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STATE OF CALIFORNIA

CALIFORNIA ENERGY COMMISSION

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IEPR COMMISSIONER WORKSHOP ON ROLE OF HYDROGEN IN CALIFORNIA'S CLEAN ENERGY FUTURE SESSION 2

IN PERSON AND REMOTE VIA ZOOM VIRTUAL MEETING

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Rosenfeld Hearing Room (Hearing Room A)
1516 9th Street,
Sacramento, CA 95814
(Wheelchair Accessible)

TUESDAY, JUNE 21, 2022

1:30 P.M.

Reported By:
Peter Petty

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PJ Callahan, Center for Transportation and the Environment
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P R O C E E D I N G S

June 21, 2022 1:32 P.M.

MS. RAITT: Welcome back to the afternoon part of this 2022 IEPR Update Workshop on the role of hydrogen in California's clean energy future. Again, I'm Heather Raitt, the lead for the IEPR. Just reminder, all of our IEPR workshops are recorded. And so, we will be linking our recording to the CEC's website shortly after the workshop, and we will have a written transcript that will be posted about a month later.

If you need or want to find the meeting schedule and the presentations, they're are all online, on the Energy Commission's web page for the IEPR, and, just, we have a few ways for folks to participate today. We'll have some limited time to take questions from attendees using the Q&A feature on Zoom. You can ask questions just hitting that Q&A function. Or if you're in the room, you can write them down and give them to me.

And if you'd like to make a comment, you use the raise hand feature, and we'll take comments at the end of the afternoon. But again, the comments are just for making comments. We won't be responding to questions during the public comment period. And if you do have a question, please use the Q&A function.

So, with that, I'll just turn it back over to Vice Chair Gunda. Thank you.

VICE CHAIR GUNDA: Thank you, Heather for kicking off the afternoon session. I want to just begin by thanking all the panelists in the morning. We had some excellent discussion on, generally, the updates from the state agencies on the different initiatives from CEC, PUC, CARB, as well GO-BIZ, kind of talking about the hydrogen hub and the opportunity there.

So, it was a really good discussion. We then discussed about the forecasts of hydrogen opportunities in an economy wide decarbonization. And to Matt Lewis from LADWP and Yuri from SoCalGas, was an excellent conversation. Subsequently, we had some comments, kind of encouraging us to broaden the discussion beyond the electrolytic hydrogen. That -- that kind of, that took a lot of discussion today to, you know, also including the biogas side of it and other opportunities. But also really challenging to think about, you know, what are all the opportunities for hydrogen? Which is perfect, because we're going to dig into that this afternoon. Thinking about the near-term opportunities for hydrogen and different applications, including MDHD --

(OFF MIC)

(Pause)

Can you hear me now?

So, I was on a roll there. So, I'm not sure I can repeat. So, what I'm gonna say, is thanks to everybody in the morning. And welcome, everybody, for the afternoon. And we're going to look into — jumping into some media topics then I will hand it back for, for jumping.

MS. RAITT: Perfect, thank you. So our — we'll move into — our panel is on — so, third panel, first one of the afternoon, on the current use of hydrogen and near-term opportunities to expand the use for medium-duty, heavy-duty, and off-road, as well as marine applications.

And so, our moderator, back from this morning, is Jane Berner from the Energy Commission. Thanks, Jane, go ahead.

MS. BERNER: Thank you, Heather. Well, you just explained our panel and I'm — the esteemed panelists are listed on this slide here. But, before I get to introducing them and having them do their presentations, I'm going to take just a couple of minutes to go over the current use of hydrogen for light-duty fuel-cell electric vehicles before we get into the, the full panel.

So, next slide, please. And actually, you can keep going.

I want to recognize the current light-duty fuel cell electric vehicle market, because it is largely where hydrogen is used today in California in the transportation sector. As I mentioned this morning, the Clean Transportation Program funds public hydrogen refueling stations to, to support the deployment of SCEVs.

I wanted to take a minute here to show our station maps. The image on the left showing the entire state, and the ones to the right, zooming into the Bay Area and South Coast, where most of our stations are located. The ones shown with green icons are the open stations, and the ones in red are the ones that are planned for which we have locations.

So, and, as in all of our programs, we consider how these investments will benefit disadvantaged communities, which is why we've included those in yellow in the zoomed-in map.

Next slide please.

These stations support the over 12,000 fuel-cell electric vehicles that have been sold or leased in California to date. That includes 826 in quarter one of this year. This slide gives me the opportunity to highlight the Zero-Emission Vehicle and Infrastructure Statistics website that was created by, and is maintained by, our talented friends in the CEC Energy Assessments Division. This website includes several pages, including the ones shown here, on new ZEV sales. And when I made this slide, I hovered over the FCEV cumulative sales, which brought up the line chart showing in the center of the screen there where –– how cumulative sales have grown by year. So, this website I just wanted to point out has a lot of different ways to look at data for all ZEV types and, as well as infrastructure.

Next slide please.

(Pause)

And finally, I wanted to mention that there are two annual reports prepared about the deployment of hydrogen refueling stations in California. These reports are required under Assembly Bill 8, and we often refer to them as the AB 8 reports. The one shown on the left is the summer AB 8 annual evaluation that the California Air Resources Board prepares. And the one on the right is the Joint Agency Staff Report that the CEC and CARB prepared together. That's due at the end of each calendar year.

Since we do a lot of analysis already related to light duty FCEVs and the stations that support them, we're not really focusing on them in this particular panel. But again, I just wanted to acknowledge what a large part of the current hydrogen transportation market they are in California before we delve into this discussion about additional current and near term uses in the medium-duty, heavy-duty, off-road, and marine spaces.

So, now that I’ve made this short presentation, I'm pleased to be able to introduce and turn the flow –– floor over to our esteemed panelists. I'll introduce them one at a time as we go through their presentations. And so, I'm going to start with Dr. Amgad Elgowainy. Dr. Elgowainy is a Senior Scientist and a Group Leader at Argonne National Laboratory, who leads techno-economic and environmental lifecycle analysis of hydrogen fuel-cell vehicles and battery electric vehicles.

He has contributed to the development of the environmental lifecycle analysis models that many of you know as GREET. And, he has led the development of a hydrogen infrastructure techno-economics suite of models. Dr. Elgowainy, please come on camera, and, like to welcome you to make your presentation.

DR. ELGOWAINY: Thank you Jane, so much. Can you hear me?

MS. BERNER: Yes.

DR. ELGOWAINY: Okay. Excellent. Thank you. So, thank you for the introduction. Today I will give you a sense of analysis in general about hydrogen infrastructure vehicle applications, where we see the opportunities, where are the key challenges, for the fueling in particular?

Next slide, please.

So, I want to start with this slide. This slide actually shows, I mean, where are the opportunities for hydrogen vehicles? If you start by looking at the green line, this is really -- the vertical axis here is the cost. The horizontal axis is the storage amount for batteries. The slope of that green curve is the battery cost. And it, I mean, it could be any number, right? Today or future there will be some slope. There's $1 per kilowatt hour of usable battery storage.

And then if you look at the very bottom, you will see the dotted line, this is the hydrogen storage. And all other things yield lower than the battery storage. So, the batteries is at 171-50, hydrogen tank is about $15 to $17 per kilowatt hour. If I adjust for fuel economy, you know, batteries are more efficient, then I would increase the slope of the hydrogen storage as they adjust to the economy. And then, I lifted that below curve up, because there is, as you see on the far left, there is the fuel cell as an overhead, there is a battery hydrogen powertrains i—— are hybrid.

So, you'll see over there, there is a crossover point in the middle of the chart. On the right of that crossover point, the hydrogen powertrain is lower cost then the battery powertrain, and on the left of that crossover point, you will see the green line is below the blue line, just means the batteries could be more attractive.

So, this kind of chart is a space for powertrains that, whenever they need more storage means higher VMT means higher energy intensity of the powertrain, then hydrogen can be attractive. Of course, I put there in the yellow box is a feeling cost, the charging cost could key factors as well.

Next slide please.

(Pause)

So here, I would like to highlight something related to fuel costs. Fuel costs is related to two things. I mean, one of which, if you look on a per service provided, whether per mile, or per passenger mile, or per ton mile —— it relates really to how much energy is consumed to produce a service you want it. And that strongly depends on the powertrain efficiency. Here is show three cars. This is just illustrative. I mean, diesel engines, for example, for the medium/heavy-duty vehicles, become very efficient when the engine is operating near full load.

However, hydrogen fuel cells, they will peak near part-load, as you see there, 60-65 percent, about, drop near full load. So, you could see if your duty cycle, and this is very important. If your duty cycle, such as that you are mainly in part-load, the fuel-cell efficiency could be significant compared to the diesel internal combustion engine. And here, I am focusing only on medium/heavy-duty vehicles that are diesel operated. And if you are near full load most of the time, like longer haul trucks, then the efficiency benefit will erode. Why this is important?

Next slide please.

So here you see two examples. You see the classes, look at the table below there. Classes, like trucks. Diesel is roughly 6 miles per gallon of diesel equivalent. Hydrogen could be 15, 16. So, this is two and a half the fuel economy ratio to diesel. At $2 a gallon, hydrogen can be five, and competitive. If diesel at $4 a gallon hydrogen could be 10 and be competitive. Like today, it is $6, and we could be even $15 and be competitive.

But look on the right, Class 8. Fuel economy ratio is closer to one. This means that if diesel at two, then hydrogen need to be at two. I don't have much room there to be competitive. So that fuel economy ratio that is decided by the duty cycle and the how more efficient or less efficient, will play into competitiveness of hygiene costs and whether you could really sell, sell hygiene at a premium and be competitive or not.

Next slide please.

(Pause)

So here I saw, like, an example of infrastructure. Can we skip next slide please? This is the gaseous delivery pathway. If you look next slide, it will be the liquid delivery pathway. And I want to give another key message there. So, fuel economy ratio duty cycle is important to fuel costs.

And, next slide please.

(Pause)

And then you have the liquid pathway. You liquefy and remove liquid hydrogen. Liquid is more attractive. I will show you why.

So, next slide please.

(Pause)

So, we use, really, our techno-economic models to understand the supply chain. Actually, the resource liquid is also gaseous. What is the impact of onboard storage and things like that on the economics, and also on the carbon intensity? So, we use for that our model, HDSAM, that is also publicly available. And the link is there at the bottom of the screen.

Next slide please.

So, some outputs of the models, we get really some insights. You know, in California, hydrogen sells at $15-$16 a kilogram. I mean, if you look at the first pie chart on the left, you see production is a small portion. Packaging delivery is another big portion and then fueling is even the bigger portion. And you see fueling is mainly compression, storage, pre-cooling refrigeration dispensing. So, it is very capital intensive.

One thing I want to point here, this is another key message. That tank reserve, highlighted in yellow, demands a lot. Is very favorable, really, for taking on board energy storage. But it demands a lot on the fueling components, and therefore you see the two or less, maybe $1 per kilogram production suddenly inflates to 15 or 16. Why? Because that onboard storage has a significant impact. So, whether it at 350-bar or 700-bar. Type three or type four. I mean, even futuristic tanks –– all of these could really play a significant role on the cost of hydrogen.

Next slide please.

So here we show, actually the value of liquid delivery. If you di–– deliver liquid, you deliver it cheaper today. And then, you could you–– really use the liquid to fill current onboard storage, 350 bar, 700 bar. But you could also do futuristic onboard storage like cryo-compressor or low-pressure liquid hydrogen tanks. And these will have significant impact on your fueling costs.

Next slide please.

So here are I show four groups. The first group there on the left is gaseous supply with different –– different fueling grades. This is a 350-bar compressed hydrogen tank. This is only the station contribution. Up to $5 per kilogram for the past feeling. If you do 700-bar it will be even higher about 30, 40% higher.

Now, the second group there is the liquid supply. Same thing. Same onboard storage tank. You see, you could cut the fueling contribution by almost half. So, liquid actually. is very attractive. You could get the cost of the molecule lower, you could really design your station at a lower cost. And then on the far right, you see actually even if we avoid all these high-pressure carbon fiber tanks, you go into a cryogenic liquid tank. Your fueling costs could be significantly lower, and it could be effectively less than $1 per kilogram. This is only contribution of the station.

Next slide please.

However, delivering liquid is really cheaper. I mean the station costs could be cheaper, but liquefaction really is very energy intensive. State-of-the-art today is ten kilowatt hours per kilogram. It could be up to 12 or 15 kilowatt hours per kilogram depending on electricity. You see two liquefier in California. They're the North Air Product discovered by Linde.

This actually would, depending on the electricity carbon intensity, liquefaction could add two or three kilograms of CO2 per kilogram of hydrogen. So yes, it is attractive economically, but we need low carbon, low cost of carbon, low carbon electricity for liquefaction.

Next slide please.

(Pause)

Here, I want to come back to that—— you just have to (INDISCERNIBLE) hydrogen fuels (INDISCERNIBLE) details to be more attractive at the near-term. Against the fuel economy this a big deal. This is a big deal for fueling processes that it gives me room to sell hydrogen at premium over diesel. This is attractive from greenhouse gas perspective. You see on the left. Busses, car, trucks, fuel economies near 2.4-2.5, even with, with SMR hydrogen, the blue bar, significant reduction compared to this.

Transit buses, you get 40 percent reduction fuel economy wise you need 1.7. Drayage trucks, 1.6. You get 36 percent reduction. With longer haul, you will get marginal reduction with this SMR. And if you do liquid, it could be even worse than diesel. Unless you go all very green, as you see on the far right. And then the yellow bar there is California, like 50/50 or 60 percent SMR, 40 percent renewable. You could see, really, what does it mean for the different location.

Again, I would like to emphasize the importance of the vocation and the duty cycle on the fuel economy ratio, which will play both in carbon intensity and the competitiveness with respect to costs.

Next slide please.

