electrical things like contactors, pre-charge, reverse current protection, these are things that integraters usually take on, we put that inside the enclosure. The air systems that deliver air to the fuel cell are inside that enclosure, as well. And the interface is very, very clean, so the idea that it's very easy for the OEM to take the --

the fuel cell system and integrate it into their bus platform, much like they would as part of their standard manufacturing processes.

And so we found that 60 kilowatts was a good multiple -- a good granularity that could be easily multiplied. If you wanted to scale up to higher power you could very easily take Celerity and put them in -- in (inaudible) type configuration.

It's -- this unit, it's about 300 millimeters. I'm going to speak metric now. It's about 375 millimeters in width, about 980 in -- in height and 800 in depth, so it's a very -- it's a taller configuration and designed for engine being for a bus or a truck, and be ganged up accordingly.

Now along the theme of -- of taking it further for integration of buses and trucks and getting economies that way, as well, too, we took a step further by offering Celerity Plus, so Celerity is the fuel cell. Celerity Plus is the bundled system that we have with Siemens. And so the bundle system is a pre-interface preconfigured configuration between the Hydrogenics fuel cell system and the Siemens ELFA drive. And what that really means for OEMs is that you can order the Celerity Plus system from Hydrogenics, you order the Siemens ELFA drive from Siemens, those components arrive at your dock and you know they already work. So

they're preconfigured. There's no additional software. The OEM does not have to become a fuel cell expert to understand how to make the fuel cell work. That's all -- that's what we mean by the bundled package.

And we debuted Celerity in October '14 -- 2014 at APTA in Houston. And there was a lot of interest generated from that, too, so we're very, very excited to see this product in these projects here so we can demonstrate how -- the viability and of getting to market with this technology, so --

COMMISSIONER SCOTT: Thank you.

Let's go to Bob.

MR. DEL CORE: Question? Hey, Bob.

MR. R. NGUYEN: Hey. Good afternoon.

MR. DEL CORE: Good afternoon.

MR. R. NGUYEN: Thank you for the presentation. Have you had your technology installed in a vehicle in actual applications elsewhere?

MR. DEL CORE: Yes. So -- so maybe just a little bit more of an intro.

So Hydrogenics, we're a publicly traded company. We've been around since 1995. We've deployed the fuel cell systems in many vehicle applications, going from class -- light duty, very light duty up to heavy duty. So we put them in buses, trucks, delivery vans, and then even going

right down to forklifts and delivery vehicles and that sort of thing. We're a company that is very comfortable putting product out there and working with OEMs. We're also very comfortable at the other end of the spectrum doing the complete integration.

So -- and some of those projects, and I think we have a total of -- of 70 mobility applications to date, not counting these ones, where we've actually either provided components, provided some engineering support to go halfway, or actually have taken the vehicle provided and performed all the integration work ourselves and deploy that -- that vehicle. We've done that work in -- in Canada, and also here in the U.S., in Europe.

The project that we're doing with -- with Proterra that Kent mentioned, actually, is a project where we're supplying some of our HT (phonetic) technologies, the -- sort of the pre-Celerity technology. And in that case Proterra is doing integration work, very much like what New Flyer is doing.

So, yeah, so we have heavy duty and deployment experience. All the applications where we've deployed our fuel cells are high utilization, high duty cycle-type applications, a lot of start/stop, usually hybridized to one degree or another with either alter capacitors or -- or battery energy storage. And -- and we've developed the

controls to manage the energy accordingly so that you can either, you know, dial in the fuel cell to your ideal operating point, either for efficiency or performance, accordingly in all those applications.

MR. R. NGUYEN: Okay. Have you come across with any issues with soliciting maintenance of your system that requires you guys to be -- actually be on site to service the vehicles, or could you train the fleet mechanics to diagnosis and solve those -- those issues?

MR. DEL CORE: Yeah. So that's -- that's -- we have a service group and a service network, so we have a global presence. We have offices in Europe. And kind of broadening out a little bit, we have offices in Europe and North America. And, of course, we're establishing a presence here. We have a service and support team that can either travel globally, or even locally based. So we have also a service person here in California supporting some of our -- of our current projects now.

