**Sheryl**: Okay. Hello, everyone. Good afternoon on the east coast and good morning on the west coast. We have a great webinar today, Hydrogen as a transportation fuel in rural communities and a wonderful set of speakers. I'm just going to give you a little introduction to N-CATT, the National Center for Applied Transit Technology and I'm Sheryl Gross-Glaser, the director of NCAT. There we go. N-CATT is the newest Technical Assistance Center. We just launched in October 2019. And we are a partnership between the Federal Transit Administration and the Community Transportation Association of America. And our mission in a nutshell is to produce resources for small urban, tribal and rural communities and also to do some on-site technical assistance, which is, of course now virtual. And we're doing that through our statewide summits as well as strike teams for particular communities.

And our jurisdiction, if you will, covers a whole range of technologies. And when I say technology, I mean, basically technologies that are being developed and emerging and becoming adopted by transit agencies. And if you want to learn more about us, you can go to N-CATT.org. That's N dash CATT, two T's dot org. We have lots of stuff up there and we have a monthly newsletter. We're on all types of social media. So, without further ado, I will start the substantive part of our webinar with our two speakers from the Center for Transportation and the Environment, otherwise known as CTE. First, we have Alison Smith. Allison, is an engineering consultant and electric utility specialist at CTE. Allison, is also writing our white paper, white papers on electric vehicles and hydrogen fuel cell and she's been a great resource getting together the speakers for these webinars.

She provides project management and analytical support for advanced transportation projects including battery electric and hydrogen fuel cell vehicles.

And next we have Cory Shumaker. One second. There we go. Cory, also is at CTE, has 10 years of hydrogen experience, and he's a hydrogen and fuel cell engineering consultant for CTE. And his roles include project support through project development, project management, stakeholder coordination and outreach. And without further ado, I'll let Alison and Cory begin their presentation.

**Alison**: All right. Thanks, Sheryl. So, I'm going to start with just kind of a quick overview of who you'll be hearing from today. So, first Cory and I will give a quick introduction to hydrogen and fuel cell electric vehicles, and then with that kind of background knowledge, we'll turn it over to industry experts from Plug Power, Lightning Systems and SARTA. So, you'll hear from a manufacturer who builds fuel infrastructure in fuel cells. Somebody who builds fuel cell electric vehicles, and an operator. Not quite sure- yes, and then we'll end with a Q&A session. So, about CTE, who is the Center for Transportation and the Environment? So, we are a nonprofit engineering and planning firm.

So, we've been in the Zero- Emission transportation space for over 25 years. And I think the description of we are both a nonprofit. And our goal is to ensure that new technologies are successful when they are introduced into the marketplace to advance our mission of clean transportation. And we're also an engineering and planning firm. So, we have a lot of engineers and technical expertise on staff to help people deploy these vehicles successfully. Everything from the research and prototype development stage through deployment and large-scale transition planning.

So currently, we are working with I think, about 70 transit agencies across the United States to deploy Zero-Emission buses. And it really does cover a wide swath of the US transit agencies of all sizes, including multiple federal agencies, who are looking at Zero-Emission buses. So, then I'll give a quick introduction on what is hydrogen. So, you might hear hydrogen described in a lot of different ways. But I think what's most critical to think about when you're thinking about fuel cell vehicles is that it is an energy carrier.

So, it is a form of energy that can be used in a number of different ways. So, on these vehicles, it's using a fuel cell. So, you press hydrogen through the fuel cell, and you get electricity out of it. And the only other thing you get out is water vapor. So pretty simple. And then the other big thing people will ask when they are thinking about hydrogen is whether or not it's safe. So yes, it is an energy carrier. It has a lot of energy associated with it, but that's true of any fuel. Diesel has a lot of energy associated with it as well. But in many ways, hydrogen is safer than some of the fuels that people are more familiar with. So, it's non-toxic, always a good thing. And if there is a leak in a hydrogen tank, for example, big gas is lighter than air, and it just escapes into the atmosphere and eventually continues into outer space. And there's no mess to clean up like if you have a diesel leak.

So those are a couple of qualities there that make hydrogen unique from fuels that we're used to dealing with, but in some ways safer. And it is a very common industrial gas use, from everything, from rockets applications to steel refining, so people know how to handle hydrogen and there are multiple organizations that have put in safety protocols and standards for dealing with it. And I particularly want to highlight the Center for Hydrogen Safety, which you can find at h2tools.org as a great resource for learning about hydrogen and safety aspects of it. So, and then the other thing that I think is really critical is that hydrogen has many, many different applications. And it can provide a lot of different benefits to communities.

So, I'm just going to walk through this graphic here, which covers a lot of these benefits which range from, you can have local hydrogen production to using hydrogen as the energy storage mechanism, because it is a carrier of energy. It's a clean fuel, there are no tailpipe emissions, like water vapor.

There are opportunities to create partnerships with others in your community. And it has a better vehicle range than some other electric vehicles on the marketplace. So just going through some of these so you can create it locally. So, if you're in a community where you've got a solar or wind resource, you can create that electricity right there in your backyard. And if you have water you can combine those two and get hydrogen out of it. So, this is through an electrolysis process. And then another option would be if you have natural gas, whether that's natural gas from the ground or from a bio gas or like a local agricultural business, you can use that natural gas and steam to create hydrogen as well.

So, a couple different options for where you can source your hydrogen. And then it can be used a number of different vehicle application. So, there's a fueling station, not unlike diesel or CNG fueling station that you might have today. And that fueling station allows you to dispense hydrogen into any type of vehicle. So, transit vehicles are a great example. And another widespread vehicle is fuel cell electric forklifts. There are thousands of hydrogen powered forklifts across the country. So can use it for a lot of different things. And not only for transportation applications, but you can use it as backup power.

You can use the fuel cell in a vehicle. But you can also use the field fuel cell as a generator. And it can create electricity for critical community services. So, you maybe you have a power outage or something like that you can use your fuel cell generator to create backup power for things like your local hospital, schools or emergency services. So, there's a lot of different applications, which means a lot of opportunities for partnerships with people in your community to help make this a reality. So, at his point, I'm going to hand it over to Corey to talk about the vehicles themselves, and how do you get them into a fleet.

**Cory**: Thanks, thank you, Alison. So yeah, I'm going to go over some of the things that are involving implementing a hydrogen fuel cell fleet. First, I just want to give you an overview of the vehicle itself. So, this is actually a passenger vehicle though the components are essentially the same just in different sizes for a bus or a cutaway. So, from the picture above, you can see that there are a number of components inside of a fuel cell electric vehicle. And I think it's important to understand that it is an electric vehicle, hydrogen gets turned into electricity through a fuel cell which powers an electric motor which powers the axles.

So, in that sense, there are many of the same components in a fuel cell electric vehicle that you'll find in a battery electric vehicle, such as an electric motor, and a battery pack and a controller. And there are also some components that you'll find in a fuel cell electric vehicle that you would also find in a conventional vehicle such as a cooling system. And so, training for these components can come from an OEM and it also can come from some of the equipment providers themselves, so that these vehicles can be properly maintained. So, the training can be done in the same way that you would be trained to use a CNG vehicle or if you were to be trained on any conventional type of fuel.