And this will be my last slide. That carbon intensity, especially in California, translate int costs depending on the dollar per CO2 avoided, the credit given there. It will translate, really, into economic value. So, liquefaction is not without economic value. It will translate in the California market into some data. So, it is important to get the benefit of liquid, but also to reduce the carbon intensity of liquefaction.

Thank you very much.

MS. BERNER: Thank you, Amgad. Next up is Peter Chen. Peter Chen is a mechanical engineer with the CEC's Energy Research and Development Division in the Transportation Unit. He manages grant solicitations and a portfolio of projects focused on hydrogen as a pathway for decarbonizing heavy-duty, on-road, and off-road vehicles. And he's just a great co-worker. Peter, I'll turn it over to you.

MR. CHEN: Thanks, Jane. Likewise, you're great to work with. So, earlier this morning, my colleague, Rizaldo Aldas, presented a high-level overview of CEC's investments in green hydrogen research and development. I'll be going into a little bit more detail on our portfolio of R&D projects focused on hydrogen for transportation end uses.

Next slide please.

So, to begin, I would like to give a brief overview of the Gas R&D Program which has funded a lot of our recent hydrogen research work. The program's goal is to find R&D not adequately addressed by competitive or regulated entities, while also supporting key state energy policies including the transition to cleaner energy, greater reliability, lower costs. And increased safety.

The program prioritizes benefits towards under-resourced communities as well, including job creation, improved air quality, and economic development. The program has a $24 million annual budget and it's funded through an investor-owned utility gas consumption surcharge. So, it's very analogous to our much lighter EPIC program, which serves the electricity side.

Next slide please.

So, the $24 million budget is allocated towards several research topics, including energy efficiency for buildings and industrial sector, renewables and advanced generation, transmission and distribution, environmental research, and transportation. Since around 2018, and the establishment of our economy wide, decarbonization goals, the program has included more hydrogen-related initiatives, as we see a role for hydrogen as a renewable molecule that can help decarbonize these hard to reach and uses, where electrification can be a lot more challenging.

So, for this presentation, I'll be focusing in on our transportation portfolio, again, with the lens of targeting hard to reach end uses and subsectors where we think hydrogen makes sense.

Next slide.

So, over the past four annual Gas R&D Program budget plans, we've invested a total of $19.1 million towards hydrogen-related transportation initiatives. Starting with our fiscal year 19/20 budget plan, we targeted hydrogen fuel-cell demonstrations and rail in marine applications at ports through the H2RAM solicitation. H2RAM released summer 2022 as a joint solicitation, combining our gas R&D program funding with the Clean Transportation Program funds.

We funded the vehicle design demonstrations and our Clean Transportation Program funded infrastructure. A year later, we released a solicitation targeting hydrogen truck and bus technology integration and demonstration projects, and now we have two active projects kicked off.

Looking forward at our most -- our two most recent budget plans. We are shifting focus a little bit from vehicle demonstrations to address barriers for refueling larger pieces of on-road and off-road vehicles and equipment. We actually proposed the same initiative in back-to-back years with the goal of developing a single larger solicitation that combines these two years of funding. And with that, we help to attract more applicants, get more ambitious projects, and also be able to target more of these emerging sectors like rail, marine and aviation, that we're hearing a lot of interest about for –– for hydrogen. So in the following slides, I'll go into a little bit more detail on each of these initiatives and I'll also highlight some projects we've funded.

Next slide.

To start off, I like to highlight the HyZET project, or the Hydrogen Zero Emission Tugboat project. It was funded out of the H2RAM solicitation. Just some quick background on –– on tugboats, or towing vessels. They are a type of commercial harbor craft that operate around ports, inland waterways, and shipping channels. And, among other tasks, they are used to assist oceangoing vessels, or, like, container ships when they're docking and undocking at a port.

There are around 229 tugboats operating in California waters, and they largely rely on a pair of very powerful diesel engines making them very challenging to electrify, and also relatively high emitters. The gas R&D program funded a project to conduct a design and feasibility study of a hydrogen fuel-cell powered harbor tug for future deployment at the Port of Los Angeles.

The team con—— consists of a consortium of hydrogen and maritime industry experts, as you can see on the slide. And the design will be based on an existing tugboat operated by Crowley at the Port of LA today. The objective is to address key technical and safety challenges and ultimately prepare an actual design that can lead to a future deployment. The project will also evaluate critical questions about how to handle liquid hydrogen fuel systems onboard a marine vessel, and also investigate potential bunkering or refueling solutions at the port.

When looking at missions, marine vessels account for some 60 percent of diesel PM and 62 percent of NOx emissions at the Port of LA. So, converting these vessels to zero emission will be, you know, absolutely critical for improving air quality around portside communities, obviously along with the benefit of decarbonization. While most of these emissions are attributed to the larger ocean-going vessels, the project will help establish a design and regulatory pathway for decarbonizing the maritime sector, broadly, with fuel-cells and with liquid hydrogen.

In terms of status, the project will complete a majority of its technical tasks this year. And they're looking for follow-on funding to actually build the vessel. They recently completed a preliminary design, as you can see on the slide here. And some of their next steps include doing a -- a detailed cost benefit analysis, and also developing the refueling infrastructure plans in partnership with the port.

Next slide.

So, moving on to the Sierra Northern Hydrogen Locomotive Project, also funded out of H2RAM. Just a quick background on switcher locomotives. Switcher locomotives are older, and usually lower power, freight locomotives that operate in and around ports and rail yards. They assist in putting together trains before those trains ultimately move across the country. Unlike on-road vehicles, many switcher locomotives are still powered by diesel engines with very minimal emissions after-treatment. So, they do have a big air quality impact to the local communities.

We have an active project to build and demonstrate a hydrogen fuel-cell switcher locomotive at the port of West Sacramento. Sierra Northern Railway, a Class 3 short line railroad that operates around the port, is retrofitting one of their existing switchers with fuel-cells, compressed hydrogen storage, and batteries.

In partnership with the Clean Transportation Program, a sister project was funded to develop a multimodal hydrogen refueling station, which will support both the fuel-cell locomotive and on-road vehicles at the same site. This unique station design will benefit from economies of scale, hider–– higher utilization, and also, the surrounding community will hopefully benefit from infrastructure that supports ZEV adoption across these multiple transportation end uses.

When looking statewide, locomotives contribute to 12 percent of NOx and 8 percent of PM 2.5 emissions. So, this project helps establish a pathway to address these emissions with hydrogen and the fuel cells. And we –– we definitely see, you know, wider adoption, especially beyond switchers and into the line haul freight locomotives as being critical for improving air quality for communities located around rail activity.

The project team is currently refining the detailed design of the locomotives and the various modules, and they're preparing for detailed design reviews with the Federal Railroad Administration or FRA. And that'll be critical for ensuring their design meets rail safety standards. And hopefully, we can get the locomotive ready for a demonstration mid next year.

Next slide.

So, we recently kicked off two projects to demonstrate hydrogen fuel cells for heavy duty trucks, specifically with challenging duty cycles. One of the projects is with Cummins Electrified Power. They'll be devel—— demonstrating hydrogen fuel cell trucks for an industrial gas with delivery operation with air products, which involves pulling heavy payloads of cryogenic gases, and also using a power takeoff system to offload the gases for their customers.

The other project is with GTI Energy, Symbio, Michelin and Facurecia. That project will involve extended regional haul, or long-haul operations, between the Inland Empire and northern San Joaquin Valley. This type of operation is —— is quite challenging due to develo—— long routes, and also the limited refilling opportunities.

Project objectives include improving fuel cell vehicle efficiency, lowering costs, assessing feasibility of emerging solutions, like liquid hydrogen onboard storage for trucks, which the previous presenter alluded to as a emerging technology. And these objectives will be met through design out to optimizations of the controls, battery storage systems, and also the use of some next-generation fuel cell modules.

Both projects are targeting around 500 miles of range for -- between refueling as well. And the projects also include workforce development -- aspects, where the technology providers plan to engage with local community college students through EV-technician training programs, and also engage with existing service and repair facilities with the hydrogen fuel cell truck technology.

Next slide.

So, this is my last slide. Our latest transportation initiatives out of the gas R&D program are focusing on more innovative hydrogen refueling solutions to help decarbonize heavy transport, which were defined very broadly at this point, as medium and heavy-duty on-road vehicles, including trucks and buses, mobile off-road equipment such as ag, construction, mining, cargo handling equipment, and this emerging off-road sector, which includes rail, marine and aviation.

So, when looking at the hydrogen refueling network today, it's largely designed and dedicated for light-duty vehicles. And, you kind of saw that in Jane's opening remarks. We see that there is a need for further R&D, in terms of standards, equipment, and refuel efforts to enable hydrogen refueling for these larger and more emerging heavy transport applications.

Some research targets that we have in mind include enabling higher flow rates, lowering hydrogen delivery and fueling costs, improving reliability, and also redoi—— reducing energy losses throughout the conditioning and distribution of hydrogen fuel.

This initiative is being developed into future funding opportunity, targeting a release later this year. And, we are actively coordinating with our agency partners including the CEC's own Clean Transportation Program yet again. And also, the California Air Resources Board, you know, with the hope of maximizing the benefits of these funds across multiple programs.

And with that, I —— I'll conclude my presentation.

MS. BERNER: Great, thank you, Peter. Next up, we're gonna switch gears and talk about a different project, the NorCAL Zero project with PJ Callahan. He is a Lead Engineering Associate for the Center for Transportation and the environments, or CTE. PJ leads projects across the industry, including battery electric and fuel cell transit vehicles, Class 8 drayage trucks, and the nation's first full size automated transit but. He co-authored reports to the California Air Resources Board, and several transit agencies, on fuel cell electric transit bus performance. Take it away, PJ.

MR. CALLAHAN: Thanks, James, for the introduction and for having me here today. And thank you to Amgad and Peter for the great presentations that I hope to be able to build on here. As Jane mentioned, I'm here to share with you some highlights of our NorCAL Zero Emission Drayage and Regional Operations with Fuel Cell Electric Trucks, or the NorCAL Zero project, funded primarily through the Clean Transportation Program, the Energy Commission and CARB’s Clean Transportation Incentives.

Next slide, please.

So, CTE, if you haven’t heard of us, are a 501c3 nonprofit. Our mission is to improve the health of our communities and the planet with the focus on zero emission transportation technologies. You know, just using our skills and engineering and planning, to focus on both battery electric and hydrogen fuel cell electric technologies. Most of our hydrogen work focuses within our prototype development group, and with a strong focus in California where there are dedicated state and local funding programs that we've already covered here today for advancing the hydrogen economy.

We have four —— four service areas overall. Smart deployments focus on deploying larger amounts, in particular to these transit agencies that have these types of vehicles and technologies and complete the transitions helping agencies look past their initial deployments into the full zero emission transitions, and then some education outreach activities covering all of these.

We have a national private presence. We're headquartered in Atlanta, but I'm based out of our Berkeley office, and we have satellite offices in LA and Minneapolis, St. Paul area.

Next slide, please.

So here are just a few examples of some of the fuel cell electric vehicle projects we've managed over the past several years. The Energy Commission and Air Resources Board have been really critical in funding the development of these vehicles in their associated building infrastructure. We’ve been working with UPS to build and deploy two different purpose-built vehicles through viability for parcel delivery. One in West Sacramento, the other in Ontario.

And one of the most impactful projects we've completed that has really set the stage for medium and heavy-duty hydrogen vehicles, is the fuel cell electric bus commercialization consortium, where we worked with AC Transit and Orange County Transit Authority to deploy 20 New Flyer fuel cell electric buses.

This project really helped to lay the groundwork for future bus deployments, with commercializing New Flyer’s technology at –– at scale and around the country, and –– and has helped pave the way for our NorCAL Zero project, which will be the largest deployment of its kind in North America when the trucks hit the ground next summer.

We're also excited, they recently awarded the V2B Oakland Project, to demonstrate the viability of using these buses as a bus-exportable portable power system in emergency response situations to provide backup power to community facilities.

Next slide please.

I think we've –– we’ve covered this additionally in some previous presentation, but just to highlight these again, one of the few key advantages to using hydrogen as a transportation fuel that we've demonstrated in several of these projects, is the fast refueling time offered compared to charging an equivalent battery electric vehicle with refueling times more comparable to their conventional diesel equivalents. Hydrogen allows fleet operators to really maintain their current schedules and reduce the amount of changes to their logistics and schedules in their transition to zero emission vehicles.

So largely, hydrogens can also reduce the amount of additional electrical infrastructure which is required on site when supplying -- with centrally produced and distributed hydrogen, either in gaseous or liquid form. The energy density of hydrogen allows for longer ranges than we see with battery-electric vehicles, affording for wider adoption across a range of duty cycles. And the payload on board is more comparable to what fleet operators are used to carrying with diesel trucks. So again, reducing the amount of changes to their logistics and schedules, and number of vehicles they need to operate to maintain their -- their current operations.

Next slide please.

So, building on these projects that we've managed and the lessons learned in the space, we're working with several industry leaders and funding agencies to deploy 30 Hyundai fuel cell electric trucks operating in and around the Port of Oakland, slated to begin operating in June of 2023. We started the project last year and expect to continue it through the first three years of truck operations, including in the spring of 2025.

The project is funded with close to $53 million in total funding with grants from the Energy Commission to the Clean Transportation Program, and the California Air Resources Board with cost share grants provided from the Bay Area Air Quality Management District, and the Alameda County Transportation Commission.

The trucks will primarily operate in and around the Port of Oakland, reducing the amount of diesel particulate matter emitted in a community that's historically been really overlooked on issues of air quality, located adjacent to the major transportation corridors that service the area in and out of the Port of Oakland. And lastly, we're building a fueling station at the East Bay Municipal Utilities District facility, right nearby to the port.

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So, it takes a lot of teamwork and coordination with leaders in the hydrogen industry to execute a project as large and groundbreaking as NorCAL Zero. CTE, we're serving primarily as the grant recipient and project manager with cost share mentioned provided by BAAQMD and ACTC. Macquarie is an international investment firm that's getting involved in zero emission space. They'll purchase and own the trucks from Hyundai and lease them to a leading international logistics provider and Globex America. First Element Fuel has a really established track record of successfully deploying fueling infrastructure through many CEC's programs in California, and they will build and operate the station at East Bay MUD with fuel supply from Air Liquide.