And the model is different. So depending on -- on what the issue is, either we will dispatch somebody to go in and look at something. Of course, before we do that we have a detailed review where we get on the phone and understand what is the root cause. You know, often times we find that the, you know, integraters will have a checklist that they'll go through and they'll rule out anything on their

side, and then try to help isolate the fuel cell issue.

But things like connectors, you know, the issues that are usually common are things like, you know, connectors; right? They always tends to be an issue in the field. Seldomly, you know, would we bring -- where there's been cases where a fuel cell would have to come back for diagnosis. Hydrogenics used to be a test station company. We used to manufacture testing equipment for the industry. And so we actually have a lot of fuel cell test stands where we can put fuel cells on, quickly diagnosis what the issues is if there is one, and -- and redeploy. So we have equipment to do diagnosis. We have people that we can dispatch. And we train.

You know, so in a deployment we realize the value and the importance of having the support onsite, rapid, especially an application like transit where uptime is very, very critical. And, you know, you do not want a transit bus down for any length of time while you're waiting for parts to be, you know, swapped out, right, accordingly. And the fleet operators, of course, too, you know, time is money. Productivity is important. Nobody wants their vehicle sitting on the side. So, you know, we will support in whatever mode is comfortable for the customer. If they have their own mechanics, we train or we dispatch resources accordingly.

MR. R. NGUYEN: All right. One more question on -- on the fuel cell itself.

MR. DEL CORE: Uh-huh.

MR. R. NGUYEN: How, you know, how durable is it? I mean, like you talk about it like diesel engine, a million miles before you have to rebuild or get a new engine.

MR. DEL CORE: Sure.

MR. R. NGUYEN: How long does a fuel cell last?

MR. DEL CORE: So we have data that shows that we're -- we're getting over 16,000 hours of operation. You know, and when we project further, you know, there is a natural degradation that takes place with fuel cells as they run them. And we know the slope of that curve and we know what it looks like, so that's very exciting. You know, again, in the 15, 20 years we've been developing fuel cells we've really seen the lifetime increase; right?

You know, in applications what's really critical are things like making sure that you have good fuel quality, you know, those kind of impacts. So under -- under the right fuel conditions and air conditions you'll get very, very long life of performance; right? So fuel quality is important, which is why we see electrolysis is a very key way to produce that fuel. Because with water electrolysis you always get consistent high purity hydrogen which --

which helps in your fleet deployment, which is an important thing. So we see lifetime go up.

We've -- we've reduced the costs of our fuel cell systems over the last 20 years through a number of ways. Number one, simpler architecture. If I showed you a process flow diagram of our very first system you would find that it would look a lot like -- like a nuclear plant, you know, and there's a lot of complexity there. The engineering that we've applied over the years has helped reduce cost, but it also helps with durability because now you're removing parts that potentially could be parts that fail and -- and bring you offline. So costs have come down because of simplicity, and also through volume, that we have been deploying fuel cells in mobility applications.

But also the same technology is being deployed in stationary power applications. So on -- on a side note, for example, we've just delivered a 1-megawatt stationary power system to a customer in South Korea. We have a joint venture operation going on that we recently announced. So this is -- this is a 40-foot container with 1 megawatt of the same type of fuel cell that we're -- the same technology that's being used for -- for that. And -- and, of course, when you get the megawatt class size it also helps to, you know, drive down cost and lead to architecture simplifications.

COMMISSIONER SCOTT: Thanks, Bob.

Kevin?

MR. WALKOWICZ: Yeah. Thank you for the presentation.

Just to follow on that, so you -- you are a supplier of stationary fuel cell systems?

MR. DEL CORE: That's the other part of our -- our business, as well, too, yeah.

MR. WALKOWICZ: Are these units that you're producing for the mobile applications, are they -- can you, you know, work the economy of scale and get that same exact unit as a stationary product somewhere and sell -- sell a lot of them there and then start selling them on the mobile side, too? Is it -- is the same box that I'm looking at or does it have to be kind of reengineered in many ways to be a stationary product?

MR. DEL CORE: Yeah. The -- the stationary technology is based on our, what we call our HT series technology. It's more of a fundamental building block, kind of a general purpose fuel cell. And that can be deployed kind of anywhere. Celerity is really designed especially for medium and heavy duty applications. So it has everything needed to -- to tailor -- it's tailored specifically for mobility.