So, what fuel cell electric vehicles are available today for transit agencies and others? So, there are 40 to 60-foot buses provided by New Flyer and ElDorado National Corporation, ENC. The one picture to the right and the top is an ElDorado National, the one on the bottom right is a New Flyer Xcelsior CHARGE H2. As far as the cutaways and some of the more typical rural transit vehicles, there's a cutaway that's being developed right now by Lightning Systems, which we'll hear from more later. That's going to be using a hydrogen fuel cell.

They're also doing the same thing for transit passenger van. And then when it comes to light duty vehicles, small fleets of light duty vehicles that can be [inaudible 00:11:54], can be a Honda and XO. So, the picture on the bottom left is the Honda fuels for the SUV. And these are actually readily available to the public. And we have about 8500 fuels electric vehicles in California, not so many outside of California. So, we're talking about filling the fleet because that's the other part of this, you have to get the vehicles, you don't have to fuel it.

There's really no one size fits all solution. So, you'll go through some steps that I'll outline in a few slides about how to come up with the proper plan. But there's many factors that will influence the configuration of your local fueling station, such as how many back to back fills you'll have, how many vehicles will be in your fleet, how you're going to get the hydrogen to your facility. So, in sort of the sequential order, you have a hydrogen delivery looking at this graphic, and that can either be delivered or created on site or it can be trucked in. It can be trucked in via either liquid or gaseous. It's stored on site.

If it is a liquid will have to go through a vaporizer to turn it from a liquid to a gas. It then gets compressed and sometimes it will be chilled depending on the pressure that's required and your solution may or may not require a chiller. It's dispensed. And then there's usually some-, sorry, there's some high-pressure storage before the dispenser then dispense into your vehicle. So, there's a few steps here. And it can be a bit overwhelming just from looking at this graphic right here. But I assure you that there are a lot of organizations out there, including CTE that can help you through this process and make it actually quite easy to implement at your facility.

So when you talk about hydrogen sourcing, there's gaseous delivery, liquid delivery, on site production, gaseous delivery, it's very common, and this is a gaseous tube trailer that gets delivered to your facility, and then it is offloaded onto or actually it's parked on site and then connected to the compressor and then that compressor offloads it to the on-site storage and then it's dispensed into the vehicle. Liquid delivery is a similar way which the hydrogen is delivered but it's in liquid form. And a liquid tanker will actually come and fill up an on-site liquid hydrogen tank.

The liquid or the natural gas companies have compared it similar to a milk route, where you'll have a liquid tanker that hits multiple stops and just pops off the liquid hydrogen at each stop. So, on site you'll have a liquid hydrogen tank that'll feed into the vaporizer and compressor, which will then go into the storage, dispenser and the vehicle. If you do on site production, either by electrolyzer or by natural gas, as Allison give you a picture of earlier. Essentially, you can have a containerized solution to do either electrolysis by feeding at water and electricity, or you can have a containerized solution by feeding it natural gas to create hydrogen. Both of those containerized solutions can be done on site to create hydrogen.

If you're going to have an electrolyzer you need the hydrogen-, excuse me, you need water and electricity and electricity came from solar or wind, and it goes into the compressor storage, dispenser and vehicle. One thing you can see in common with all three is it doesn't really matter how you get the hydrogen to your site. It needs to be compressed, stored at that higher pressure and then dispensed into the vehicle. So, when you talk about funding, because this type of fueling can come with some associated costs that are going to be higher than perhaps are used to. Examples of funding sources include on the federal level is the low no emissions program. And then on the state level, it can vary and one of the examples is the VW funds.

If you're in California, there's also some other programs available as well. So, I encourage you to look at your State's website and see what programs potentially could be available. When it comes to partnerships within the community, it's important that if you are going to be going on an on-site natural gas, steam-methane reformation system that you've talk to your local utility. If you're going to be doing an on-site electrolysis system where you would like to use like electricity and water to create hydrogen, and it's good to talk to your electric utility about that. And if you're going to be having hydrogen delivered, then you can talk to a local natural gas company. It's also important to see what other partners in the area may be willing to partner up with you. And so, I think this is a concept that I was going to talk to a bit more.

But there are currently 35,000 plus hydrogen fuel cell forklifts in the country and there's various warehouses spread out. So, you may be surprised about the short distance actually, between where you are and the next hydrogen use. So, it'd be interesting to see how those partnerships can line up and to potentially share a fueling infrastructure or perhaps a fueling pathway. So, when it comes to actually implementing a hydrogen fuel cell vehicle fleet and infrastructure now there are certain steps that you should follow, we recommend, an action plan here. Reach out to peer agencies and learn from their experience of the zero-emission technology. There's been some great success stories out of California.

And AC Transit specifically has maintained fuel cell bus for over 10 years, about 35,000 hours way above the expectations for that vehicle and that fuel cell. And there's other transit agencies such as SunLine. And of course, we have started here with us, which is going to talk about their successes as well. So, there are transit agencies to reach out and learn from and inquire about their interactions and how hydrogen went for them. So, it's good to develop that support, externally. And then you want to also develop support internally within your agency for pursuing hydrogen fuel cell technology.

Get a few people within your organization on board with this idea. So, then you can move forward with a planning study. So, it's important to evaluate the feasibility of your idea, depending on how many vehicles you would like to implement that may determine whether or not an on-site production makes sense or hydrogen delivery makes sense. And so, it's important really to do a full planning stage to understand your opportunity. Then you want to connect to local partners and speak to local and state officials about your project proposal.

It's important to get the local fire marshal included in this discussion, any planning or environmental departments for your local city, who has jurisdiction in your area, it's important that they are in the know on this and so there's some procedures for permitting later in the process. And you identify opportunities for collaboration with potential local partners with warehouses if possible. Also, the funding you want to see what available options you have either state or federal level.

So, then you're going to pursue and hopefully secure funding for a fuel cell electric vehicle fleet deployment, and the cost associated for infrastructure. And this can be detailed in this study. And also, it should be important to include what sort of facilities upgrades you'll require in order to maintain your fuel cell vehicles within your maintenance base, there'll be normally addition of a hydrogen detector in the bay. And ultimately, you want to create a project plan to execute that plan to fully implement your hydro fuel cell electric vehicle fleet and infrastructure. So, if you're interested in learning more, we actually have a zero-emission bus conference coming up online September 15, through 17th.

This will be covering both battery electric and hydrogen fuel cell electric. And I think there'll be a lot of great speakers that can speak to their experience. You also hear from technology providers as well. So, this could be a good knowledge resource if you are interested in getting more information. Of course, we have a lot information to give you today, but that's all for CTE from Cory Shumaker, and Alison Smith. We thank you for listening to us.

**Sheryl**: Okay. And I have one very quick question about that conference, Cory. Since it is a zero-emission conference, is that also go into electric vehicle, battery electric vehicles as well as hydrogen fuel cell?