And once deployed, the trucks will be serviced at a local service provider in San Leandro, NorCal Kenworth. They'll be providing the maintenance for -- for the trucks and will need to conduct facility upgrades to maintain the vehicles safely and -- and comply with NFPA codes.

Additional project partners include the TSRC at -- and UC Berkeley, working with the West Oakland Environmental Indicators Project to collect data for reporting and conducting community engagement activities to gain support in and around the West Oakland Community, and demonstrate the benefits that the project can bring to air quality in the region.

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And this is just an overview of the station location at East Bay MUD, located right near their digesters. There will be enough fueling to accommodate up to 60 trucks with extra storage to supply the nearby markets including a light duty retail fueling station onsite.

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We believe this project is -- is really one of our most impactful to date, as I mentioned. Building on the Fuel Cell Bus Consortium and a lot of our other demonstration work that we've done. The NorCAL Zero project will demonstrate commercial viability to fleet operators introducing a new fuel cell truck OEM and Hyundai to the US market, and a new fuel supplier, First Element Fuels, first heavy-duty refueling station to expand the hydrogen refueling network with 10 to 20 minute kilo-- 60 kilogram fills. Like I mentioned, up to 60 trucks with a sort of innovative fueling protocols pushing the industry forward to -- to even, to bring the fill time down even further.

An additional benefit is to provide local workforce benefits through the NorCal Kenworth facility in San Leandro. Bringing along workforce training aspects to the project as well. And as I mentioned, reducing those harmful emissions in and around the port. The -- the fuel supply will be guaranteed 54 percent renewable fuel content supplied through Air Liquide's recent—— recently announced and initiated North Las Vegas facility with a zero CI score, for the first three years of the project.

And here you see just a brief timeline. We're expecting the trucks to be fully deployed by June of 2023, and we will report on their first year of performance evaluation the following year in 2024, and then the trucks will fulfill their six years of service through 2029.

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And here's just a snapshot of some of the progress that we've made so far, just in the —— kind of the first year already of having the project kicked off. So, we've divided the project into several sub-teams focused on the truck build, with Hyundai, the infrastructure build, with First Element Air and Air Liquide and East Bay MUD, and the maintenance facility upgrades, involving NorCal Kenworth and Fiedler Group providing the facilities assessment, and the community outreach strategy sub team.

So, just where we're at so far, we have obtained the CARB Executive Order to operate on public roadways in California recently in April. We completed the vehicle production plan, which outlines how the trucks will be built, the timeline for build, and testing, and deployment and shipping to the United States. And we are -- Hyundai is currently prote-- conducting prototype testing in California, both Northern and Southern California, to inform final specifications for the trucks.

First Element Fuel, on the infrastructure side, has completed a preliminary Hydrogen Safety Plan that will be finalized and submitted to the Hydrogen Safety Panel for review. We are working through the demolition of the existing site. I was there just about a month ago and saw the existing building on site already coming down. And so, working through that. And then the station, actual permitting is also active and ongoing for the future build out.

And lastly, as I mentioned here, the -- the facilities assessment is complete to assess what's necessary at the NorCal Kenworth facility to safely maintain hydrogen vehicles to meet compliance in order to, you know, actively vent hydrogen from the building in the event of -- of a hydrogen vent from the vehicles.

And we're working through the upgrade permitting currently with -- with Fiedler group and the building architects. And we’re also drafting the community outreach plan, again with UC Berkeley's TSRC and the West Oakland Environmental Indicators Project. This will include community meetings, outreach to drivers and web materials to educate the community on the project and the benefits that it will bring.

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So, looking beyond the NorCAL Zero project, we still have a long ways to go to achieve a commercial hydrogen economy at scale. The early-stage development projects that we've been doing are really critical to carving out new technologies and introducing new OEMs into a competitive marketplace to advance commercialization, but there's still a lack of options available. We need to drive investment in trucks and port and off-road vehicle demonstrations, like the ones that Peter was just mentioning, to continue to increase the amount of commercially available options for fleet operators.

In tandem, there's a lack of available refueling infrastructure, specifically for individual owner operators who may not have the capital to finance their own stations and rely on publicly available refueling infrastructure. Specifically in the heavy-duty market, there's just a lack of infrastructure to support their deployments currently. So, looking forward to –– to driving investment in, in this area as well. Obviously, there's currently a high TCO. We really need to scale the vehicle and fuel production and distribution, which California is really leading the nation on by investing in projects like NorCAL ZERO.

And lastly, the technology readiness is still, you know, still has a way to go to progress. Even though we're demonstrating a range here of up to 500 miles, there are several duty cycles, not just for short-haul drayage, but long-haul regional trips. And many independent truckers really operate a variety of routes to continue to stay in business, and they really require a one size fits all solution, where they don't have to be assigning vehicles to specific routes and can just kind of dispatch across their different variety—— varieties of routes. Additionally, we’d like to see some additional weight reductions on both the vehicle to increase payloads, and achieve total parity with the diesel payloads, for these types of vehicles.

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And this was mentioned in an earlier workshop panel, but it's really hard to talk about hydrogen, especially in transportation right now without talking about the Hydrogen Hub Initiative announced by the DOE just recently. So, I think this is covered in an earlier panel, but the DOE just released Notice of

Intent to fund four more regional clean hydrogen hubs to incentivize the deployment of renewable hydrogen production and refueling infrastructure, and with some guaranteed offtake. And we -- we really see California being able to leverage strength in the transportation end uses and goods movement, specifically it could focus on deploying transit buses, rail coaches, and drayage and regional hub trucks such as this project.

We believe California is really best positioned of all of the states or regions in getting this funding, or meeting the economic self-sufficiency in a commercialized hydrogen market with the work that we've already done to date, far beyond any other states. We're -- we're very advanced in getting these projects. We have a lot of early document transit agencies, like I mentioned, AC Transit, OCTA in Orange County, and Sunline Transit Agencies, and the list goes on, of all these transit agencies. Meeting the ICT rollout plans and adopting this type of technology and looking to scale projects like NorCAL Zero to achieve a -- this self-sustaining, commercialized market, commercialized hydrogen economy.

And very importantly, I don't think we've talked about this, without discussing the need to reduce criteria pollutants, specifically from conventional fuels, especially in our disadvantaged communities. Scaling the benefits of the NorCAL Zero project to the entire West Oakland community, and bringing the port zero-emission, and deploying zero-emission technology in our Central Valley and the areas of Southern California located directly adjacent to highways causing high amounts of diesel particulate matter. These areas have historically been -- been really underserved and overlooked on the issues of air quality, and we have the chance, specifically here in California with this Hub Initiative, to advance these and really put these communities at the forefront.

Lastly, California has a really strong position for applying to this initiative, and we look forward to working with the governor's Go-BIZ office on successful application to the state.

And that concludes my remarks. Thank you.

MS. BERNER: Great. Thank you, PJ. We have one panelist left, and he's gonna bring us home. Michael Galvin, he is the Director of Waterfront and Commercial Real Estate at the Port of Los Angeles, the nation's leading container port. Michael also oversees the port's energy business and related terminals, which support regional refinery operations, LAX aviation, fuel logistics, the San Pedro Bay Bunker fuel market, and advancement into renewable fuels required to create the zero-emission port of the future. Mike, thank you for joining us.

MR. GALVIN: Thank you, Jane. Appreciate the time. So, we can jump into the first slide. So, getting into, you know, the enabling policy that the Port has put forward over the course of the last two decades through our Clean Air Action Plan that is a collaborative effort between the Ports of LA and Long Beach, two biggest ports in the country, local community organizations, environmental justice community, as well as local and statewide agencies, really intended to reduce emissions coming from the port.

Over the course of time, as technology advances -- and we're rapidly at that last stage now going from as low as we can get, using the diesel power plants that we have, to many of our moving vehicles and moving toward zero emissions. So, the focus in the next 12 and a half years is really to get to -- all terminal equipment zero emissions by 2030. That's right around the corner, and all on-road trucks to zero emissions by 2035, with the overall goal of reducing greenhouse gas emissions to 40 percent and -- and 80 percent respectively below 1990 levels by 2030 and 2050. So, we got a big task in front of us and we see hydrogen as a major player in getting us there in some of these hard to electrify areas of equipment and auto and trucks.

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So, we’ve made a lot of progress that, like I mentioned, we're hitting our goals, the 2023 goals, and DPM, NOx, Sox, greenhouse gases, is this next goal that we're really going after and -- and getting to zero emissions will -- will help us get there, and hydrogen will play a role there.

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And all of this continues to happen while the work continues to grow our volume, maintains its resiliency, and our ability to move forward in the overall marketplace, and then continue to provide goods -- the goods movement services that the nation depends on.

These are all areas that require decarbonization over time, but the areas that we're most focused on right now, as I mentioned, are the heavy duty trucks, and the cargo handling equipment. So, we have over 18,000 heavy duty trucks that are registered in the Ports of LA and Long Beach. They're doing work in and out of the port and almost 2,000 pieces of cargo handling equipment. On top of that we have locomotives and harbor craft that also make up some of the opportunities to further reduce our emissions here in the port. But, the real big focus in the next decade is -- is those heavy duty trucks and the cargo handling equipment that can build up a large part of the overall hydrogen demand here in Southern California.

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(Pause)

So, on the areas that we've been looking at, obviously, on-road trucks are -- are a big potential, and really trying to find both on on-road trucks and in the cargo handling equipment, the right transition equivalency there, for the truckers that move goods in and out of the ports every day, and to longshore labor that moves goods around the port, and onto ships, and off onto trucks and trains every day.

So, really important that in this transition for us to help -- to create a just environment and just economic outcome for our local communities who've been burdened with the goods movement business here. We -- we want to make sure that, that we have the ability to transition, to remain resilient in doing that.

And to do that, we really need to have equipment that acts the same way the equipment does today that is fueled by diesel. And so, we've seen that hydrogen can -- can be that equipment. We're just starting to test it on a -- on a much larger scale. But, we're not seeing the same sort of duty cycle and performance issues that we have seen on battery electric in various areas of, of cargo handling equipment.

So, we see a huge opportunity there and the ranges of on-road trucks really provide the opportunity to address what PJ mentioned, is that trucking companies don't want to need to be selective in what truck they put into a certain line of business on a -- on a specific day. They want trucks to be able to be put into any line of business they need to be, whether that's going 20 miles back and forth from the port to a rail yard, or 400 miles somewhere outside the state. So that is extremely important in getting fueling infrastructure to allow for those -- those trips to happen, are important as well.

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NREL did a study for the poot to get to that issue on the on-road trucks, really looking throughout the region and up and down, and outside the state to see what trips the trucks took in various areas, and the thicker the lines mean more trucks were taking those trips. So, you can see in the densified LA County area and the Inland Empire, you have a real densified utilization of trucks but you do have quite a bit of traffic that's going in and outside the area outside the state, you know, going past 200, 300, 400 miles. And so, you need to have a type of duty cycle that's going to allow those kind of trips to happen. And hydrogen provides that –– that opportunity without having to be selective on a daily basis.

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So, the port has participated in the ZANZEFF grant. We received about $41 million in, in grant money with the opportunity to advance both on road trucks and fueling stations to provide for the network that was required to allow these trucks to get tested between here and the Inland Empire.

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So, through that project grant, we have ten hydrogen fuel cell, Class 8 that are operating in and around the region, two heavy duty hydrogen fueling stations, one of which is operational, one of which is very close to being operational, in Wilmington and Ontario, so the two endpoints between here and the Inland Empire. There's also another station being built out on Port of Long Beach property right now.

And this is all done with a partnership between Toyota, Shell, Kenworth, UPS, South Coast AQMD, NREL, California Climate Investments, really an intention to bring all the pieces on a small -- on a small scale basis together, to allow us to test these trucks on a daily basis and see how they perform and we've had really good results so far.

Next slide.

This is a picture of the trucks going up Pikes Peak. And so, unlike other types of power plants that we're demonstrating in the zero emissions area, these did not have any issues with altitude change, and were able to perform, go up and down several times without showing any type of performance failure. And so that was really important to show that they could operate in different altitudes.

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So, the locations of the fueling stations, like I said, Wilmington, right next to the port, Long Beach, right next to the port, that's being developed right now, and then Ontario, out in the Inland Empire.

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You can see some pictures of Ontario, there. Up and operational, ready to go. Adding additional tracks there's -- there's LNG tracks here. There's also diesel tracks here, and then you have a couple of hydrogen tracks associated with this facility. So, showing how you can either put this into an existing truck stop or -- next slide -- utilize a stand-alone, as we do in the Wilmington, which has two lanes and the ability to provide the same capacity fueling.

Next slide.

So, right now where we are with the testing. 30,000 miles in service. We're having really good feedback coming back from drivers and operators. Typical issues that you would see in testing any new technology that are able to be resolved on a routine basis without the trucks going down for a prolonged period of time.

There's gonna be a test run to Hueneme, back and forth for August. Like I said, Ontario is fully operational at this time. Wilmington will be online this summer. And, we've had reliability issues at -- at the stations that are typical for putting up something new, but they're operating at about 50 percent capacity right now.

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Getting out of the cargo handling equipment. These are areas that are really, really difficult to electrify because the type of power consumption that you have in different cargo handling equipment, and really, the cycles. These vehicles run often, you know, 24 hours or 20 hours a day, and that-- there's limited time for refueling in between shifts. So, you really need to find a technology that is going to allow that to refuel similarly to how diesel does today, and hydrogen gets you pretty close to that. Fueling time is -- is maybe double of diesel, so maybe instead of 10 minutes, you're looking at 20 minutes to refuel. But, the ability, the range that it has after that is, is significantly similar to diesel. And so, from an operational perspective, from an ILWU perspective, it works the same way, it'll be easier to transition for this cargo handling equipment.