You know, on the -- on the HT technology there's

more integration activity required. And for -- for customers who are comfortable doing that, that's -- that's where we offer and place that -- that product. But the requirements for mobility are very different from stationary. You'll have -- in a stationary application you may or may not have load following, you may costs and output type power requirement. Under heavy duty mobility applications you're looking at a high dynamic duty cycle. And the fuel cell is actually very dynamic and you will be doing a lot of the contributing to the drive cycle output. So you can either have -- you know, you can operate the fuel cell at a steady output as a range extender battery charger as you -- as you want to, or you can power plan in a load following manner. It's response rate is in seconds.

MR. WALKOWICZ: It seems to much more transient ultimately?

MR. DEL CORE: Yeah. So the point being is that the whole architecture, the enclosure, everything else, the packaging is designed for heavy duty use in a heavy duty environment which might see anywhere from 18 to 20 hours of operation a day in a transit or truck application.

MR. WALKOWICZ: Are you also -- with this package you've put together are you looking at bidirectional, and I'm thinking maybe military applications, you know, some of the medium and heavy duty trucks they have there, but they

also have the need for mobile stationary power generation. Are you -- any -- any thoughts along that line as far as trying to expand into kind of a propulsion plus export power capability?

MR. DEL CORE: The -- the export power part, you know, would be another device off the -- the high voltage bus; right? And if that's a requirement, then -- then it can be done. We have projects in the past where we provided a power kickoff for certain customers. But, you know, the fuel cells a power generator, so it can be used as prime power or a range extender. And then what you do with that power, you can decide.

But, you know, ideally here the intent for Celerity is -- is specifically for mobility applications. You know, if on the truck, for example, if there was an interest to have a power takeoff you could configure that, that would be an add-on item.

MR. WALKOWICZ: Another inverter to put on?

MR. DEL CORE: Yeah, another inverter or something at the voltage that you desire; right? But it's really about a specific system configured to make it easy to integrate for the OEM who wants to put it in their product offering and increase their -- their portfolio to their customers.

MR. WALKOWICZ: And I was reading somewhere, you

were quoting a $90,000 to $100,000 payback over 12 years, is some of the numbers I saw. Is that still -- that was -- that was --

MR. DEL CORE: I don't think I quoted that number. Was that --

MR. WALKOWICZ: No. That was out of one of your earlier reports here that I was reading.

MR. DEL CORE: Oh, it's that one? Okay.

MR. WALKOWICZ: Out of here, yeah.

MR. DEL CORE: Oh, okay. I'll have to go back and --

MR. WALKOWICZ: Anyway, what -- yeah, what -- so what's the payback period? I don't know, what's the incremental cost? Did you talk about incremental costs and annual savings and what's -- how many years to pay off the -- your system?

MR. DEL CORE: Yeah. So -- so every calculation, there's assumptions and -- and constraints; right? And, you know, a big part of the total cost of ownership is the fuel cost; right? Now the fuel cell pricing, it's -- it's something that we -- we kind of set when we know exactly what the quantity and the size of the fleet is. And you'll find this, actually, in general with suppliers of -- of technology that if asked to give speculative quotes there's always a great degree of uncertainty. And you'll see a lot

of, you know, margin stacking that goes into that price. And it's become sort of the first high level pass.

But when there's a very well defined order it's a lot easier for technology providers to say, okay, we can come into this price and they can work with the supply chain, you know, because we know our costs, we know how to -- how to work it.

So having said that, you know, a fuel cell bus that is in the $1 million to $1.2 million range is possible. I mean, ARB has published some numbers as to, through their research and outreach, as to what they see the prices of fuel buses being today. You know, this fuel cell pricing would fit within that and make it work.

So the fuel cell, the hydrogen fuel cost is a big part of it. And hence, my point about scale, that, you know, if we -- the nice thing about trucks and buses and is that they consume a lot of hydrogen. A typical bus might consume 40 kilos. A truck will do the same sort of thing. If you have a centralized fueling station and you bring in these vehicles that are pulling down each 40 kilos that deal with each fill, that's a lot of consumption, that's a lot of utilization. And with that it's -- it's -- I mean, it turns into bargaining power; right? So that's more going with the idea of getting the fuel costs down with a centralized location of fueling a station.