**Cory**: Yes.

**Sheryl**: Okay. Excellent. Thank you. All right, we have our next speaker Al Cioffi. And Al, has tons of experience, 36 years of management and executive leadership experience in telecommunications, reliable power, reserve energy and alternative energy industries. He started his career at AT&T Bell Labs 40 years ago and he's held numerous engineering operations, project management, Product Management, customer advocacy, marketing roles, and he has experienced at very large multinationals such as Marconi and General Electric, as well as started experience and turnaround experience at Valerie Power, Pico too and UNIPOWER and he currently works with Plug Power to advance the commercialization of hydrogen fuel cell technology in motive applications adjacent to the commercial market. I'll let him explain that. Okay. All right, Al.

**Al**: Thank you. Thank you very much, Sheryl. Just a sound check to make sure everybody can hear me. Thank you for inviting me here and tuning in and listening. Just tell you a little bit about Plug Power. We believe we are the leader in the hydrogen fuel cell in the hydrogen as a fuel space. Our market of the industrial material handling fork truck fleets. A sampling of our customers listed on the bottom of this slide. We're up to now 30 flags, just a little bit more than 34,000 because we're in the middle of third quarter.

We're adding thousands of fuel cell motor power units every month, every quarter. Those 34,000 units have collectively traveled in excess of a billion miles. And that is given us a base of experience and an economy of scale. We're already producing our own membrane electrode assembly, we're already producing, fueling systems, we've got about 100 fueling stations that we've put in many of these customer locations. We've got very deep experience here. We provide our customers in excess of 27 tons of liquid hydrogen every single day. By comparison, the next highest purchaser of hydrogen as a fuel is NASA. They buy about 10 to 12 tons a year of course, they burn it all into rocket tests.

Our customers tend to burn it less spectacularly a little bit more controlled methodology throughout the year. The thing about fork trucks that I would like to point out though, is that they are incredibly harsh. They operate in incredibly harsh conditions. We see 40 G's of shock regularly fork truck is carrying seven, 800, 1200 pounds of load. It's a small rubber tire, there's no shock absorbing system. When you go from the warehouse floor onto the warehouse dock onto a trailer that's parked, you've got that two- or three-inch gap you can really shock things. We operate very, very well in cold environments.

We have some customers that operate frozen foods, and we go from a negative 30-degree Fahrenheit environment up to 100-degree Fahrenheit environment in August on the truck, all within about 30 seconds and we also do rapid start stops. That rapid start stop really stresses the engine, really stresses the fuel cell. So, we believe we have a very robust solution that we have been able to deploy in one of the harshest conditions and we've got collectively over a billion miles travels. So, we believe the value proposition here. And the reliability and the safety record are really unchallenged at this point.

So as people have talked about before how does a fuel cell work? You can think of it as a battery, in a battery you put electricity in, you get electricity out. With a fuel cell, you put hydrogen in air and you get electricity out. Okay? The big difference between a battery and a fuel cell for motive applications, though, is that the battery access both the storage tank and the engine, whereas in a fuel cell, just like you do with a diesel engine or a gasoline engine or natural gas engine, you can separate the tank from the engine, okay, and that really is plays into the next item and that one recharge times are driven by the battery electrochemistry that it just takes so much time to move electrons around and to make that chemical reaction happen and to do it safely, whereas the fuel cell is not where you have to fill up the energy you put the hydrogen into a separate tank and then the tank feeds the fuel.

That's a really big distinction because fuel cells will operationally perform very much like diesel and gasoline engines except without the emissions. So, how do we do this? How do we get 34,000 units out into the field? The product we make that fuel cell will married together with a separate fuel tank down there, we put all of this together into a drop-in replacement for conventional batteries.

You'll see here a classroom pallet jack, for those of you that are familiar with that, in this yellow outline is a Plug Power Gen drive unit that used to have a lead acid battery, maybe a lithium ion battery. Now, the amazing part about this is that our real market, our biggest market is in indoor warehouses where you'll have 150, 200, 250 vehicles operating under one roof. You can imagine if you try to use propane or diesel or natural gas, the emissions coming out of those vehicles in such a small concentration literally is a killer issue, it would poison the atmosphere and kill people. So, our customers have had to, from time immemorial, utilize batteries in these applications, they really had no choice, they had to use a zero-emission vehicle.

Now, our customers willingly replace a perfectly good zero emission battery with a zero-emission fuel cell. It's not that they've done this demonstration projects, they've done this 34,000 times and they consider this to be mission critical and a big productivity increase. So why is it that people willingly do that? And the answer is compelling economic value. We do this, our customers do this with basically the benefit of a federal investment tax credit, no direct instead of money, no direct rent money, and so that the economic value that we can provide here in operations where operating times have to be long and the loads are relatively high, is we feel like is very compelling. So why is that? Okay.

And I've highlighted a couple of things here, you have very long recharge times with batteries. You have operator downtime by going back to slide here. The model is that this battery is it takes eight hours to charge the lead acid battery so you cannot take the vehicle out of service that long. You have to remove the battery from the vehicle, put it on a separate charger and then put a freshly charged battery inside onto that vehicle. That takes time. And that battery change-out mechanism leads to lots of operator downtime, it also leads to duplicate assets because the batteries will be off- the battery powered vehicle will not run continuously.

So, customers have to have more vehicles in their warehouses in order to keep their productivity up. The other thing that happens is that the performance drops throughout the shift and it drops with temperature. We all have experienced that any of the batteries that we use in our personal devices as they start to get low on charge things slow down, okay. You've got operating in a remote-control car, you'll know that the car slows down at that the battery starts to discharge for a while.

That is a real productivity hampering mechanism in some place like a considerable Walmart warehouse was trying to ship things into peak of Christmas season. That is really a big deal. With electrical charging infrastructure, you also can attract demand charges because if you're putting all these batteries aren't charged at the same time, which typically happens, the electric utility will assess your demand charges. And as the vehicle ages, as the battery ages you will lose capacity at that as well.

Our customers have told us directly that they can see anywhere from 15 to a 25%, we've got some customers claiming 100% of productivity improvement. I'll give you a one anecdote, one of our customers and our customers consider all of this information to be extremely competitive and proprietary. So, I can't identify who they are. But we had one customer tell us that they typically plan their new warehouses with 354 trucks. And 88% of the cost of operating fork truck is in the lease and in the labor cost associated with that energy is a very small portion of operating these things. They told us that when they switch from batteries to fuel cells, they can plan the same level of productivity with only 250 vehicles.

That is a huge, huge savings. This is real money that we're talking about here. And that's why our customers willingly replaced their zero-emission batteries to zero-emission hydrogen fuel cells. So, what does this mean in the commercial power world? What does this mean in commercial on road vehicle world? If you look at these operating criteria here, I've got the box check for internal combustion engines. Internal combustion engines do very well in operating buses and drives trucks and delivery vans and taxi cabs, they do very well in all of these things except for emissions. A battery powered equivalent vehicle what will always have compromised performance compared to an internal combustion vehicle except for the emissions.