On the yard tractor demonstration, we're doing a -- one a-- two a tray pack right now. Phoenix Marine has tested some yard tractors and they'll be testing a top handler that the belief is if that top handler works the way they expect it to, that it's pretty much going to be applicable to all other potential cargo handling equipment areas.

YTI is also demonstrating a yard tractor and a top handler, and there'll be an RTG development deployment later on this year. And then the HyZET project that was already discussed previously in relationship to tugs and -- and getting into the marine side, which obviously the marine side of the business and the marine shipping side of the business is really the largest demand part out there.

And we're working very, very closely with our partners in the Port of Shanghai right now to create this green shipping corridor with a zero emissions shift in that quarter by 2030. That'll be the next step after we get the land-based issues addressed.

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(Pause)

So, looking forward, it's important to continue these demonstration projects and to continue to work with partners that we have. Toyota has been a really big partner of ours, being able to really advance technology and allow for different types of ideas, retrofit ideas, or retrofit operational equipment that can –– that –– where people can buy equipment now not worried about that they're going to need to get to zero emissions in 2030, because they'll be able to change at the power plant.

So that's really been important, and we'll continue to demonstrate that type of technology in the next year or two. Hopefully as we drill up towards the final application for the Hydrogen Hub that was discussed previously, and we think we can put a –– a very good application together, focusing on the ports in

Southern California, Northern California, and all the industries around both, to show that there's a significant amount of demand here that can match with supply within the state, or close to the state of California, to provide that long-lasting sustainable hydrogen economy.

So, we need to do the overall cost down, that was discussed previously. The hy-- H2Hub is extremely -- will be truly helpful in pushing this economy in the right direction, and then letting the private sector and other partners take over and -- and build it to scale. But, the most important thing is that we create this open ended market that can be built to a significant scale in between 100 thousand and 300 thousand metric tons, you know, in the next 10 to 15 years to really meet the market demand that we have, and the goals that we have to create a zero-emissions port here in Southern California.

And, I believe that is last slide. So, thank you very much for allowing us to present today.

MS. BERNER: Thank you, Mike. So now, I think we're gonna get into a discussion period. I'm gonna turn it over to Vice Chair Gunda to start us off with questions from the dais, but I also want to invite um, Amgad, PJ, Peter, and Mike to go back on camera so that we're already for taking questions. Thanks.

VICE CHAIR GUNDA: Thank you, Jane. That was —that was a wonderful set of presentations, you know, to Amgad, PJ, and Michael, for your respective organizations. Thank you for everything that you're doing in — in advancing the conversation around the fuel cell and hydrogen applications, and in the different MDHD, off-road, and marine applications.

So, a couple of questions that I want to start off with. But before that, just, Michael — I did have a chance to ride in one of the Kenworth-Toyota trucks this — two days ago, along with Chair Randolph. Really appreciated the ride. It was very quiet. And, the interesting thing that I learned about it was, it was just too Mirai stacks put together.

So, one of the conversations I had was the importance of the technology translation from light-duty vehicles to heavy-duty, versus the other way around, and how important it is to think about all scales at the same time. But, just wanted to call that out. I really appreciated that.

So, to all four of you, before I go to the question at the CEC team, congratulations on, on the different projects that were greenlit and the collaboration between the transportation division and the RDD and just creating a slew of both R&D and DND project. So, congratulations on the work. Really thrilled to hear about all that.

So, all -- all four of you could weigh in on this, just a 30,000 foot level question, you know. You know, looking at the deployment of the technology over the last decade, you know, hydrogen fuel cells. I mean, what are, what are the lessons learned? And now, are you all looking back and saying, you know, we've -- we've done as well as we thought we did? We thought we would want to do? You know, what went well? What didn't go well? And any, any learnings as we move forward.

(Pause)

Maybe I'll put my Michael on, on kind of --

MR. GALVIN: Sure. I'll jump in. You know, it's, been relatively new for us to, to get involved in, in the testing of, of the equipment. I think the bigger thing that I've learned from talking about issues with others as we deployed in the passenger vehicle area, was having resiliency in the supply chain of, of equipment that you don't really think about. And so, so that could be dispensing equipment, it could be technological equipment related to the fueling.

These are issues that became a big is-- became a big concern. All of a sudden when you, you built out stations, and then you found out that all of the dispensing equipment was built by the same manufacturer. And so, when there was a technological problem with one piece, the supply chain stopped at that point and you didn't have resiliency there.

And so, I think as much as, you know, I try to simplify it, as much as we can learn from the oil and gas business today, it's taken us a long time -- 150 years to deploy that business and make it extremely resilient, redundant connective. That's what we have to really strive towards in the hydrogen economy as well. And every single piece of the supply chain, from storage, distribution, into the region to distribution throughout the region, to the dispensing, it has to be redundant.

It has to be well connected. You gotta bring as many partners as possible to meet -- meet the need, because there's going to be pieces of it that fail. That fail in distribution, that fail in the end user, and you want to be able to make sure that that failure doesn't create a failure for the entire system, but it's just a small failure and you have other pieces built up. So, you have the resiliency and the redundancy to be successful long term. So that's something that I've learned in the last several months as we've been working through, through these issues.

(Pause)

VICE CHAIR GUNDA: Thank you. Anybody else want to weigh in?

MR. CHEN: Yes.

VICE CHAIR GUNDA: Great, Peter.

MR. CHEN: So, this is –– this is Peter. And I, I think there are definitely a lot of lessons learned. You know, from the CEC perspective, we've invested in, in light- duty stations. You know, we’re, we’re a leader in that, and we have 58 open retail stations. Jane, kind of presented on that earlier.

And, and definitely, I think, as we move into more heavy-duty station deployments, we –– we have understanding of, you know, what the kind of pain points are with the current light-duty stations. There, there aren’t –– there have been reliability issues, there's been supply chain issues.

So, when we think about scaling up, we definitely need to keep those in mind. And, you know, for one example, interesting lesson learned, I think, is kind the, the transition to more liquid hydrogen delivery pathways for larger capacity light-duty stations. I think that translates directly to how you might want to plan around heavy-duty stations that might need a lot more hydrogen on site than, than a typical likely one. So yeah, definitely I think there's a lot of things we can take from the light-duty station deployments.

MR. CALLAHAN: This is PJ with CT. I'd also like to chime in here with a couple additional points. I would definitely second what, what Mike was saying about the resilience in the supply chain. And, just kind of add to the conversation that hydrogen as the potential to be, you know, even more resilient than, you know, typical battery deployments based on the ability to still truck in hydrogen from other, other areas when there is a grid-down scenario. It's much harder to charge a battery electric vehicle when there's no power, but you can still continue to fuel by bringing in hydrogen from other areas. So, still an additional benefit there.

Just specific to, to Hyundai, and, and some lessons that we've learned there. You know, they've, they've been operating these vehicles, a very similar vehicle, different –– slightly different box-truck configuration, in the Swiss market. And they've obtained over 2.3 million miles with, with hardly any issues and, and really high uptime. So, they're operating very similar to their diesel trucks. And so, we're learning that with, with those deployments and they've got a payload they're able to pull -- hoping, you know, to, to basically mimic this deployment and expand on it in the American market.

So, these, these trucks really are technology ready. I mentioned technology readiness for the broad commercialization of, of the technology across the sectors, but these trucks themselves are really proving to be really technology ready. And, you know, Hyundai is, is working through being vertically integrated within their, their design. So, that helps to improve the overall design and performance and the benefits in, in terms of being able to modify the vehicles.

We really see that, that just one more point -- that there's not necessarily a one size fits all solution in a lot of these markets. What works for parcel delivery may or may not work for other, other applications. That's why we built two different types of vehicles with UPS. And so, it's a -- it's important to have a lot of communication with the OEMs that are, that are building the vehicles, building these demonstration programs, to really, you know, work through these issues and advance the technology.

(Pause)

VICE CHAIR GUNDA: Thank you. Amgad, did you want to weigh in?

DR. ELGOWAINY: Yeah. From an analysis point of view, we have seen two major things. One is the cost of the station, in the recent solicitation, has been dramatically lower than the previous one. The scale is bigger. So, we know there are big economies of scale. We know costs came down with its rapport or with fueling demand.

The other thing is like, I mentioned earlier, the, the liquid supply will be key, or a larger demand, fueling demand a ton a day or bigger. Liquid will play a key role there. And we have seen, like, almost half of the new stations now source liquid compared to a much higher percentage, compared to the previous ones. So, liquid will be key for low fueling costs. Especially with higher fueling daily demands.

VICE CHAIR GUNDA: Thank you. I have a couple of more questions, but I want to first go to Commissioner Monahan.

COMMISSIONER MONAHAN: Well, I have a really quick, simple question for Amgad, which is -- you had said that the liquefaction process is more greenhouse gas intensive. I didn't see on the -- on the slide exactly what that translates to. Can you give us some specificity on what that means in terms of greenhouse gas emissions?

DR. ELGOWAINY: Yes. Yes, so -- so liquefaction today is state of the art. You wouldn't get better today. State of the art is 10-kilowatt hour to liquefy a kilogram of hydrogen. So, we know our kilowatt hour, if you look at the US average grade today, it is about 440 grams per kilowatt hour times ten. This translates into 4.4 kilograms of CO2 per kilogram of hydrogen. If I use just the US average grade.

We know California is cleaner. Actually, California grade is less than half of the US carbon intensity so rather than 4.4 kilogram of CO2 penalty for liquefaction, it might be two, closer to two. Of course, this is where the state of the art, like ten-kilowatt hour per kilogram.

Some plants will liquefy at a higher, like, energy intensity. Maybe 12, maybe 15 kilowatt hours per kilogram. And then, you will see that energy intensity tie in, tie in the carbon intensity of the grades that really supplies the liquefier will bring, really, the carbon intensity of the liquid, I mean delivery, significantly higher than a gaseous pathway, for example.

So. there is some trade off there. This is why I say, you want low-cost electrons, but also you want low carbon electrons because if you increase the carbon intensity just simply by liquefying, it may hurt, really, the GHG credit you may get under the LCFS for example.

COMMISSIONER MONAHAN: Right. But over the long run as we decarbonize the grid, that –– that will go away or shrink?

DR. ELGOWAINY: Exactly.

COMMISSIONER MONAHAN: Thank you. And Mike and PJ, it was really great to hear about the projects. Mike, I had a question for you about how long the trucks have been operating –– the ten trucks –– how long have they been on the road? How long, how long has it been since they've acc–– you know, for accumulating the 30,000 miles?

MR. GALVIN: You know, I believe it's about a year that they've, that they've been out there operating. I think that is about the timeframe.

COMMISSIONER MONAHAN: Okay. And are the ZANZEFF and the NorCal projects, are –– are you talking to each other? Like, what's the relationship between the two projects?

MR. GALVIN: I think there's similar funding that, that was allocated in, in different ways generally. So, our people on the environmental management team here are, are definitely in coordination with others that are doing similar projects around the state. So, I'm, I'm imagining -- I'm not directly in contact, but I think that those teams are in contact.

COMMISSIONER MONAHAN: And PJ, I know that the, the NorCal trucks are not yet deployed. But, what's your -- what is your vision for how they intersect with the ZANZEFF project?

MR. CALLAHAN: That's, that’s a good question. Like Mike said, I'm not necessarily involved in a lot of communications that go on between, between ourselves and the ports. But you know, I just see the ability -- I saw recently the Volvo Lights Project, which you may be familiar with, down in Southern California, came out with a guidebook. And, and lessons learned from their key projects, and taking some of those lessons and applying them to our projects, and communicating and, you know, having these types of workshops where you can hear about their success and, and their challenges that we can then go and apply to our project since we are a little bit, you know, behind. Or are just, you know, our project is just coming on board a little bit later. It's, it’s useful to see these other projects, you know, take a little bit of a trailblazing approach and, and we can learn from a lot of those, a lot of those hiccups in their projects.

COMMISSIONER MONAHAN: Yeah, I mean, my understanding is that these are the only two major fuel cell Class 8 deployments in, in California. And so, they're, they're really -- they really are unique. Everything else has been on the transit bus side, which CTE has been deeply involved in. But this Class 8, big trucks -- beyond transit, these are the only two projects I'm aware of. Of the scale.

MR. CALLAHAN: Yeah. Yeah, and we do draw a lot on that kind of experience. A lot of the, the lessons learned in that fuel cell bus consortium that we, that we did with AC Transit and OCTA. Just the communication that required with the OEMs. I think it was mentioned earlier, but the gaseous delivery is one thing that we're learning as you look to scale these projects. Pre-cooling at the AC Transit Station was really necessary to achieve the fast fill times, and that was a lesson learned directly in the transit agency, that we're now applying with for some fuel and, and other industries, and as we expand into Class 8.

COMMISSIONER MONAHAN: Well, I'm really looking forward to the deployment in NorCal, because I did get to ride in the Hyundai ones here, and I thought they were out, and then I was very disappointed to learn that they were actually just prototypes and they weren't yet on the road. So, looking forward to seeing them.

And I'll pass it over. Fritz?

(Pause)

MR. FOO: Hey everyone, thanks -- thanks for the good presentations. Just had one question. Do you offer, especially for those with projects -- have renewable hydrogen procurement criteria, or any kind of target, and if so, how do you all account for that? And if you don't, you know, maybe is there any thought as to what that might be?

I think I was looking at the slides and I want to say that there was one renewable hydrogen target, maybe around 30, 40 percent. But, I would love any clarification on that?

MR. GALVIN: So, I can speak for -- in Los Angeles, by direction from our city council, and, and our own policies, that we want to hit a full green hydrogen which based on 100 percent renewables. How we get there as a question, because that's not going to be available at scale in the timeframe that we're going to be starting to deploy the new cargo handling equipment and, and on road trucks.

And so, we're going to have to understand the market's going to provide what the market's going to provide in the meantime to allow us to build the demand by deploying these, these vehicles. But the goal is, is in -- what we're doing through the Hydrogen Hub application in Southern California, is focused on renewable hydrogen 100 percent. And, and that aligns with what we see our power grid system getting to in Los Angeles by 2035, which is 100 percent renewable by that timeframe.