MR. WALKOWICZ: Okay. Thanks. I have two more questions. I want to make sure I steal all Matt's questions so he doesn't have anything to work with.

Have you considered the energy storage piece of it? I think you -- I saw somewhere an 80-kilowatt battery pack. Is that on both -- both the truck and the bus? And have you considered a plugin charge depleting version of that?

MR. DEL CORE: Yeah. So on the -- on the bus it's an 80-kilowatt hour pack. On the truck it's 110-kilowatt hour. And, you know, have we considered a plugin option? The feedback that we've been getting from -- from users is, you know, one fuel type is ideal, right, so, you know, it's -- although you could improve efficiencies by having a second plugin port. And you almost want to have, at least even from a maintenance point of view, a charge port that as you're -- as you're developing the vehicle, that you can charge the battery from a second source.

But in terms of operation, the nice thing about a fuel cell bus or truck is that it's as close in operating characteristic as a standard diesel vehicle is for the fleet operators. So there's really no -- no change. They don't have to change their operating mode. They don't have to schedule when they deploy vehicles. They're not restricted by infrastructure limitations, so, I mean, electric works --

works well. I think there's a point where scale becomes question. Whereas, hydrogen infrastructure is actually, in my mind, quite simple, a lot simpler, and can be deployed and deployed and replicated in -- in multiple places a lot easier, so it's easier to scale a hydrogen fleet. And operators treat those vehicles just like they would a standard conventional powered one.

MR. WALKOWICZ: And the last question, you mentioned infrastructure. I'm noticing the hydrogen storage, is that 5,000 psi --

MR. DEL CORE: Yes.

MR. WALKOWICZ: -- for both these systems? Is there --

MR. DEL CORE: And in these projects, yeah.

MR. WALKOWICZ: For both of them. Are -- do you have plans to go to the 10,000 level? I know that's -- a lot of the light duty manufacturers are going to that. Is there any common infrastructure issues that you're going to foresee as far as a, you know, central fueling location or just technology out there that needs to go? You know, are you going to need to go to 10,000, or any plans to do that?

MR. DEL CORE: Yeah. So in these -- this project we're at 5,000 psi. And, you know, it's also because we have the real estate and -- and -- to accommodate the tanks. So there's not as much as a, I don't want to say pressure

to -- to go to 10,000 but -- as a driver, right, to do that. So -- so, yes, 5,000 psi for these vehicles.

To -- to go to seven --

MR. WALKOWICZ: You can talk in metric if you want to use metric.

MR. DEL CORE: Yeah. You know, I can speak metric and -- and SAE no problem.

But to go to say a higher fueling pressure, right, what would be needed in an essential fueling station is -- is more compression, different compression, some intermediate storage, and -- and dispensing. So if -- if it was so desired that the centralized location --- centralized fueling facility for heavy duty were to feed lighter duty or vehicles, you could t-off and -- and plan accordingly to have that additional infrastructure to make that happen; right? It's a lot easier than going say the other way where you're working on the -- the automotive side to try to make it accommodate a larger fleet; right?

So -- so it's just a matter of additional equipment. If -- if energy density is really an issue, then that would be a reason to raise the question, why don't we up the pressure? But we think we can meet the range targets with the -- the 5,000 psi systems on the vehicles, and according to our weight budgets and calculations and weight distribution and performance that we're assessing now.

MR. WALKOWICZ: No infrastructure concerns?

MR. DEL CORE: Not -- not that we see, other than -- other than that we'd like to site a larger centralized station, yeah. But, yeah, technology-wise we don't see any barriers there.

MR. WALKOWICZ: Okay. Thanks.

MR. DEL CORE: Okay. Thank you for your questions, Kevin.

COMMISSIONER SCOTT: Thank you. Margo?

MS. MELENDEZ: So I guess my only question was related to infrastructure, also. So are you just using existing infrastructure that's at both of these facilities?

MR. DEL CORE: Yeah. So --

MS. MELENDEZ: Because I didn't see them noted in here. And I would think making sure that that infrastructure is robust and running is going to be petty important.