But the fuel cell powered vehicle actually checks all the boxes. And these things here all-weather operations, asset and space utilization, the productivity of your workforce, your refueling recharge times, the cycle performance of the vehicle, can handle all routes and all missions on demand without having to wait for a charging function to happen. All of those things apply to commercial vehicles that operate in high capacity and high daily utilization rates. Certainly, transit buses fall into that category.

So, this topic has been covered very well by Alison and by Cory. You can do all of these different things, you can have hydrogen delivered, you can have it reformed on site via steam reformer, you can electrolyze water. The thing is that and I mentioned that we've operated and constructed and operated over 100 of these stations so far, by the end of the year we'll be over 115, not sure where we are in the schedule. We've got a very heavy schedule this year. As what one of these plants typically looks like there's your hydrogen liquid tank, some guest storage tubes, and vaporizer, some compressing and it's all managed through this in here that takes all of these sources of hydrogen that can be deployed on site and puts them all together into an intelligent manifold and drives through a dispenser.

So, the point is here that a hydrogen solution is flexible, forgiving and scalable. You can scale this up and down. If you mess up, and you only plan to fuel 20 vehicles, and you wind up that you have to fuel 25 vehicles that may or may not require any upgrade to this station, you might have to put in a bigger compressor and that may be about it, you may have to add another dispenser. If you screw up with charging of a battery vehicle and you needed 25 chargers instead of 20 chargers, that's a new capital project.

That's a new capital request project that's very long-time delays and that's very expensive to do. Hydrogen fueling is very flexible, very forgiving and very scalable. You can scale this up and down. So, I like to put this slide up because this line here represents the conventional thought on fuel cell electric vehicle charging that as the fleet size is very small, fueling with hydrogen gets to be expensive and complicated. And the opposite is true with battery electric vehicles. It's easy to try a battery charger.

But as you scale it up, it gets very complicated and very costly. We like to believe that we operate high- Plug Powers figured out operate on this green line here, the initial cost and the efforts are very, very much lower than portrayed. Like I said, we built 100 of these stations, we have lots of experience and we've got lots of scale economy on how to drive these materials and deploy them easily. The other thing we do is that those that hydrogen plan that Cory, so expertly walkthrough, we do that as part of a turnkey package. We take care of all those issues. We take care of permitting.

We take care of construction, we take care of the fire marshals, we take care of the local authority with jurisdiction, we take care of all of those things. Typically, once we get permitted, we can have a site turned up and running in about 16 weeks. If there's long lead time delivery on some tanks or things that we don't make, it might take a little bit longer if a local fire marshal has some difficulty and they take a little longer to convince them, but we have yet to fail to convince any authority or any fire marshal to not deploy a hydrogen solution. And we do this on a turnkey basis. So, when I talk about these forgiving ranges here, there's a very broad range of solutions that can be brought to bear.

We've talked all about these various issues here. The way in which we take these pieces in and manage them through this manifold through the compression storage and dispensing. This is I don't want to say formulaic, but it pretty much is formulaic. We can scale this up and down as we need to. We have customers that start out with a couple of kilograms of gas delivery every day or every week. And we have some customers that are getting large liquid deliveries that are making their hydrogen on site via steam-reformer coupled with liquid delivery. So, we can scale this up and down.

The initial investments are not outrageous for about the price of the fast charger we can get you started on a full dispensing and storage solution with a delivered gas for getting started. So, we like to believe and we really do offer a broad range of customizations that can give you a cost-effective solution with numbers that probably you might not be accustomed to seeing. So again, I mean this is what it looks like, we take care of delivering the molecule, we take care of putting in the infrastructure, we take care of putting in dispensers both indoors and outdoors, these dispensers are of our own design as well. And we are a full-service provider of critical hydrogen to enable all of your needs and get you on the zero-emission journey like you want to get on. So, there was my comments. Thanks for listening.

**Sheryl**: Okay, thank you so much. Our next speaker is going to be Keith Lehmeier and Keith, tell me if I'm pronouncing that incorrectly. Keith is director of new product development at Lightning Systems where he's responsible for managing engineering programs for new products. His first role in new product development was as the engineering lead and project manager for the development of Lightning Systems first all-electric platform, the Lightning electric Ford Transit, and he has since directed all other new products development for the company.

And prior to his current role, he served as the project engineer for hydraulic hybrid trial programs in the US, UK and in India, and he developed Lightning as a control and system engineer-. He joined Lightning, I'm sorry, as a controller and system engineer in 2015 responsible for helping develop and implement the company's hydraulic hybrid system, and I will let Keith, take it over from here.

**Keith**: All right, thanks, Sheryl. Great. So yeah, my name is Keith Lehmeier, I work for Lightning Systems. And what we do is develop zero-emission power trains for commercial vehicles. So, the way we've architected our system is that we're really battery agnostic as well. Or I'm sorry, we're energy source agnostic. So, whether it be a BEV or a fuel cell we're compatible with both. So, we're located in Loveland, Colorado, we have about 140,000 square foot facility. We do all of our engineering design, production and manufacturing in this facility. So, sort of the premise of how we do our businesses is we take conventional vehicles from OEMs such as Ford, GM, Gillick, Vaughn haul, etc.

We develop an electric powertrain kit for them, you can see that on the picture on the left. So, the idea is we leverage the engineering that's been put into a conventional vehicle in terms of the vehicle systems such as the body, doors, suspension, etc. And basically, just replace the IC powertrain. Our big value add is in software and vehicle integration. We have a lot of pride We do all of our control internally. And we have the support of these OEMs to integrate to their vehicle system. So, we can reuse a lot of the vehicle systems such as an ABS controller, restraint control module, etc. So, what this means in terms of a product is when somebody gets in one of our EVs it feels like a commercial vehicle that they're used to, signs the noise and emissions of an IC power train.

One of our other value ads is in our product called analytics. It's basically a build on of your standard telematics, one of the things that we found in fleets is that finding a telematics provider is relatively easy and there's a lot to choose from, but that a lot of fleets get that data and aren't necessarily sure how to use it particularly with the case of FCEVs or BEVs and so we provide a value add in turning that data into usable information. So, this is a roll up of our current commercial vehicle offerings. We offer a class three through class eight truck and bus. In the class three we have a Ford Transit that's available both as a truck in terms of moving equipment, as well as a bus, passenger vehicle.

Class four is the E450, that's ubiquitous with airport shuttles, rural travel, etc. Class five we offer an F59 which is multi-use vehicle, food trucks, delivery vehicles etc. as well as an F550 which is basically the larger version of an E450, commonly utilized for passenger transport. Into the class six space we have a GM product that's a 6500 low cap forward. And then in the class seven and eight space we offer both a transit bus repower as well as a motorcoach repower and I'll talk about that a little further.

Specific to fuel cells, we've developed two concepts to date, the Ford Transit, which is again the smallest vehicle that we offer, it's a 10,360 pounds GVWR. It's targeted at a range of about 135 miles again, again, that's going to be very specific to the use case. And then on the larger side of things, we have a class six vehicle which is again that truck we saw on the last page that's the largest truck you can drive without a commercial driver's license. One of the advantages of the way that we design our systems both with respect to fuel cells as well as BEVs is that it's a very modular system.