So, so, we're focused on building out a hub that is going to provide the same type of resilient renewables, but through hydrogen in that same zone. And -- are there some issues there? And you know, it would be helpful if, if state legislation lined up with that as well, and regulated the hydrogen business and market the same way that the grid is regulated, and then you would have some consistency there to, to drive some of these other issues regarding naysayers that, that talk about -- the grid is going to be renewable by this timeframe, hydrogen, we don't know.

And so, those are some issues that, that we, we manage on a local level, to try to unders-- explain to people what our goals are and what our objectives are, as far as proliferation of the fuel as 100 percent renewable. But there would be some assistance there on the state level if we get to that point. And I'm sure we will, as time goes by, you know, we're at a very nascent state now, but I think we can get there. And then, we'll have two energy systems that, that are basically held up to similar standards.

(Pause)

VICE CHAIR GUNDA: Great. Just a couple of questions, high level here. So, the first one is, and especially Michael, you had kind of talked about, you know, the, the opportunity for, you know, community benefits in terms of, you know, aid quality and such. I think PJ, you also mentioned. Has there been active engagement with the community in, in kind of, showcasing giving tours, explaining this opportunity? If you can share that, that would be great.

MR. GALVIN: It's a step that we're getting ready to, to get into next. So, through our interaction plan, we have quarterly meetings with 200 to 300 stakeholders, depending on who participates on a given quarter. And there are community members embedded within that as well. And so, as we're getting our Hub application team together here in Southern California, that is a step that's right in front of us, is to start talking about hydrogen, the huge environmental effects that it's going to have on local communities with the ability to take all the emissions out of the air that currently exist from those land-based operations.

And then layer that on with the economic benefits that we want to be able to pump back into these communities. So, we're just going to start that process. A - education on hydrogen and why it's important and why it's going to get us there faster, and in a way that make the ports continue to be resilient as, as they are today. And two, what are the other benefits that are going to come from that? And we really think that that's why it's so important that we, we keep this money as much as possible from the DOE in California to benefit Californians, so that they're the ones that are receiving the benefits, because they're the ones that endured the burden all those –– all this time.

So, I think that that will be the messaging that we put forward in our application. But getting these groups, it's a conversation that's just starting to happen in regard to how we're going to do that. But that's going to happen the next 30 days for sure in regard to the Hub application.

MR. CALLAHAN: Thanks, tanks for that, Mike. It's definitely something that's on our radar, and I'm really glad you asked the question. Just last week we hosted -- we were participants in an event at the East Bay Bridge yard underneath port in the East Bay Develop-- Economic Development Association. A block party event bringing together members all over the community in different, different, working through different nonprofits and air quality issues, and showcase the trucks. And there was a lot of interest generated from a lot of different community members, just kind of demonstrating how important this technology is going to be for these, these community members.

We also hosted, just today, down at the maintenance facility, in San Leandro, a sort of show event with the, the service provider NorCal KW, to further engagement on the servicing side. And we're working with West Oakland Environmental Indicators Project, as I mentioned, to start drafting the community outreach plan to see what exactly this is going to look like.

So, I think this is another opportunity for us to, kind of, take some lessons learned from the ZANZEFF projects in terms of how they approached community outreach as we look to develop our own plans. But it's certainly a really important issue, and I don't think one that can be talked about enough when we're talking about a zero emission technology and, and reducing the,

the diesel particulate in these communities located next to highways that have just been historically so overlooked.

VICE CHAIR GUNDA: Thank you. Just a, you know, one last thought and I will pass it back to Heather for the next section here. So first of all, and again, congratulations to each one of you and, you know, thanks for all the great work that you're all doing in, in advancing the clean future for California.

So, one of the things I mentioned, you know, in my opening, kind of, comments was -- one of the hopes we have for this workshop is to have some tangible recommendations on how we continue to advance the hydrogen conversation. So, I don't know how prepared each one of you are to, to speak to that but, you know, if there is one or, you know, maybe two things that we could solve and what would your recommendations be?

(Pause)

MR. GALVIN: My, my main one is what I mentioned already, and aligning regulation of the hydrogen markets and electric grid, I think would help to clarify a lot, a lot of the issues related to concern from, from different organizations about the proliferation of hydrogen. So that there has been a debate going back and forth that, well, we know when the grid is going to be green. We don't know when the hydrogen is going to be green. And so, we can make that our policy, we can make that our plan here. But if it's not backed by the state and rules, then we're not as -- on as solid ground as we can be. And so, I think that is very critical in, in moving forward in the next couple of years.

(Pause)

VICE CHAIR GUNDA: PJ, do you have anything to add?

MR. CALLAHAN: Yeah, definitely. Our, our key takeaway would just be that we really need to continue to ramp up and scale our deployments like I mentioned. This is one project, you know, it will be the largest to date of 30 trucks. But that's, that's really not going to do it. We need to continue to advance and, and really deploy at, at large scale, and that's why this H@ Hub program is -- the timing is, is perfectly aligning with projects like this. And, it's really going to help be, be -- it's going to be critical to proving the technology and, and driving down the cost of deploying not just 30 trucks at the Port of Oakland, but 100, 1,000 trucks at the Port of Oakland, ports of LA, Long Beach, 1,000 buses all across the state. And, and reaching that scale on, on the vehicle and off-take side which will drive the production and, and the business case for that as well.

MR. GALVIN: And, if I can just add to that, more grant money is always helpful, because that can continue to allow us to drive the marketplace that PJ was talking about. The faster we can get the equipment and the trucks deployed, and into commercial availability, and get the cost down, the better we'll be all around. Right now, the Delta is, is very large, and so taking a lot of potential money, when you look at the Delta between diesel and hydrogen, then you—— the Delta between electric and —— battery electric and hydrogen. So, more money will allow for us to deploy more, test more, and get a—— adapted to the marketplace quicker, and to commercial reliab—— availability as soon as possible.

VICE CHAIR GUNDA: Wonderful. Amgad, did you want to add anything, or?

DR. ELGOWAINY: Yeah. If I may add, so back to to my presentation. I think you want to focus on the vocations or classes where you get the best bang for the buck, your environmental benefits. And these are where your duty cycle will allow you a higher efficiency compared to the diesel incumbent.

This will help you economically it will help you with carbon reduction. And the why it is that way is because most of these, like, locations where you're high -- you have high fuel economy ratio, are mostly urban. It will help also with the air pollution issue, and the impact on communities.

The second thing is also, plan to think about how to expand the liquid hydrogen supply network. And this will be also key to enabling a low-cost hydrogen fueling.

VICE CHAIR GUNDA: Wonderful, Peter, do you want to close this off?

MR. CHEN: Yeah. A little -- I'm preaching to a choir here. But yeah, I definitely see a role of, you know, continuing doing this government supported pre-competitive R&D and demonstration projects. I think we’ve, we've heard it here already. But, it can be really important to de-risk issues and kind of the mysteries of using hydrogen as a transportation fuel, you know, before letting private industry take over and really develop a self-sustaining market.

You know, we have existing programs in place. You know, we have EPIC, Gas R&D, Clean Transportation Program, and a lot of mechanisms to, you know, support both established companies and also startups, entrepreneurs, with innovative ideas on how to how, how to use hydrogen efficiently as we, you know, look to decarbonize the police, very challenging end uses.

You know, I think another key thing to think, that I'm always thinking about is, how do we refuel, you know, larg–– larger pieces of equipment. You know, we're talking about a lot of land uses now. You know, heavy duty trucks, cargo handling equipment, et cetera. They store an order of magnitude more hydrogen onboard than, than a light duty car. And if our, you know, infrastructure –– our –– I think our infrastructure needs to be developed with that scale in mind. And there, there's definitely room for more research into that space, as we scale up.

(Pause)

VICE CHAIR GUNDA: Thank you. Thank you all so much for taking those questions. I said to Heather, do you want to

MS. RAITT: Sure, thank you. So, yeah, and I checked with Jane, I think we're ready to move on to –– we got a couple of questions from attendees and Tomas Ortiz is here to moderate those. So go ahead, Tomas.

(Pause)

MR. ORTIZ: Thanks, everyone. So, we have, currently we have two questions. So, I'll start with the first one. The first one is from Robert Perry, of Synergistic Solutions.

(Pause)

One second, sorry.

(Pause)

So, the first question is: “Are there currently plans to co-locate large MDHP –– HD EV charging and refueling stations with utility scale generation storage and electrolysis capacity along major transit corridors, such as I-5, 101 and 99. It would seem that productive planning in this area would incentivize private investment in long-haul, MDHD FCEVs. These facilities don't have to start large, but should be designed with enough room to expand according to need.”

MS. BERNER: And this is Jane. I was actually thinking this is probably a question, I'll say, for the CEC in terms of plans for funding. And, I just was gonna add that we did recently have a workshop related to several concepts. Both EV charging, and hydrogen refueling stations for MDHD uses, including some for long-haul trucks. I’ll –– if –– I'll try to find that link and put it in the chat to that workshop. That might be of interest to you. And thanks for the idea of also including utility scale generation storage and electrolysis. I think the, you know, where the hydrogen supply, and if there can be grid benefits is something that, yeah, we will be looking at more closely when we develop these solicitations. So, thank you

MR. ORTIZ: Okay, and then thank you for that. We have one more. This one is John Banner. Question for Peter Chan: “We're developing a greenfield MDHD green H2 refueling/fast recharging truck stop on I-10 in in Riverside County. Our R&D funds available through your advanced H2, H2 refueling infrastructure solutions for heavy transport, develop and demonstrate innovative H2 refueling solic–– solutions, funding lane to assist with preliminary design, F-E-E-D, et cetera?

MR. CHAN: Thanks for that question, John. So unfortunately, I can't speak to the details on, you know, what's eligible for the solicitation since it's still being developed and we haven't released it yet. But you know, I, I think generally speaking, you know, this type of projects, building out, you know, a green hydrogen shared refueling, recharging truck stop, I think that's a really important type of project. And definitely, I think the workshop that Jane highlighted, or mentioned, I think it does include a concept that, that's similar to, to what you're talking about here. And Jane, maybe you can add more details or correct me if I’m wrong.

(Pause)

MS. BERNER: I was just –– I'll think Esther for adding in the link to the workshop where the information is. I was just supposed to do it and to beat me to it. And so, Esther is one of our staff that did a lot of work on that workshoo-- workshop.

(Pause)

MS. RAITT: Alright, so I think that's all the questions. So, thank you so much Tomas and to Jane for moderating, and to the panelists, Amgad, and Peter and PJ and Michael, greatly appreciate your time and expertise.

So, we will move on to the next panel on emerging projects and opportunities for hydrogen in economy-wide decarbonization. And, we're joined again by Rizaldo Aldas from the Energy Commission.

MR. ALDAS: Thank you, Heather, and good afternoon, everyone. We are in panel four, welcome. This is the last but certainly not the least panel of the day. We have five panelists or speakers to discuss emerging projects and opportunities for hydrogen in economy-wide decarbonization. Our panelists will talk about different projects, perspectives and of course on renewable hydrogen, particularly hydrogen production.

And we have to get insights from them on what worked, what didn't work. What else are needed? Is regulatory, policy, incentives, technology, is all of the above? Increased renewable hydrogen production and the contribution towards a decarbonized economy. And then, of course, this morning, we heard about concepts of green hydrogen. So, that's a question related to the economy. And that -- the question for me there would be what -- which could or would help us to get a carbon neutral? Is it the color scheme? Focus on the process? Or carbon intensity? And so, I think we will also hear some insights or feedback on those kinds of questions.

And without further ado, I will ask Sara Gersen, Senior Attorney with Earthjustice to kick us off in the presentation and discussion.

MS. GERSEN: Well, thanks so much, and good afternoon. My remarks today address why it is essential for California policymakers to focus on promoting zero emission technologies for producing hydrogen. But for a much broader look at hydrogen policy questions, you can download the report I co-authored with Sasan Saadat, it's available at the website at the bottom of the slide. It's called "Reclaiming Hydrogen for a Renewable Future: Distinguishing Oil and Gas Industry Spin From Zero Emission Solutions.

Next slide.

Now, to understand why a transition to zero emission hydrogen matters, it helps to understand how hydrogen is produced today. Each year, globally, industry produces many millions of megatons of hydrogen from fossil fuels through processes that are so building, that hydrogen production alone contributes more climate pollution than the entire nation of Germany.

Here in California, the predominant method of producing hydrogen is to crack it off of fossil gas through a process called steam methane reformation. Steam methane reformation doesn't just emit climate pollution, but also significant amounts of coal forming pollution, like NOx, particulate matter and carbon monoxide. And, because California’s hydrogen production facilities primarily they exist to supply oil refineries with the hydrogen that they use. The hydrogen production facilities are polluting the same fence line communities that bear the brunt of refinery pollution.

Next slide.

Fortunately, there is a zero emission, hydrogen production techn–– technology that is well understood and ready to scale. That is renewable electrolytic hydrogen, also known as green hydrogen, which is produced using 100 percent renewable electricity to split hydrogen from water molecules. Exclusively relying on renewable electrolytic hydrogen would both protect public health and avoid the gamesmanship and inaccurate carbon accounting that can plague productive pathways that rely on biofuels.

If go to the next slide I have an example to illustrate this.

So, this slide summarizes key data from two actual hydrogen production pathways that CARB has certified to produce LCFS products. On the left, you have a real production pathway that uses steam methane reformation of fossil gas at a facility in Wilmington California, which is a disadvantaged community overburdened with refinery pollution.

The producer pairs the fossil gas in takes from the gas pipeline with the environmental attributes of cattle manure gas in Indiana, and CARB certified this pathway to claim that is hydrogen as a carbon intensity of negative 287 grams of carbon dioxide equivalent per megajoule. Now, compare that the production pathway on the right, which uses zero emission electrolysis powered by solar resources. CARB certified this pathway to claim that this pathway a carbon intensity of zero carbon –– zero grams of carbon dioxide equivalent per megajoule.