MR. DEL CORE: Yeah. No. That's a good question and on point.

So SunLine Transit has existing infrastructure that -- that will be -- be used in their scheduling and planning for the use of this truck.

For the port demonstration we have a solution for mobile fueling if we need it. There's also four stations that we can tap, one of those being, you know, Cal State

L.A. at the top of the corridor. If we need to fuel, we can fuel there. We've already had discussions. So there's -- there's multiple sources. And we anticipate by the time that we're -- we're out there, there might be some other -- maybe, yeah. Yeah. So, thank you, Margo.

MR. MIYASATO: Well, Kevin was right, he took a bunch of my questions. And then Margo finished it up with my last question.

So just looking forward to seeing more about the Daimler trucks. That looks really exciting. So keep in close contact with your local Air Quality District.

MR. DEL CORE: Will do. Thank you, Matt.

COMMISSIONER SCOTT: Very nice. Thank you so much for your presentation, Rob.

MR. DEL CORE: Okay. Thank you.

COMMISSIONER SCOTT: So we have come sort of to the -- the end of our presentations. I want to just make a couple brief remarks.

First, I'd love for the Energy Commission staff that are here to raise their hands, just so you can see the folks on the medium duty and heavy duty side who work so hard every day to help manage your projects. Thank you, guys, so much for the work that you do. This -- these are a great set of projects. We've got a whole bunch more in the medium duty-heavy duty category, so I appreciate the -- the

good work that the team does.

I want to thank Larry for his excellent presentation this morning.

There are a couple of themes that I heard. I won't -- I won't hit on all of them. But I think that we -- we heard through a bunch of the presentations the critical role that the OEMs play in order to accelerate a lot of these technologies from being an engine into being a vehicle that can then, you know, get on the road and do the different types of duty cycles and duties that we need for those vehicles to do.

You heard today a really broad range, actually, of medium duty and heavy duty vehicles and technologies, from natural gas to hydrogen, electric, not retrofit kits but, you know, kits that can go into -- into the vehicles. And -- so it's exciting to see the -- for me especially, the broad range of projects that the Energy Commission has invested in.

Another theme that we heard, I think was that -- the supply chains. We really need supply chains out there that can be built and grow fast enough to help support this industry. We -- we learned in some places you have to -- you have to build your own because here's maybe only one other company that -- that builds something, or there's maybe one or two companies and it's not quite what you're

looking for in terms of the supply chain. So I appreciated that point as we went through today.

I heard -- I heard a few folks say you can't put a square peg into a round hole. So keep your eye on the Energy Commission solicitations. And so one thing I would recommend -- recommend to all of you is, as you know, we do pre-solicitation workshops to really think through how we want to design our solicitations. And so to the extent that you are participating in those, that helps inform strategically what we're thinking about funding. So I wanted to throw that out there, as well.

Let's see, I, you know, I just -- I found the whole day to be really interesting and informative. I learned a ton. And I hope that the rest of you all did, as well. It's -- it's really great to see how, I think, the CEC-funded projects, some of the ones that we're working on in partnership with South Coast and others, have -- have come along, and in some instances how they've really spurred the industry along. I think that's very exciting.

I want to thank our Presenters for terrific presentations, they were very thorough, they were very interesting, and for letting us really do kind of a close look. We put you guys under a microscope today as we -- as we looked through the projects. And so I appreciate you being brave enough and willing to come in and talk with us

in detail there.

And I'd love to thank, also, our reviewers. Because we gave them, you know, this -- this binder full of a whole bunch of additional background materials to read through so they could really know and understand the projects and ask you guys the tough questions that they asked today. So reviewers, thank you so very much for your insightful questions and bringing your expertise to this area, as well.

I'd like to thank Tom for bringing the truck down so we could -- we could see some of these technologies in real life and have a chance to literally kick the tires. You know, that was -- that was very cool. I enjoyed having a vehicle here.

And last but certainly not least, I want to thank my team, Rhetta DeMesa and O'Shea Bennett who help support Matthew Ong and Tim Olson as they put this together. And just a huge hearty thanks to -- to Matthew and to Tim, because we couldn't have put this merit review together without Tim and Matthew's leadership here. I know they did a lot of pre-preparation with all of you to make sure that we had such a great day.