So as Cory mentioned, a lot of the components with a BEV and an FCEV are the same, or similar if not the same. Things like the electric motor, transmission, power, converters, etc. And what we've done with respect to energy storage is continue on with that modularity. So, in a large vehicle, we may have three engines, in a small vehicle we may have one but they're the same engine in each case. And so that really allows us to cover a lot of different vehicle platforms without having unique designs between them all. And so, this is Lightnings view on the BEV vs FCEV landscape.

The chart on the left shows an analysis that we've conducted that basically compares where an FCEV makes sense and where BEV makes sense. And this is, of course, a simplified analysis, because there's a lot of things such as infrastructure, and some of the other items that are spoke to that are excluded. This compares strictly cost, payload and range. And what you see from the chart is that the initial cost of a fuel cell vehicle while it's more expensive, the architecture lends itself well to expanding at a lower cost. So, the cost per incremental kilowatt hour is much less than a BEV. And the result of this is, as you see, in this particular case crossover, approximately 160 miles range. Now-.

**Sheryl**: Keith, I have one question, since you're right in the middle of this. I assume that the technology is advancing while we speak. Is one of the changes we might see in the future advances in terms of that range?

**Keith**: Yeah, absolutely. I mean both in the case of a battery electric and fuel cell electric vehicle, technological advancements are going to both flatten the slope of that line as well as bring the offset down. One other point to note on this chart is and I don't know if this is particularly relevant to passenger transport or not, but if payload is paramount, a fuel cell makes sense over a BEV pretty much all of the time. Because the gravimetric density of hydrogen is much higher than what you can get out of a lithium ion battery.

And so, I guess to summarize the chart on the left, we put together this four-quadrant system on the right that- and of course, this is overly simplified, but this is a good starting point in terms of where BEV makes sense and we're a fuel cell makes sense. And so, to summarize that high payload fuel cell makes a lot of sense, long range fuel cell makes a lot of sense, both fuel cell all the way. And so, Lightning’s particular take on it is there's applications that makes sense for both. Really, it comes down to what the use case of the particular vehicle is. And then one other thing I'd like to speak to the way we've designed our system is available for a repower as well.

So, what we've done is design a modular system that can be used in a vehicle that's not new. So, as I mentioned, we take existing OEM vehicles and we remove the powertrain and the fuel system, exhaust system, etc. And we install our ZEV kit. One thing that this lends itself well to is it doesn't necessarily have to be a new vehicle. So, this picture of this bus here is actually a 2004 Gillick that we repowered for the city of Boulder here in Colorado.

It's kind of a nice story because it had a blown engine, blown transmission, they had written it off on their books and came to us. They have a strong initiative to go green. And the economics of a repower are much more favorable than buying new electric buses. So, we took a 2004 bus and transformed it into a 2018 electric bus. And this is because of the way we've designed our system. We can have this mentality with other vehicle platforms as well. And again, that's agnostic to BEVs and fuel cells. All right, I think that's all for me.

**Sheryl**: Okay, thank you so much. And next up we have Debbie Swickard. And Debbie, is with SARTA in Ohio, she's been there since 2012. She began and started as a transit agency in Ohio. She began as the finance department manager and completing the consolidated annual financial report. And she moved in 2014 to become the grants manager and as the grant’s manager, Debbie is responsible for finding, writing and submitting grants, verifying allowable funds expenditures, federal reimbursements, ODOT and federal audits.

That's it gets complicated and reporting. And SARTA has been awarded low or no emission research grants and a whole bunch of other funds including CMAC funds 5307, 5309, 5312 is just a few for hydrogen diesel electric hybrids, bio diesel and dual fuel CNG diesel vehicles and a hydrogen fueling station. And SARTA, I don't think this is well known. Has the largest hydrogen fleet outside of California with 13 hydrogen, 40 foot and 530-foot vehicles and eventual goal of going completely zero-emission with their vehicles fleet. And Debbie, it's all yours.

**Debbie**: Thank you, Sheryl. Can you hear me all right?

**Sheryl**: Yes.

**Debbie**: Okay. Hello everyone. Like Sheryl was saying, I'm from SARTA. And we're a tier two agency. We are located in Canton, Ohio. We have a 576 square mile radius service area in Stark County, Ohio. Most of you know the Football Hall of Fame. Well, that's where we're located. We provide about 2.5 million, 16 paratransit rides per year, and our goal to be completely low or zero-emission transit agency. We do have a few fueling stations one’s diesel. We have two for CNG for public and for ourselves and a hydrogen. Right now, it's just our hydrogen fueling station but we will go public once it becomes necessary when the demand gets up there. So, you've decided to go hydrogen or electric now your funds really start.

How are you going to pay for it? Well, we've noticed since we started in 2016, we had research grants to start funding ours. And it was a lot more expensive then because the technology wasn't out there as much for transit. We had limited opportunities. So, the vehicle costs were quite high. There are so many ways of looking at it. The US EPA, the State EPA through DERA grants or through their AFV grants, depending on the agencies that you have there. The US Department of Energy, state funding, do you have SDRs or in Ohio, we have the OTP2 grants, and they're specialized for urban transits. But you've got your 5310, your 5311. Those are geared towards rural and tribal 5339. I don't know if every state has that. But we have that here in Ohio, besides discretionary through the FTA.

You also have your low no, and the bus and bus facilities. So, keeping an eye out on what grants are out there is the key to know who is funding. 5307 even though you're rural and your tribal talk with an agency that's nearby, because you could partner with them and see if you can become a sub recipient and get funding. Perhaps they're also going with battery electric or with hydrogen, and you can join with them through joining forces. It also reduces cost if you buy in bulk.

So that's one way of looking at it. Go talking with your MPO of the area on CMAX funds or if they've got any specialized funds that they might have. MPOs have a lot of resources so speak with them. Also check grants.gov, I know some agencies haven't been familiar with it. But if you go to grants.gov, they can link you up that if there's a notice you're automatically get that information and it's very, very helpful. The same thing goes with the Department of Energy or the EPA or your state, you can get automatic linkups.

Also talk with your local utilities and merchants. I was working with an agency, a nonprofit rural in a county near us. And we worked with merchants in the town that the agency couldn't afford the vehicle, but through subsidizing by the merchants of having their add on vehicle for a year, two years, they were willing to put up cash. So, there's all kinds of creative ideas that you can use in order to get funding. Statewide Contracts, talk to your state. I know in Ohio, we have state contracts that we can purchase off of. Some of the vehicles currently are not CNG hydrogen or electric ready, but we are teaming with outside manufacturers in order to get them the way that we need them.

These drive prices down, the more we purchase, the costs will come down. One thing that we've done is stack grants. Okay, you might want to purchase five vehicles, but you don't have the funds in one grant. The grants are getting very competitive now with a lot of agencies wanting to go with zero-emission, either electric or hydrogen. They're getting competitive and the vehicles are expensive, and the funding amounts that they're putting out as the total awards is not increasing. So, you've got to get creative on how you're going to be able to pay for what you want to purchase. In order for us to get the first set of vehicles that we got, I needed to stack a whole bunch of grants and put them together. But if you look at it, the total for the spending was 13 million, almost $14 million for these eight buses.