This comparison is very troubling, because the pathway on the left, which relies on a polluting technology that is already standard and lowest cost, represents a far more lucrative LCFS credit generation opportunity than the zero-emission technology that's still nascent in the market.

You may have the rare entity that chooses the zero-emission technology because it has a public interest mission. Here, the example on the right is a production pathway that was submitted by Alameda County Transit. But any profit maximizing company will have a strong incentive to maximize LCFS revenue by simply following business as usual, producing hydrogen from fossil fuels, and relying on a crediting scheme to claim that their hydrogen is carbon negative. And this does nothing to catalyze the market for zero-emission hydrogen.

Next slide.

So here, this slide presents a few ideas for catalyzing the market for zero-emission or green hydrogen. The first priority should be displacing the hydrogen that's already in use to supply chemical feedstocks to businesses like refineries, with the zero-emission hydrogen. And addressing that public health and carbon pollution imperative that I discussed earlier in my talk. I understand that mandating this transition maybe outside of the CEC’s jurisdiction. But, you can certainly note in the IEPR report, that it will be much easier for new applications that run on hydrogen to access zero emission of hydrogen if facilities like refineries stimulate demand.

Second, whatever the CEC and other public entities are using taxpayer funds to support the hydrogen project, they should never spend those scarce taxpayer resources on polluting hydrogen production processes. And finally, CARB should implement SB 1505. Back in 2006, the legislature order CARB to conduct a rulemaking to require a third of the hydrogen dispensed from publicly funded fueling stations to be produced from renewable electric resources.

It's been more than 15 years and CARB has failed to implement this mandate. But, to fill this gap, and CEC can and should include grant conditions whenever it funds fueling stations and other projects, that require the grant recipient to dispense or use renewable electrolytic hydrogen.

Next slide.

In closing, I want to urge all of you to never let questions about scaling up as to zero-emission hydrogen overshadow the real questions that should be driving policy debates. Which are first, how do we confront California’s air pollution crisis? And second, how we decarbonize the economy?

Because hydrogen is not going to be the best tool for most sectors, and California needs to focus relentlessly on deploying the zero-emission solutions that are ready to scale today, without waiting for the market for zero-emission type project to mature.

Thank you.

MR. ALDAS: Thank you Sara, appreciate your -- sharing your ideas for catalyzing markets transitioning to zero-emission hydrogen, and, uh, different other ideas. With that, we'll call on Brenor Brophy, he is Vice President of Project Development of Plug Power, to invite his presentation. Thank you.

MR. BROPHY: Thanks very much. And thank you to the Energy Commission for inviting us to present today. We appreciate the opportunity to tell you about our California Green Hydrogen Project.

Next slide please.

So, plug power has been in the hydrogen business for more than 25 years. We pioneered the first viable economic market for fuel cells in the logistics sector powering forklift trucks, and that's enabled us to sell more fuel cells to sell -- to accumulate more operation hours than literally anybody else in the world.

We purchase more merchant liquid hydrogen and deliver more hydrogen than any other single entity in the world, over about 40 tons today, and we operate well in excess of 165 refueling stations behind the fence across the entire United States. Plug Power has the entire supply chain for hydrogen. We make the fuel cells for the applications, everything from forklift trucks to Class 8 trucks, we make electrolyzers to produce hydrogen. My responsibility is building hydrogen production plants. We make the equipment for the liquefaction of hydrogen and use that equipment in our own plants. We make the transportation and storage for liquid hydrogen, and we operate a logistics network across the entire country delivering liquid hydrogen to our customers.

Next slide please. So, Plug's footprint is pretty large. This is a -- it's even an outdated map at this point. But we have customer locations across the entire United States. Our, you know, top tier customers or our folks like Amazon, Walmart, Home Depot, Lowe's, GM, Kroger. We, we estimated during the pandemic about 30 percent of all groceries consumed in the US were transported on a Plug forklift at some point during their transport to market. So, Plug is deeply embedded in material handling logistics space, and deeply embedded in the supply of hydrogen.

Next page.

So about two years ago, we decided that we could make our own green hydrogen far cheaper than we could buy gray hydrogen, which is what we're forced to buy today. When anyone says green hydrogen costs $2 a kilo, you cannot go buy gray hydrogen for that. It costs a lot more than that, and believe me, it's considerably cheaper for us to make our own green hydrogen than it is to buy from the industrial gas companies.

So, we announced a network of 500 tons per day of liquid green hydrogen production by 2025. We have announced plants in New York, Georgia, in Texas and of course California. I'm happy to say we have already got an operating plant in Charleston, Tennessee, 10 tons per day. And Plug is the only company, other than one of the industrial gas companies, to build and operate and own their own hydrogen liquefaction facility.

The New York and Georgia facilities are under construction as we speak. The first production in Georgia is expected to start within the next four weeks. That's a two ton per day facility, just a small facility. But Georgia New York will be online by this time next year. New York is 45 tons per day and Georgia is initially 15 tons per day, and those plants will go to 75 and 45 tons per day respectively in a phase two. The Texas plant and plant in Louisiana, we will break ground on this year and start construction. And our California project, I'm going to get to –– it holds a couple of slides of its own. So, I'll, I'll hold for that.

The idea here is a national high resilience network of liquid hydrogen supply. We know better than anyone how the existing supply chain for hydrogen looks. We deal with it every single day and we understand that high resiliency in the supply is, is critical. The other important point here is 500 tons per day is two and a half times the current size of the liquid hydrogen –– the entire liquid hydrogen market in North America today.

We're obviously building ahead of demand, but we're doing that to plant a really large flag on the top of a really big mountain to indicate to first adopters that you can go with hydrogen for your transit buses, for your truck fleet, and the fuel supply will be there and that's absolutely intentional. Give a clear signal that you don't need to worry about the supply of hydrogen going forward.

Next slide please.

So, just really briefly, what is green hydrogen? Why do we call a hydrogen farm? Our California project is sunshine and recycled water. So, we're just taking water and sunshine like any farmer, we're processing it, we're getting -- we're liquefying it, and then it's going towards the logistics space, which is our core market, and the heavy-duty freight space. So, it is sunshine, water, for clean fuel.

Next slide please.

This is the location of our project in California. So, it is in West Fresno County. It's just eight miles south of the city of Mendota, the cantaloupe capital of the world. This part of the Central Valley is one of the most economically disadvantaged areas in our state. It is one of the areas that is mo-- disproportionately affected by diesel pollution.

It's -- gets none of the economic benefits of that pollution, it just gets to sit next to Interstate five and, and Highway 99 and enjoy the pollution without any of the jobs that come with that. So, I think it is particularly apt that it's this community that's going to participate in the economic advantages of starting to produce a replacement fuel for, for diesel. The facility itself is over 2,000 acres, and -- of, of a solar farm, new-build solar. And, the hydrogen facility is just a small, a small postage stamp within that larger solar farm.

Next slide please.

So, the rendering there is actually of our Georgia plant. I don't have a nice rendering of the California plant yet. But, clearly wouldn't have green grass and trees like that. The plant we're building is 30,000 kilograms, or 30 metric tons of liquid hydrogen. That's 120 megawatts of PEM electrolyzers. That puts it in the top tier of electrolyzer -- PEM electrolysis plants in the, in the world. That's the same size as our phase one in New York.

And I'm delighted to say this will be California's first new build hydrogen liquefaction plant in 36 years. I had to go back in history, and I think Air Product’s plant in Sacramento came on board in 1986. So this is finally another new liquefaction plant. And that'll take California's liquefaction capacity from about 40 tons a day to over 70 tons a day. So, we're delighted. We are strong believers to, to -- in liquid hydrogen as, as an excellent method of storage and delivery of, of hydrogen.

This is 2,000 acres of what's called priority least conflict, excuse the typo, least conflict plan. So, this is land that is withdrawn from irrigated agriculture. It was in fact, damaged by over irrigation over the previous decades, and its land that was studied for all conflicting uses and prioritized for renewable energy development. So, it is one of the best places within the state where we can build on extremely degraded land and put it to a use that will generate jobs, and economic development, and clean fuel for the state.

It is a 300-megawatt AC solar farm that is a new build solar farm as part of the project. The hydrogen production plant itself is about 30 acres in one corner of that. It will have storage for half a million gallons of liquid hydrogen, that's about 134 metric tons, or, you know, call that four, or five days of production. And that goes to the high resiliency aspect. All of our plants have significant on-site storage of fuel, so if a plant goes down, it can cover its customers in the short term, and then neighboring plants can cover it in a longer-term shutdown scenario.

This plant is 100 percent green. So, on an annualized energy basis. So, that means every megawatt hour that we use for synthesizing the hydrogen, for liquefying the hydrogen, and we talked about that earlier -- liquefaction takes about 10 kilowatt hours per kilogram, and also transport, because we will deliver this hydrogen on fuel cell Class 8 trucks to, to –– that we can't think of something dumber than a replacement for diesel being hauled by a diesel truck. So, we won't do that. We'll be an early and enthusiastic adopter of fuel cell trucks.

So, all of the energy that we need for, to all the way to, to delivery will be solar energy, solar based. We're currently in the environmental impact review, California CEQA process. That is anticipated to complete in August of 2023. After that, we've got construction permits, and we would hope to start construction in late '23 with a, a opening in early '24. So, a little over a year of construction. So, we are far advanced in, in this process. Apparently, also involved with the large load studies and electrical interconnect studies with PG&E.

Water is always a concern in the West. We say whiskey's for drinking, water's for fighting over. So, a good rule of thumb is for US gallons of water per kilogram of hydrogen. And I would just like to reiterate what several other speakers have said, that existing fuels –– diesel, gasoline, and even natural gas, use between four and seven or eight gallons of water for the equivalent energy content that hydrogen produces.

So, at four gallons a kilogram, we're actually at least no worse and probably better than the equivalent fossil fuel that we replace. Water is still a concern though, and this project is funding a new 1.2 million gallons per day, so about ten times what we need, tertiary water treatment plan for the city of Mendota. So, the city does not have a recycled water plant currently. In fact, it has a significant issue with disposing of its waste effluent. So, this solves the problem for the city.

We will build it for the city, pay for it, and then we will deed it to the city, so the city owns the plant. The project pays full commercial rates for the water, because we want to make sure the city has an income stream to enable them to operate and maintain the plant, and then whatever they want to do with the other 90 percent of the water, be it irrigating their school playing grounds, street trees parkland, they have that water to do as they wish.

We do not use water for cooling. It's dry cooling only, which is a significant savings on water, and there's zero offsite waste discharge. So, we have thought, not just about how do we make really clean fuel with 100 percent clean energy, but how do we absolutely minimize our environmental footprint of the plant. And we think that this is a model for the energy transition, right? This is, this is the oil field of the 21st century. It emits no pollutants, and it only uses green energy, it runs on sunshine. With that I'll conclude my presentation.

Thank you.

MR. ALDAS: Thank you, Bill, and thank you for sharing the extent of Plug Power’s activities nationwide. The network of 500 tons per day of liquid hydrogen, more importantly for me, I'm really excited to hear about your plans and update for the hydrogen, green hydrogen plant in Fresno County. Those attributes are -- really looking forward to see that built and operated. And with that, let me call on Dave Edwards, Director and Advocate for Hydrogen Energy with Air Liquide, to provide his presentation. Dave, take it away please.

MR. EDWARDS: Thank you very much. I look forward to, to engaging with the CEC and with the public on these interesting topics. It's always, it's always kind of nice to go last. We get to show the examples of how the real world is responding to all the opportunities that are out there. I think Brenor did a good job of showing the electrolytic side of things. I'm going to show you some other examples of things we're doing at Air Liquide. And I think together, they represent what the industry as a whole is transitioning toward in, in this new market.

If you can go to the next slide.

I think everybody is probably familiar with Air Liquide, we’re a large industrial gas company that's been around for about 100 years. Hydrogen, just one of many of our products, and traditionally as an industrial project. And now, as we think about it in these new energy applications.

Let's go to the next slide.

For us, hydrogen isn't anything new. We've been in this market for more than 50 years. We think about that in terms of the variety of production methods, the variety of supply chain, and the variety of uses for the hydrogen. And all three of those are changing as we think about this new energy market that we're entering into. Production is shifting toward renewable and low carbon, supply chain is shifting toward fuel markets more so than gas supply markets, for example. And, the customer is very much shifting toward the energy applications more so than a traditional refinery and ammonia off takers, for example.

Let's go to the next slide.

What I really want to do is, is talk about two projects that Air Liquide has not. And not because they're specifically for California, but because they're representative of the kind of production facilities and that kind of challenges that we're faced with in the market as we think about these new markets. So, the first one is our new plant that's in North Las Vegas, Nevada. It came online earlier this year. Our grand opening was about a month ago and we're now in full production, supplying California and other -- other regions of the West with low carbon, liquid hydrogen.

This was an investment of about $250 million. It's about 30 tons per day of production. And you'll hear the 30 tons per day tied to liquefiers commonly, because that's the typical industry large size liquefier. There are plans by ourselves and others to make that larger production facilities, or to have multiple liquefiers at single sites to go beyond 30. But 30 is going to be a typical scale for the largest liquefiers that you see in the US or anywhere else in the world for that matter.

An important characteristic of this project is how quickly it could come online. We began construction in 2020. We began planning just a few years before that, and operation and delivery, obviously now in 2022. So, a very short timeline from initialization through to production.

The second project I'd like to talk about is not servicing California, but it's servicing the East Coast of the United States and Canada. And it's located in Becancour, Quebec. It's about a $40 million investment for us. A 20-megawatt PEM electrolyzer, which produces about eight tons per day of hydrogen. There's a liquefier on site that also had to be expanded for this specific application. This project began in 2019 and operations and delivery started last year.