And, you know, I threw out maybe a year or so ago, you know, I'd love to do a merit review, kind of a mini one, the way that Department of Energy does for all of their

projects. And Tim just grabbed that and ran with it, so I love it. Thank you so much for your vision and your leadership in this space.

So that's -- that's kind of my closing remarks for the day.

Tim, do you want to say anything before we go to public comment?

MR. OLSON: Only that -- that if -- we have a docket, open docket on this. There's no date, no deadline for comments. But if you have anything in writing you'd like to submit or a recommendation, things like that, please submit it. Here's the reference to how to -- how to do that.

COMMISSIONER SCOTT: Great. So I only have one blue card. If you wanted to make a comment -- and he's waiving at me -- then please -- please feel free. This is from Ryan Schuchard from CalStart.

So please come and make your comment. And we're going to have -- we have a three-minute limit on our comments.

MR. SCHUCHARD: Commissioner Scott, esteemed reviewers and colleagues, thank you for a great discussion today and for the chance to comment. And also, congratulations to the Presenters and their teams for showing some really exciting advances. These are some of

the milestones that the world is waiting for. And I know that many of you would like to be in Paris, but even though you're not take solace in the fact that these are exactly the milestones that are -- that are being discussed there, and California specifically.

So my name is Ryan Schuchard. Excuse me. I'm Policy Director for CalStart. And I want to offer just a few points that summarize what we'll provide in the -- the written docket.

But first, let me just tell you that CalStart feels a sense of guardianship for this program for a few reasons. Number one, we cosponsored AB 118 and AB 8 which led to the program's formation. We've been involved with over 15 projects in various roles from a program administrator to team member. We were involved with the Proterra and Motiv projects you heard about today. And we've been a partner to the Commission, regularly setting up meetings, providing technology advice, and creating reference documents like CalHEAT that many of you are familiar with.

So I'll just give four quick points. And then we'll just leave the rest in the -- the written docket.

So firstly, at a very high level the -- the program, the ARFVTP program from our perspective plays a really critical role in the commercialization ecosystem.

Developing new technology requires several steps along a commercialization arc. This starts with early R&D, goes to early stage demo, then -- then more wider scale piles (phonetic) and demos, and then on to early market penetration and incentives.

And this program is really instrumental in that second step. And in that way it is complimentary with other California initiatives that focus on the previous step and successive steps. So we think it's -- it's really important.

Secondly, as the studies showed today, there is -- the program has been a huge success. So we think of success in this as vehicles being commercialized and being sold in the marketplace, and indeed we're seeing that. We saw several case studies where that's happening today. And there's other case studies you didn't hear about today. For example, the Caterpillar, a large excavator project is saving 5,000 gallons of diesel annually per machine, and it's also now being sold in the marketplace. So that was the second point.

And the third point, there are a few tactical improvement opportunities, and I won't go into too much detail now, you can read those in the remarks, but I'll just say a couple of ideas now.

One, we would love to see increased engagement and

investment by private sector fleets, essentially corporate fleets that can propagate this kind of technology throughout their supply chains and in their operations in California and beyond. And that could be done in part through funding through a third party that could help to make that work.

And then secondly, we would also love to see inclusion of a wider set of technology options that -- that support the goals of the program, mainly vehicle retrofits and things that are low increment and high scale products like start-stop technology. So I'll leave it at that on the third.

And then the final, the fourth point, just to wrap it up, we think this is a program --

(The timer rings.)

MR. SCHUCHARD: -- (inaudible). The program has a clearly proven track record. There's a long technology of pipeline -- excuse me, a long pipeline of technologies that need to be developed. And this is really one of the only programs of this type and size, and it's a reason why California is a leader in climate change sustainability. And I was pleased to hear at least one testimonial today that it has actually drawn a company to -- to this state, and probably more.

So I'll leave it at that. I'm happy to further discuss today or afterwards. And thank you very

much.

COMMISSIONER SCOTT: Thank you, Ryan. And if you have a business card that you wouldn't mind handing to our court reporter, he would like that to get -- make sure he's got your name spelled correctly.