This was back in 2014. We started, we actually out of our pocket only paid 693,000, which is a normal diesel 40-foot bus. So, if you get creative on how you can stack your different funds, it becomes easier and easier. The one thing to remember though, is if you're going to stack your funds, have an idea of when you've hit your mark of when you can start ordering and what funds you're going to need because you need to have that vehicle in, so that you don't lose funding. You've got it obligated.

So just keep that part in mind, and you won't have any problems. Right now, we're going after five 30-foot hydrogen buses. And we've got our first one has just been delivered. We've got the four, there'll be here by the end of the year. And you can see stack 2017 and 2018 money from three different areas. We also got vendor funding, because this vendor wanted to get into the market. So, we're working with them. And it's been working really well so far. So just remember, what you want to do, how much you're going to need and where can you possibly get that money from? Our station here again, we stacked money, as you can see on the total project was $2 million. That was for infrastructure inside the building, because we only have CNG.

When you go to hydrogen, anything that has a lighted source needs to be changed out. So, we had a number of different things, our heating system had to be changed out so that there wasn't any type of ignition if there was any type of a fuel leak. Then you've got the different type of- your safety that comes into play. Everything between the concrete pad, the station, the pumps, the inside of our maintenance facility in our garage, everything came out to about $2 million. And there again, you can see by stacking, we only paid $63,000. So that's not very much coming out of our local funds. It's almost like playing poker and you want to stack. You want to get that funding put together.

Now this year, we are putting in additional pumps because of the time when we brought it in the technology was so new, we didn't know if we were going to be expanding, we didn't know quite what to do. So, we held off, now we're going to be putting in two additional pumps because we're going to increase our hydrogen fleet. And that we need to increase our equipment just slightly and put the pumps in. We don't have to do anything to our infrastructure or our pads or anything like that. Out of this one, we don't have to stack any money because the money came from our local MPO, our Metropolitan Planning Organization, they came out and said, yes, we're going to give you the money for it.

So, they even put it at 90% would have normally been 80%, $137,000 is not much to put out for. This is what our station looks like, in the foreground here this is our CNG. This is our hydrogen pump. We're going to be adding in two more pumps. And this is our actual station. You saw the diagrams earlier between the compressor and the tanks and all, our hydrogen is brought in like they were talking about the milk trucks, they come in and they fill this tank, ours is upright because of space. We did have to get a special permit because of how tall the unit is. But it is possible to do and also because of our footprint at our facility where we had- we needed the space.

But behind this concrete barrier here that goes all the way around it is complete the vaporizer, the condenser, everything that's needed in order to turn that liquid hydrogen that's delivered into gas and that is pumped underneath the grounds to our facilities right here. Right now, we have our pumps set for the 40-foot buses. When our new pumps come in one will be for 40 foot, one's going to be less than 40 foot because they have a slightly different adapter kind of like your diesel and your regular gasoline pumps, they have different types of nozzles on them.

The difference between the vehicles they require different poundage when the fuel is put into the vehicles. We are extremely happy with our hydrogen. I've actually drank the exhaust that came from our hydrogen vehicle. It's warm water, and I'm still living and it's two years since, so it's quiet, you can actually have a conversation inside of a 40-foot bus going over the roads for fixed routes. It's an amazing type of transport. If you've got any questions or you need any assistance, we've been doing this in the Ohio area in the cold weather. We've done studies on it that have been online. Give us an email, ask questions, we'll be more than happy to help you out. And for that, Sheryl, I'll turn it back over to you.

**Sheryl**: Okay. Let me take back control. Okay. All right. Okay. If anyone has questions, they can put that in the QA that would be the best thing but if you put it in the chat box, we'll be paying attention to that as well. So, I have a question. We've talked a lot about putting in the technology and what to do when you're planning for a hydrogen fuel cell system. But what about in terms of maintenance and training of transit staff. Are there any special considerations when it comes to hydrogen fuel cell as opposed to electric or conventional energy sources?

**Cory**: Yeah, I could go ahead and take that. But go ahead. I mean, Debbie. Yeah, you're- did it.

**Debbie**: Oh, I just want to say, it took our guys about 40 hours. And they learned the OEM came in, work with them. Three of our service techs became certified. And then they've been teaching the rest of our maintenance crew. As far as our drivers, same thing. They got 40 hours training on the buses. They were certified. And then we went down the list.

**Sheryl**: Okay.

**Cory**: Yeah, I was just going to say the OEMs will usually take a step in and provide the training.

**Sheryl**: And what about maintenance, is there anything special to know about maintenance?

**Cory**: Debbie, would you say that the OEMs also provided that training to train the maintenance workers as well?

**Debbie**: Yes, they did. We've got ElDorado’s and ElDorado’s we were able to purchase a special toolkit and it was about $4,000. And it helps a lot, our guys now it's so easy to work on them because you don't have moving parts. You don't have a combustion engine. There's a lot of things that you don't have to deal with, with a hydrogen bus.

**Sheryl**: So, it’s actually easier to maintain than internal combustion engine?

**Debbie**: I would say, the guys would have said at first, no. It's so new. But after they get used to it and they know what to look for, and they know what the problems are, it's easier.

**Alison**: I think one of the important things is that it is also to be aware of high voltage training can be a new thing for an agency if they have not had zero-emission vehicles before and then just learning about hydrogen, but-.

**Debbie**: Thank you Alison, that was a good point.

**Sheryl**: And what about partners? I know that there were some discussion earlier about other institutional and industrial partners in a community. Can you expand on that a little bit? And what kind of partners, maybe transit agencies have joined with in implementing hydrogen fuel cell? And since you're pausing, somebody asked a question, which is what is the maintenance cost per mile difference? Does anybody have data on that?

**Alison**: I don't have anything off the top of my head. But the best place to go for that information is going to be NREL report. So, they have been monitoring the maintenance cost for hydrogen fuel cell buses for a number of years now and they put out public reports on that. So right now, I think the numbers are sometimes higher, but I don't have the diesel cost per mile, but I also don't have- some of those are older vehicles. So, it can be difficult to compare a vehicle that was deployed, even in 2015, to one that will be deployed in 2020. So just keep that in mind as you look at those reports.

**Sheryl**: Okay, okay.

**Al**: So, I would point to the investment community reports. I mean, as you might imagine, the large investment banks have a very high interest in green and clean technologies, and electrification of vehicles is very high on their radar screen. And every analysis I've seen, because with an internal combustion engine, you've got a transmission that's got fluid, you've got engine oil, you've got internal combustion that builds up sweat and grease and things like that. You don't have any of those kinds of things with an electric vehicle. Okay, and so electric vehicles in general, are accepted as being lower maintenance cost and internal combustion engine. So, both battery electric and a hydrogen electric will benefit from that shift in technology.