So, this has been in operation now for, for a calendar year or so, and we produced quite a bit of liquid hydrogen for these new energy markets. Because it's in Quebec, the electricity used for the electrolysis is almost entirely hydro powered, and therefore a extremely low carbon grid that we're tied into.

These are representative of the kinds of scales and the kinds of project investments that are going to be needed by our company and by others in the industry. But, let me talk about some of the challenges that we're faced with.

If we go to the next slide.

Just to show that it's a real project, I actually have a picture of it, although the sphere is now painted white and has Air Liquide painted on the side. If you go out of Las Vegas to the northwest, you'll see, you'll see our facility there in operation and you'll see our trucks on the highway, leading to a number of locations in California and otherwise.

This plant is tied into both the electric grid and the natural gas grid. We then use renewable natural gas and environmental attributes in order to reduce our carbon intensity for the feedstocks. And, our electricity is essentially through the purchase of entirely renewable zero carbon wind and solar credits within the state of Nevada, for example.

That allows us to produce low carbon hydrogen, and allows us to be flexible with how our feedstocks are managed and what our customers are demanding from, from transportation fuels and other applications in the region.

If we go to the next slide.

This is an overall picture of the Becancour site. So, while the previous facility, the North Las Vegas facility is a single production facility, this one actually is multiple production facilities in one. And the reason I want to show it, is because it's a microcosm of what the future of hydrogen looks like. This facility has a steam methane reformer, it's actually in the top left of this picture. It has the new electrolyzer, which is in the blue building at the very bottom, which looks like a warehousing building, but you can see it's tied right to the grid there for example. It also has a waste hydrogen source coming from a chlor-alkali plant, shown in the top right of this picture, where we take a waste hydrogen stream that's impure, we purify it to pipeline spec, and then can liquefy it or put it into our local pipeline.

From a supply perspective, we have liquid -- you can see the small sphere that's located at the site, and a liquefier on site. We have a pipeline that goes to local industry uses, and then we have trucking. You can see, kind of in the middle of that picture, there are some trucks loading liquid and gaseous hydrogen.

And so, the reason I think this is an important picture, is because it shows the flexibility of hydrogen. We're using multiple feedstocks -- renewable natural gas, fossil based natural gas, renewable electricity, and a waste feedstock from industry, all as our feedstocks. We have three different production processes, actually four different processes, including purification, liquefaction, electrolysis, and reforming. And then we have three different distribution modes. We have on-truck, we have by pipeline and we have by liquid, and on-truck can be both liquid and gas.

So, if you look at all of those different combinations of hydrogen, it really represents the flexibility that hydrogen brings to a region. By being flexible with how it's produced, how feedstocks are managed, and how you're supplying the local industries. It's really a representative of what, potentially for example, a hydrogen hub might look like in different regions of the country.

In California that, that availability of feedstocks might be different than it is in Becancour, might be different than it is in Texas, might be different than it is in the state of Washington or other regions. But I think we're always going to find the need for this flexible production and flexible use of hydrogen. And that's why this is an interesting project to show, even though it isn't directly feeding into California. It can be representative of the future.

Let's go to the next slide.

One of the things that I was asked was to discuss the challenges of using biogas, and the, the cost of purchasing environmental attributes for biogas is one aspect of the challenges. In particular, since there's no RFS approved pathways for hydrogen, even though we're eligible for pathways, without those approvals, we can generate RFS credits. And as a result when we buy EAs, we buy them at the market value, which includes the LCFS and the RFS values for CNG applications, and so we end up at a disadvantage and pay a premium.

If the federal EPA passes the RFS pathways, this will actually reverse, because hydrogen will then become the most valuable place to be putting biogas. And so, that's an anticipated change in the market that we would -- could look forward to, potentially in the coming years if the current administration approves those pathways, for example.

Another challenge is the availability of EAs, the supply is limited today. The Nevada plant that I showed requires essentially the -- all of the renewable biogas from two large landfills, or from 20 dairy digesters. So, a fairly significant impact on us. And when we purchased those EAs, it has to be done in large quantities, and they come with expiration dates where you either use them or lose them.

Our customers in California are demanding zero CI, because that's what allows them to maximize HRI credits in their light duty stations, for example. And therefore, it's a combination of landfill gas and digester gas that allows us to blend it to a zero CI delivery, for example. And therefore, we have to be creative with how we purchase and how we manage those EA credit systems.

The second -- the, the next challenge is something that I think people don't really think about upfront, and that is that the value of those credits gets shared and p-- along the entire supply chain. That the LCFS and RFS credit value doesn't get passed directly to the customer, because there's also the site operator, the gas producer, the pipeline operator, the credit traders, the hydrogen producers, and the station operators in that, in that credit value chain looking for value.

So, go to my next, my next and last slide.

One more challenge for biogas is the limited impact of EAs. We know that the LCFS program, for example, doesn't allow for process energy to be considered. Only feedstocks can be considered in the carbon reduction using EAs. This is actually a penalty, not just for the use of RNG, but it's also a penalty for the use of renewable electricity and reducing carbon intensity, in that we have to use grid average, even if we're using renewable credits like we are in, in Nevada, for example. And, and so, for the -- a natural gas reactor, the heating, the compression, the liquefaction all of those are not credited with the process energy.

And the last thing I would say is, another challenge and this one isn't a CEC challenge as much as it is a challenge just for the industry as a whole. The CARB pathways can be very complex. If you think back to that Becancour plant, for example. If we were to establish CARB pathways, LCFS pathways, for each one of those combinations of the supply chain, there could be dozens of pathways needed for a single site.

Because of the combinations of feedstocks and energy usage, because of the multiple supply schemes, we result in these multi-- multiples occasion of pathways. In addition, pathways are determined by and require plant operating data.

Essentially, you can't generate credits until your performance is established by 90 days of operation. And as we've found in Nevada, and with any large plant, startups can be very challenging and likely don't have good operational data for, for some period of operation. And while these are challenges -- and it may sound like I'm, I'm asking something different of CARB, I'm actually -- would like to point out that CARB has been exceptionally accommodating as we go through this for the first major plant. Realizing that within the LCFS program, within hydrogen pathways, our plant in Nevada is the first significantly sized plant to come online.

We're seeing some of the –– some of the early growing pains of going through this process the first time. They've been exceptionally helpful in working with us to go through that.

With that, I look forward to the questions. Thank you.

MR. ALDAS: Thank you Dave. Thank you for sharing the –– some details on your two projects that, as you said, could be representative of the scales and projects that we might see in the future here, as well as your insights on the challenges of using biogas.

With that I would like to call on Dr. Robert Do, the President and Chief Executive Officer SHG H2, to share his thoughts and presentation. Thank you.

DR. DO: Well, thank you very much for the opportunity to present today. And thank you for the CEC for the opportunity to present as well. We –– we're happy that we are selected as an awardee of CEC grant for hydrogen mobility for our project in Lancaster. And I'll give some updates on the progress as we go on.

There's a lot of discussions about green energy and green hydrogen today. And you know, what we wanted to share with you is the carbon negative hydrogen. And some of marketing people like to call it greener than green, just because you can come up with a better color.

Next slide please.

So, you just heard from Air Liquide. What was described there with the SMR. As we know this, the steam method reformer is probably responsible for 95 percent of all the hydrogen produced in the US today. And, the way it's done is fossil fuel based natural gas, as you're look at first line there, it goes into a the steam methane reformer.

Now remember, you have to burn natural gas in order to, to heat up the reformer. So, there's a combustion at that level in the reformer. So, there's flue gas coming up and CO2 coming up at that level, which is going to be very hard to capture. And then, it goes into the standard steam, water to gas shift system. And then after that, you know, PSA and producing the hydrogen.

What we are proposing it at SGH2 is a very similar process, as you can see. Instead of utilizing fossil fuel, we're using biogenic waste product. You know, biogenic residues from either forestry, aquaculture residues, or even, you know municipal residues, as long as they are biogenic. Going to a gasification process, which then generates the same synthetic gas, which is hydrogen and carbon monoxide, and then the same process of a shift converter, and then producing, in this case, green hydrogen.

Just reminding the audience that under California regulation, a green hydrogen -- a green renewable hydrogen can be made either from electrolysis of water from renewable power or from the thermal conversion of biogenics, which is what we are proposing to do.

Next slide, please.

So, as we have heard all day today, there are many ways that we need to look at, and many industries that need to look at in terms of reducing CO2. And fortunately, we have a green molecule which is carbon free, which is hydrogen. And, there are a lot of industries that cannot be decarbonized by electrification.

So, we need a green molecule, and hydrogen is that green molecule, that you can see here, that we'll be able to look at not only decarbonizing chemical industries, to steel industries, heavy duty, to rail, all the way to shipping, aviation, power generation. And you cannot just do this with electrification alone, with solar and wind. So, the establishment of a green molecule like hydrogen is absolutely necessary in order to reach our net zero goal.

Next slide.

And obviously, we talked about the urgent issues and there's two issues here, obviously. The transport sector, where you have a massive need for marine all the way to aviation. The other issues that need to be addressed is the amount of waste that we're generating. And what you see here we're looking at 2 billion tons of waste generated.

So, if there's any question about –– is there enough waste to produce hydrogen, well you should just look at the numbers that's waste that’s can be generated globally, let alone coming up from the United States. I think there won’t be –– have an issue finding waste hydrocarbon as a source of hydrogen.

Next slide.

(Pause)

Next slide please.

There you go. So, the other thing that you –– we all know, the availability of the exciting about hydrogen is the hype into X. And today, there's a lot of discussion about ammonia, a lot a discussion about methanol as potential E fuel sources. And, in order to make these E fuel sources, or to produce ammonia for the, for the fertilizer business, and to green that process, you need hydrogen.

So, we are currently working with some of the largest fertilizer company in the world, as well as the –– in discussion with the largest shipping company in the world. Because they have now decided that E methanol will be the marine fuel that –– to be used for container ships. And I'm talking about Maersk. And to make e methanol, obviously, the big requirement is a green hydrogen.

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(Pause)

So why are we talking about green hydrogen? And I wanted to just raise one issue that people wanted to hear about. We always know that hydrogen is present in H2O, right? Water. And it's abundant. It's an elegant way of utilizing it into hydrogen. But the other hydrogen in nature is in biomass, which is hydrocarbon. So, you have the H-2-O bond, and then you have the H-C-O bond. The challenge of those, is how much energy you need to extract the hydrogen from the HCO bond versus from the H2O bond.

Now, I stole this slide from the DOE. And, you can see here that these are how we say renewable or clean hydrogen are made. And according to DOE, when you look at the left side of the screen, today, this is how hydrogen is made all over the world. Either by coal gasification, which is what India and China do regularly. Or, US with the steam reforming of natural gas.

So, we need to decarbonize a sector with CCU or CCS. That would give you blue hydrogen. And the other two ways to make hydrogen, which are renewable, is using renewable source like waste and biomass, like SGH2 was proposing. Or, to go with the electrolysis of water with renewable power. Those are the two pathways that have been approved by CEC and CARB.

Next slide.

Our process, basically, is a continuous process where we use high temperature plasma heat in order to raise the operating temperature of a gasifier. So, as biomass and biomass residue and waste are entered into the gasifier, the high temperature from the plasma heat, which is raised up to 3,500 degrees centigrade, you are able to completely depolymerize the hydrocarbon molecule into the individual hydrogen and CO.

And what's beautiful, is hydrogen is one of the most stable molecule at high temperature. And so is carbon monoxide. So, we are able to get a coal gas efficiency of 87 percent and conversion of hydrocarbon into hydrogen. On our website, there's a video that you can see how the process is produced, which we don't have the time to show today.

Next slide, please.

So, this is an important slide that I want to raise. And I'm not trying to go against electrolysis, but water is an issue. California is in a severe drought, and so are the west coast and many parts of the world. And, utilizing a water maybe doesn't sound a lot when you talk about three to four gallons. But, that's only the water that goes into the electrolysis.

To get water from a recycled water plant, which we are doing over in Lancaster, you need to basically clean that water first, and then you have to demineralize that water because -- and deionize it, because any contaminants to that water would destroy the electrolytic plate. So therefore, there's additional power requirements and water requirements in order to reach and use the water for electrolysis.

So, I think that the water resource has to be a big consideration when you're looking at electrolysis. And in our case, we only use water for process cooling and plant usage in terms administration. So, the amount of water we're using a significantly lower.

But the most important point that I want to be able to show -- to take out here, is the amount of electricity that you break a water bond. The water bond is like a, a magnet. You need on average 60-kilowatt hour in order to break and get one kilo of hydrogen. Whereby, the hydrocarbon bond, the HCO bond, is a very loose bond, and we only need about less than eight kilowatt hours. So, eight times less electricity to break and remove the hydrogen to generate hydrogen. And that alone tell you a very important part why our cost is so much lower.

But the other important part, which is very important, is the availability. We are building a plant that will operate 24/7. We're not depending on renewable solar, which operates only, you know, 25 to maximum 30 percent availability, which is about 92 days a year.

We have our plan would operate 350 days a year. That will allow us to produce it on the baseload continually, and that's why we are selected to, to provide hydrogen to the hydrogen stations in California.

And then the other piece of resource that also has to be considered, is the amount of land required. We can build one of our module that produces, you know, 4,000 tons a year of hydrogen in five acres of land. Five acres of land to fuel one megawatt of power. And, in order to give the same amount, you would need two hundred times the amount of land and solar to give the same amount of hydrogen that we produce. And on top of that being a biogenic system with carbon capture, we do therefore a, what we call, a carbon negative hydrogen.

Next slide.

(Pause)

I think we covered this already in terms of carbon intensity, so we can go to the next slide.

So, our company basically will build and operate this plant, and be launching multiple projects, which produced the standard distributed system. Our, our business is a distributed energy. We would think to com—— complement the larger utility scale. We're looking at building this plant closer to the demand, and therefore reducing the amount of transport of hydrogen.

Next slide.