The other one I have is from Jerry Wiens.

And while he's walking up, if anyone else would like to make a comment, please just make sure you get a blue card over to Tim.

MR. WIENS: I'm Jerry Wiens, and I've been a Retired Annuitant for a number of years working in the PIER Program, R&D. We've supported the Cummins-Westport 9- and 12-liter engines, and now the new 6.7.

I had, actually, two questions. One, I guess Ian is not here. The picture that he showed of the blue flame in the turbine engine, I assumed that was natural gas. And I was going to ask him what the efficiency would that be? I assume it would be the same as if it was operating on diesel fuel.

But I have a question for Tom. What would the efficiency of one of your engines be in a hybrid -- in a series hybrid where it's going to operate at the sweet spot? I have another question for you later.

MR. HODEK: Okay. As far as a natural gas engine in a hybrid working in the efficiency spot, it's a lot more

complicated than just the efficiency. Right now it has to do with OBD more than anything else because it's a very difficult system to -- to troubleshoot in that regard or keep -- keep compliant.

We would have the same sort of a situation with a converter and an engine as far as a hybrid system goes. We could run the engine more -- more steady state in a series and -- and keep it there. And we've done that with the B on the diesel and transit buses. We've also done it with the L on the diesel and transit buses. So I'm assuming there would be an increase in efficiency. I just don't know how to quantify exactly what that would be.

MR. WIENS: Thank you. My other question is regarding -- can you tell us approximately how many of these engines that you've sold? How many diesel gallons have they replaced? And what are the -- the greenhouse benefits that have generated from your engines?

MR. HODEK: Well, honestly, I don't have the numbers. I apologize for that. I probably should be better prepared for that, but I do not have the numbers. I do know that the greenhouse gases are lower on natural gas versus diesel, and they're even lower now on our near zero-NOx product. As far as the actually tonnage removed from the air, I don't have the firm numbers, and I apologize for that.

MR. WIENS: Thank you.

COMMISSIONER SCOTT: Thank you. Do we have any other comment in the room? Okay.

Let me turn to Hieu and see whether we have comment from the WebEx or phone?

MR. H. NGUYEN: (Reading a WebEx question.) How will the Commission use the lessons learned to kind of -- for staff for future allocations for medium and heavy duty?

COMMISSIONER SCOTT: Absolutely. I think I talked about that a little bit in my opening remarks. We're going to take, I think, some of this information and use it as we're thinking about what we want to do in our -- as we're working to adjust to Governor Brown's Sustainable Freight Executive Order, I think there some good tips that are -- different project successes that we may want to take and consider is whether those are -- are criteria or requirements or other types of things like that that can be folded into solicitations.

And I might turn to Tim or to Larry to see if they'd like to add anything there?

Go ahead, Larry.

MR. RILLERA: This is Larry Rillera.

One of the things that we have to bear in mind is this program did not start last year. We have had a series of investments over the past, you know, decade, half a

decade plus where we have -- where companies and technologies have matured. So we need to look not just at sort of what we provided through our grant instruments, but we need to look at either other financing mechanisms or other options to engage third-party capital. And also looking at the scenarios as these companies scale up to -- to augment perhaps the pot for manufacturing.

But we'll take all the input. We continue to have ongoing dialogue and look forward to that, not just to this process but -- but in the evolution of the program going forward.

COMMISSIONER SCOTT: Great. Thanks.

What was our second comment? You said we had two.

MR. H. NGUYEN: It was a very similar question.

COMMISSIONER SCOTT: Oh, okay. Terrific.

Anybody else on the WebEx or on the phone who would like to make a public comment, now is your opportunity. Okay.

Well, thank you again to our Presenters, to our reviewers. I thought this was a fantastic day, so thanks a bunch. And I'll see you next time.

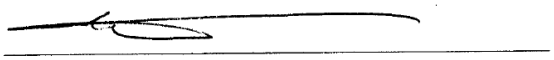
(The Transportation Lead Commissioner Workshop adjourned at 3:57 p.m.)

**REPORTER'S CERTIFICATE**

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

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 28th day of December, 2015.



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

MARTHA L. NELSON, CERT**367

December 28, 2015