**Sheryl**: Okay, thank you. And-.

**Cory**: Sheryl, you mentioned partners earlier. I just wanted to see if there was anything-. Yeah, I think, one of the things that we discussed in our white paper is the potential theoretical partners between some existing utilizations of hydrogen and fuel cells, a distribution centers that perhaps can be tied into external uses through. And Al, maybe this is more of a dreamland, but I know there's been conversations in the past at some of our conferences about dropping a dispenser outside the fence. I know that some might have started about doing that, and I'm not sure if there's-, it's really a possibility, but it'd be interesting to know from your perspective, if you think distribution center could partner with an external user of that hydrogen.

**Al**: Oh, absolutely they can. But you got to have the right one, okay. Most of our customers tend to view this stuff as mission critical. And they tend to see it as theirs and theirs alone and don't mess with my formula because I have a lot of boxes I got to move and a lot of crates, I got to move. So, I need to be competitive. But we're starting to see more and more, especially as the realization that you have a station, you have an asset that can provide clean renewable energy to lots of people and SunLine is a great example of this. Lauren of SunLine gets it. She sees the ability to provide fuel to others in the community as a benefit and also as an adjacent business model for SunLine as well. So, you've got to get the right partner to be able to do that, who is willing to branch into different business modes.

**Sheryl**: And is that encouraged as well by state policy and regulation?

**Al**: That's a mixed bag. Real mixed bag. I mean, as progressive as California is, there is a separation between public fueling and private fueling between heavy duty and light duty. And that's not always positioned to be able to foster those kinds of things.

**Sheryl**: Okay.

**Alison**: I would add that-. Oh, just from another perspective. I think the utilities could potentially be a very good partner on some of these kinds of projects. I mean, we're seeing them be very involved in the battery electric vehicle space. But hydrogen is interesting from their perspective as well. So, one of the big topics in the electric space is energy storage. And we didn't really touch on it during this webinar. But hydrogen is a very interesting option for energy storage. And so, the partnership with the utility for everything from bringing power to your site, because even if you have a liquid delivered option, you still have to power those compressors and other equipment. So, I highly recommend reaching out to your local electric utility, regardless of what kind of solution you're looking at. But there are many ways that that could be a beneficial partnership.

**Debbie**: We've been looking at producing the hydrogen on site here and we’ve been talking with our utility companies, our electric and our gas manufacturers here in the state of Ohio, on how can we turn like our nuclear power plant where we'll talking with them. And they're interested in that. We've been talking for a few years on how you can turn that nuclear into a hydrogen station, how can we get that out? Because that's one of the biggest things that we've found is the infrastructure is not set up very well yet. And I think that's why a lot of people shy away from it because of that, the infrastructure isn't built. And once that gets going, it's going to be like gasoline and CNG. It's going to take off, but talking with utility companies, that's a big plus.

**Sheryl**: Okay, we have a question about from an anonymous participant, maybe because this is about trucking, but I would guess it's similar for buses. Is hydrogen fuel cell will it ever be a viable alternative for long haul trucking? And would that be the same kind of question for intercity bus transportation, for example, would we need some kind of national infrastructure? Or is there so much growing up in different places that that may be a reality at some point?

**Cory**: I did some work on the trucking. Yeah. So, and then yeah, but I would like to say that it's a lot of that intercity return to base model. Where long haul trucking is a days of chain model. So, if you can get states to collaborate, there's I think right now 15 state, Memorandum of Understanding currently for zero emission buses and trucks. But if you were to get states to work together and create a corridor, then absolutely it's possible for long haul trucking or anything that's its long haul if you have truck stops. And I think Alison can speak to this a little bit. She talked to Trillium, but if you have a certain amount of truck stops per large distance then yeah, this can definitely be- assume as you corridor with how did you feel so can exist.

**Debbie**: Yeah. We have been in talks with Love Struck Petroleum. We've got a build grant out. This is our second year we've been going for the build grant in order to get an infrastructure from trying to get from the East Coast up through the major corridors through, Ohio and over on 80. And when we didn't receive the grant last year, and it's still out this year, but when we had our debrief, the problem they didn't understand hydrogen. So, once we get our legislators to understand what it is, what we're trying to do and how feasible it is for everyone that infrastructure is going to come. So, there are a number of major companies that want to get on board with this. We just have to get the funding in place to get it started. Get that link from East Coast to West Coast and then north to south. Yep, that's it. Once that infrastructure is in place, hydrogen vehicles will take off.

**Alison**: And I just want to add on, you'll notice that nobody has answered with any concerns about the vehicle technology. The questions are really more about infrastructure and scale up and cost rather than the ability to be a one for one replacement, yet they maybe are exactly the same. You might not find a transit bus that can go 400 miles when it's powered by hydrogen these days, but it can do almost any transit route out there.

**Debbie**: Our 40 footers are for 250 miles. That's what we do on a route during the day. It gets fueled one time and it goes out. And then it comes back gets refueled and it waits for its next route. And we're out 20 hours a day.

**Sheryl**: Wow. And so that's basically the equivalent of an internal combustion bus.

**Debbie**: Yep, it's one for one.

**Al**: I would add a little historical perspective here. I mean, I love researching and listening and understanding the history of technologies as they evolve. People take for granted today's- diesel ubiquitous and they're everywhere. But when Henry Ford started building his Model T and he had his first business plan together, it wasn't. In fact, gasoline octane used to be dumped into rivers of Pennsylvania as a byproduct of making kerosene. They just didn't know what to do with it. And it certainly was not ubiquitously available. So, it just takes some time for the two to go hand in hand. I see this as historically inevitable. The people who are making big investments are paying attention to this space. When investments come people expect to have a return. Business models will evolve and they will be implemented and I just see this as an eventuality, it's not a question of if, it's a question of when.

**Sheryl**: Okay, I have a follow up question. But before that we have another question. And how did these buses perform on steep long grades?

**Alison**: And I guess I would maybe defer to Keith, on this. But I think just depends on the configuration of the vehicle. You can have different battery and fuel cell configurations that are for better or worse in different applications but they work.

**Keith**: Yeah, I would absolutely agree with that assessment and the way that we size our powertrains, whether they include a transmission or not, is to meet or exceed the diesel performance. One other thing that's important to notice that in the case of a battery electric vehicle, when you're coming down the hill, you get the benefit of regenerative braking. So yeah, I think in either case, of a ZV vehicle, that it's not a concern. It's not a technology problem.

**Sheryl**: So, it's not like with the electric vehicles, I know there's a lot of concerned about cold weather in particular, that becomes a major factor. So, something like a steep hill is not something to give one much pause then.

**Cory**: From having some conversations with Chief engineers that are developing a hydrogen fuel cell vehicles and Keith, you talk into this too. I mean, it really depends. If you size that fuel cell to be large enough to take that demand of that power requirement to go up that hill. It'll absolutely do it. No problem. If you if you have a system that's more designed for flat and maybe when you're going up that hill, you're using more of a battery than a fuel cell because a fuel cell is so smaller, then that could be a problem depending on how steep the hill is or how far that is. But and then the cold weather there is some analysis and actually a study on this. There is some degrade in the range of cold weather with fuel cell vehicles. But it's not as much as a degrade as battery electric. I'm not sure, Keith, you have much more to add.

**Keith**: No, I also agree with that. Yeah, it's exactly a question of sizing. And that's one of the discussions that we frequently have with fleets is do you want a one size fits all so to speak, which is what the diesel equivalent would be. Or do you want to tailor your vehicles to the duty cycle or the mission cycle? Yeah, I would agree with that, Cory.

**Sheryl**: And I assume that the more you customize, the higher the cost with it, is that correct?

**Cory**: I think that would depend on what your customization comes out to right, Keith?

**Keith**: Yeah, yeah. I mean, the big concern that we get from fleets is configuration management. It's advantageous to be able to walk up to any of my vehicles and they can do any of my routes, right? That's a common thing. But because of the way we design our systems the modularity aspect back to that it's really not a huge cost driver from the upfront costs standpoint. The big concern is that configuration management in the field.

**Sheryl**: And with grant money, is it true that grants are pretty much agnostic about which the source of the zero emission fuel whether it's electric battery or whether it's a fuel cell electric vehicle, or is there a push anywhere, whether it's on the state level in Congress, from a particular sector to favor hydrogen fuel so over battery electric?

**Debbie**: I don't think that there's a push. But one thing that we have found and I think Alison, you might be able to back me up. Because the funding sources don't really understand hydrogen, they just look at the dollar amount of how much it costs. They go, sometimes the funding will go to electric, because the electric vehicles will cost less. But in the long run, it's actually costing more than the hydrogen. So, it's almost like well, we need to get as much bang for our buck as we possibly can and get the zero emission buses out there.

We're going to go with the lower cost to get more vehicles out there. But I think over time as we're trying to start our CEO here, Kurt Conrad, he speaks with them constantly to educate. It really costs more to do the electric than it does to do the hydrogen. And we need to have hydrogen at least be looked at and continuously funded for those vehicles. So, I think that's the biggest obstacle right now.

**Cory**: Yeah, I think when you let's talk about really big fleet transition to battery electric, the dollar amount for that infrastructure gets extremely large, significantly higher than the equivalent solution for hydrogen. And this is the curve that Ali, showed earlier. When you scale up, it makes a lot more sense with hydrogen.

**Debbie**: Yeah.

**Sheryl**: I'm reminded with hydrogen of like the old shopping mall and needing those anchor institutions to drive people there, are their anchor institutions for hydrogen fuel cell? So, you were talking about industrial uses with forklifts, maybe hospitals, using some of that energy and others. Do you think that that's the way we're going that there's going to be this sort of critical mass of institutions, organizations, businesses that want to adopt hydrogen fuel cell and then those benefits will then carry over to transit as well?

**Cory**: In my personal opinion, I think that transit is one of those anchors. I think that's one of that draws into a community. I don't know outside from forklifts, what potential fuel uses in Ohio, than they were for SARTA. And so, it can be one of those anchor institutions as a transit and the community can start to benefit off of trucking fleets, transit fleets that start to transition. And then as Al, mentioned, if there's potential partnerships with distribution centers, and then you're talking about there's also backup power opportunities, where if you have at a hospital, for example, a fuel cell generator that perhaps could get hydrogen from somewhere local either trans H to distribution center trucking agency that's happens to be cruising it on site, and then it could be brought over, so the community can then benefit from those anchors.

**Sheryl**: And, yes, go on.

**Keith**: Cory, I would agree with you. I think transits companies are can be one of the bases. I think the early adoption will come as Cory, described return to base fleets. So, imagine your favorite overnight delivery service, the last mile delivery companies, drayage companies that are operating on a certain route and always returned to base on a certain night. So those kind of transit buses certainly fit that model. I think that's where the early adoption will occur, because it's the easiest fueling formula and equation to control.

The easiest way to keep your infrastructure under control and to create a business case that makes sense. And once that's adopted, and people get comfortable with the idea, of I'm dealing with this other fuel. Eventually somebody will look at that and say, hey, I have an asset here that I can utilize to drive more revenue into my company and make my enterprise more valuable. I think that's where you'll start-.

**Sheryl**: Okay. Is there anything else? I'm going to ask particularly Alison, since you do look at electric vehicle technology as well. And I think that that's often the choice that people see when they want to go zero emission. They're saying, am I going battery electric or hydrogen fuel cell? Are there certain factors that make that tipping point? Or is it only that initial investment that really worries people?

**Alison**: Yeah, I mean, I think Keith, covered this pretty well when he was talking about the vehicles and there are good applications for battery electric vehicles, and there are good applications for fuel cell electric vehicles. That cost concern is definitely a big one with hydrogen fuel cell. So, we're still trying to drive down the cost of hydrogen and the cost of infrastructure. But at the same time, it's been really interesting to watch the transit agency, transit industry over the last, even just the last two years the conversation shifts.

So, when you've had things like in California, they've had the- everyone's had to put together a rollout plan for converting to zero emission. And when they started looking at the numbers and how they were going to complete their duty cycles, the interest in hydrogen started to go up a lot. So, I don't know, but makes fleet maybe the right case option in some cases, if you have vehicles where battery electric is a really good fit, and those vehicles have a lower upfront cost. And if you keep your electricity costs down it can be more cost effective. So, it just really depends on the exact application, what technology is going to be the best fit.

**Sheryl**: And I'll say we're getting toward the end. Is there a situation where you think hydrogen really does not makes sense? It's sort of a factor where you would say, if you have x factor, don't do hydrogen.

**Alison**: I don't know that there's a generic rule but you really got to look at your particular fleet and application and what fueling station options exist. So, they're becoming- there's a lot of people interested in smaller scale fueling applications at a lower price. So, it really just depends on your exact operation.

**Sheryl**: Okay, so there's no like, shortlist of factors. It seems like a pretty complicated analysis.

**Alison**: Yeah, we highly recommend doing some significant planning before you embark on any particular path.

**Sheryl**: Okay, well, that's a good thing to know. As we come to the end, are there any parting words that any of you would like to make and something you think you've overlooked or you want to emphasize before we finish the webinar? And Keith, I'll ask you first.

**Keith**: No, I don't think I have anything specific than a very intriguing discussion. Thanks for having me and be part of it.

**Sheryl**: Thank you and Debbie.

**Debbie**: I am with Keith. Good luck to you all and keep on looking at new alternative fuels.

**Sheryl**: Okay, and Al.

**Al**: I would point out that Plug Power’s experience with very complicated material handling logistic centers, putting in 100 or so stations and having 34,000 vehicles out there that the path to getting to hydrogen may be much simpler and much more economical than people may believe. And we'd love to show you how.

**Sheryl**: Okay, thank you and Cory and Allison.

**Cory**: Alison.

**Alison**: I was just going to add it. If you found this interesting and informative, please check out N-CATT’s white paper, which will be posted before too long on this topic, so.

**Sheryl**: That's right. That's right as well, this webinar. Well, I want to thank all of you for joining as speakers. This has been really informative. I know for me. And we will definitely be exploring this topic. I'm sure in the future. There's been a lot of interest from our audience in it. So, thank you very, very much.