Announcing what we consider today one of the largest baseload hydrogen, we put together, as you can see here, a consortium of some of the la—— top engineering firm, like Fluor. We're happy to also partner with Air Liquide to support us with equipment like the PIA, VPSA, even the Cryocap system and capture. We work with ABB in order to do a complete automation of our plant. And, we are also, and with Stork, the largest O & M Company to operate our plant.

Lastly, we put together a complete performance guarantee to allow our project to be project financed. And 100 percent of our hydrogen the Lancaster plant has been guaranteed to be off take by Shell and Iwatani to the largest hydrogen refueling station operator in California.

Next slide.

(Pause)

This is a picture of Lancaster. I'm standing next to the mayor, who is on the right corner here in a Toyota Class 8 trucks. The hydrogen from Iwatani will be transported from Lancaster in a hydrogen truck, so it's a closed loop system, and they are going straight to delivery the Iwatani hydrogen stations. Similarly, we're doing the same with Shell so 50 percent of our hydrogen is going to Iwatani stations in Los Angeles and the other 50 percent going to Shell hydrogen stations.

Next slide.

The Lancaster project is currently going to CEQA. We looking forward to a 16 to 18 month construction, and the plant will be operation by quarter four, 2023. As you -- as I have announced earlier, we have received a $3 million CEC grant for this project. On top of that, we are going through a public private partnership with the City of Lancaster where the CEC is a partner on the project. The offtake contract agreement -- 100 percent of our hydrogen is contracted for the next ten years, between 2023 to 2033.

Next slide

(Pause)

-- to announce that we are launching a project in the city of Paradise, which is known being infamous burn down to the Camp Fire. There, we would use biomass waste residue and we would convert that working with the Forest Service and the county to convert that biomass into hydrogen. And then, we are working with the Chart Industry Group to liquefy. So, each of these plant -- this plant will be producing 12 tons per day liquid hydrogen in the city of Paradise. This plan will be operational by 2024. And with carbon capture, this is the bioenergy with carbon capture for sequestration. So, also a negative carbon hydrogen project.

Next slide.

So, I'm going to end here. Thank you very much. I think that the next thing that we want to talk about, and the one of the question to raise, is we definitely should remove the word and the rainbow of color -- focus on looking at clean hydrogen with a carbon intensity that should be at least 75 percent lower than grey hydrogen, or three kilo of CO2 per kilo of hydrogen.

And that would be the definition of clean hydrogen, which I hope will be part of the Section 45X coming out in the –– in the new, hopefully, Build Back Better Climate Bill. But that's how they define clean hydrogen, and I think that's the, the taxonomy that we should be following. Thank you very much, and I look forward to some questions.

MR. ALDAS: Thank you, Dr. Do, for your presentation and, in particular, for sharing information about the HEA's two process and your projects in Lancaster, and in Paradise. And in particular, I appreciate the analysis in your comparison table with your products and electrolysis.

And with that, I would like to call on Nick Connell, with the Green Hydrogen Coalition. Nick is the policy director for Green Hydrogen Coalition, and will talk about developing green hydrogen definition and green considerations.

MR. CONNELL: Perfect. Thank you very much. Rizaldo, can you hear me okay?

MR. ALDAS: Yes, so we can hear you good.

MR. CONNELL: Perfect. All right, next slide. And I would like to thank Dr. Do for setting up my slides here. That wasn't planned, but it worked out perfectly.

So, um, really big on the GHC, or the Green Hydrogen Coalition. Our mission is to facilitate policies and practices to advance the production and use of green hydrogen in all sectors where it will accelerate a carbon free energy future. The GHC is a tax exempt 501c3 nonprofit organization.

Next slide.

We currently have two initiatives, where we are driving policy and commercialization efforts that together, will accelerate North American green hydrogen market. Our first initiative is the Western Green Hydrogen Initiative. This includes 11 Western Interstates, two Canadian provinces, as well as three additional states, Florida, Louisiana and Ohio.

I serve as one of the organizers, in collaboration with the Western Interstate Energy Board, as well as NASEO, the National Association of State Energy Officials, and the CEC’s Commissioner McAllister is actually one of the vice chairs to the Western Green Hydrogen Initiative.

And our second initiative is HyDeal North America. This is where we're trying to drive high volume supply chains to achieve, in some cases, sub $2 per kilogram of hydrogen delivered. Our first initiative is here in Los Angeles. We are currently in phase two of this where, we're looking at additional infrastructure and offtake more on mobility, so looking at aviation as well as maritime, and then also looking at the community impacts and ensuring that as we move forward in a green hydrogen economy, that there's a just transition.

Next slide, please.

And for my presentation, I really wanted to touch on one foundational policy recommendation –– and this is something that Dr. Doe touched on previously –– is that, you know, there's an increase confusion. I mean, it's easy for us to talk about the hydrogen shades in conversation, but when we start putting policy together, we need to start looking at it on a quantitative basis. And so at the GHC, we support defining green hydrogen based on a carbon intensity framework.

The reason for this, it opens up the debate about competition between different hydrogen production routes, as you heard from the previous panelists talking about biomass, or electrolysis, or biogas, and it allows them to compete as long as they can meet that carbon intensity threshold. In addition to that, it also opens up an opportunity for certification schemes, to where we can start to rigorously account the GHG's arising from both the site of production, as well as the upstream production.

And in here, I just included some different considerations when developing definitions. So, does it support feedstock diversity? Is a quantifiable? What is the threshold? And so, Dr. Do touched on the Infrastructure Bill, where he talked about the two kilograms of CO2 equivalent per kilogram of hydrogen. So that's already something that's happening at the federal level as well as other places internationally, including Canada and the European Union.

And then, does it consider the lifecycle impacts? Is it technology neutral? So, not basing a definition just on electrolysis or just on biomass production. And how will it be certified?

So, next slide, please.

So, when adopting a carbon intensity framework, one of the key considerations is setting up the system boundaries when defining green hydrogen. So again, you could keep this color scheme if you tied to a specific threshold. And so here, here's a key example of one way of assessing the lifecycle emissions from feedstock through the point of production.

And this is done by the International Partnership for Hydrogen and Fuel Cells in the Economy.

This includes organizations around the world, including the Department of Energy. The reason we say well-to - gate –– this is mainly because, as we started thinking about green hydro–– hydrogen production and use, there's going to be a lot of different end use applications.

So, a key example would be the LCFS program where it looks at well-two-wheels, because it's specific for transportation. And once we start moving to a mass economy, we need to start evaluating the lifecycle emissions slightly different. And this is a good way to look at not only the point of production, as well as what's going on upstream to ensure that we're accounting for all those greenhouse gas emissions.

And one thing I want to point out, is the infrastructure bill. While they do set a threshold, currently, that definition is only at the point of production. So, it is not looking at the upstream emissions. And so, the GHC, as well as other hydrogen associations, have been working with the Department of Energy and really advocating for them to start looking at it through a well-to-gate assessment. And if you go to our website, you could see a letter that we submitted to the DOE previously in regard to that.

So next slide.

So, a carbon intensity framework, it is

additionally -- it's a fundamental to establishing certification mechanisms and standards that can really help move the market initially. And so, some considerations, I won't go through all of them here, but it's -- what accounting scheme should we use? How do we get started? And also, are we gonna hurt market development or support network development?

So, in our perspective, and I'll share on the next slide is, there's really a way to where we could roadmap ourselves to get from separating, so looking at a booking claim system, to a mass balancing system. And so, the GHC we really support mass balancing. So, this is really linking the physical delivery of that renewable source, be it biogas, biomass or electrolysis through, you know, elec -- renewable electricity, down to the point of production.

However, that infrastructure and those mechanisms are not in place yet. And so, in the near term, we support leveraging existing infrastructure and systems that have worked for decades in the renewable energy and gas markets to accelerate green hydrogen market development.

And as noted from Earthjustice was, you know, when we look at LCFS program, when they're separating, you know, the environmental attributes from the actual production, we're working out different mechanisms to ensure we are actually decarbonizing the grid in the near term, and working to our ultimate long term gro-- goal of getting to a mass balance market. And we would be happy to share some of those positions as we are going through it, and you can see our previous regulatory filings as well as our position papers on some of these items.

So next slide.

And so, I just wanted to leave you with four different requirements that, you know -- as we develop a green hydrogen definition, if we look it at -- at a kind of carbon intensity framework, we have a sound, you know, a lifecycle mission assessment framework in place.

These are the four goals we should really be getting to in time. I do not believe we could get here today because we would kill market growth. And what we want to do is we want to acceler-- accelerate market growth, and we need to start working to achieve these things. So having these angles in mind will be very critical.

So, one is temporal correlation. So, when that hydrogen is being produced, timestamping it to when that renewable feedstock was delivered to that facility. So, that's one key activity and that's as a graphical correlation, so going back to Earthjustice, where they're taking an environmental attribute from Indiana and they're using it in California. Is that really decarbonizing our grid? And that's a larger question that should be addressed. So, you can always look at -- we can do it within the balancing authority, or we could do it within the trading hub for recs, or environmental attributes.

And the next is additionality. So, as we put more electro-- electrolyzers on the grid, are we expanding our renewable resources such as solar and wind? Or, are we starting to take away from those.

And then lastly, is the technological specifications. So, we really need to ensure full transparency information those use -- those resources use to produce the electricity, the biogas or biomass, and ensure that it's actually renewable in nature.

And so having these four different requirements in place in time will really start to ensure that we have a transpar-- a transparent market that really grows the green hydrogen economy.

So, with that, I will hand it back over to you, Rizaldo. Thank you.

MR. ALDAS: Thank you, Nick. And thanks for efforts at classifying hydrogen based on carbon intensity. So, I think at this point I will pass it on to Vice Chair Gunda for comments and questions at the dais.

VICE CHAIR GUNDA: Thank you, Rizaldo. Just kind of looking at time. So, we're at about 4:03, so we have seven minutes or so for a few questions from us. I don't want to delay, but, you know, if we have pressing questions we'll go longer.

So, I'll just start off with a couple of questions. So, just kind of this, this discussion around the electrolytic hydrogen, you know, which we focused quite a bit and we heard some comments this morning about thinking through other feedstocks that could provide, you know, more of a negative path. You know, Dr. Do kind of talked about some of that. And also. we had David kind of mentioning, you know, the, the opportunity that having multiple pathways and, and more of a, a comprehensive opportunity –– both on the supply side, but also distribution side, and, and kind of the overall process.

So, you know, now that we've all heard from each other, I wanted to hear Sarah, Nick, your comments –– a little bit on, you know, you've kind of talked about the regulatory structures, but, you know, as we think through, you know, the bold goals of California, you know, having consensus is very important on, on kind of short term and long term. I just want to hear your general agreements and, you know, disagreements. I think would be helpful. So maybe Nick, everybody, please go one by one. But Nick, maybe you can start.

MR. CONNELL: Yeah, I think, you know, at the GHC, we support technology neutrality. So, if we could support hydrogen growth through carbon negative resources, or zero-carbon resources, we're all for it. We just have to ensure that it is done correctly and transparently for one, the market, as well as ensuring that we're creating a just transition for those communities of concern.

So again, you know, if it's biomass, biogas, if it's electrolytic production, we support it —— as long as it really meets a carbon intensity threshold to meet our state's goals by 2045, 2030, in moving forward.

MS. GERSEN: Thank you for this really important question. I think it's very important to critically interrogate any claims about a energy resource being carbon negative. A really fantastic resource I could refer you to on that is a petition the, the Coalition of Environmental Justice Groups recently filed with CARB that spotlighted several sources of biogas that CARB has been treating as carbon negative for the purposes of the LTFS program. Which in fact, had wh—— would be going forward regardless of the LTFS program, because they'd either been funded through public grants, or had a commitment to construct them because of a legally binding settlement, things like that.

Um, I also think it's important to think about economy-wide resource planning. And I think everyone on the dais is very familiar with the idea that biomethane is not going to be a silver bullet for us to be decarbonizing the economy, because the supply of truly sustainable biomethane is so limited.

But, what I think is less well appreciated, is the enormous energy penalty being paid if you were to convert biomethane into hydrogen. You would lose about 40 percent of the energy in the biomethane you use in that process if you're using bio methane to both steam methane reformation, and as a chemical feedstock for that process. And that, I hope, makes it really clear that converting the energy in biomethane into hydrogen before you can use it is just a —— a wasteful and inefficient thing to do.

(Pause)

MR. EDWARDS: So, so this is Dave from Air Liquide. So, um, I think one of the things that's obvious from the variety of presentations is that the technology neutral route is really important. And, that the mechanism by which we evaluate carbon intensity is also very important. It captures, you know, all of the processes that we've talked about, and it captures the kind of concerns that Sara and others bring up about, you know, what is the real carbon intensity of a process and how do you evaluate that?

So, establishing standards, establishing standards that are technology neutral, and making sure that they capture the impact and effects that are important for society and for industry and for the applications is, is really important. One of the things that we haven't talked much about today is, is what's going to drive us toward the ability to bring hydrogen in at the scale that we need? And that's really the economics of its adoption.

We rely on the state in the early stages of adoption in order to establish and help bridge some of those concerns we have from an economic perspective, but it will be private investment in private industries that come forward with the huge amount of investments that will allow the energy transition to happen at scale. And at scale is when we have the biggest impact on the environment, and it's when we have the biggest impact the overall impact on society, for example.

But establishing those measures very early on what are the carbon intensity pathway evaluations, how are we going to establish technical -- technology neutral approaches, allows us then to plan for the future and make those kinds of investments. And that's, that's really the key to, to the economic drivers, but behind a lot of the, the concerns that I think have been raised here today.

DR. DO: I agree with Dave. I think the transparency of the, the technology in the LCA and Liquid's system. We're working with University of Berkeley, as well as the Berkeley National Lab. We're brought in experts from all fields in order to look at carbon intensity.

And Dave, you're absolutely right. I mean, you can put all your pathways in there. And these -- there are new pathway, CARB, basically today. have existing approved pathways. And you can take around and put it in a square hole. So, you know, we have to put in these new are pathways that go through that process. And then you have to wait until your plant is operational for 90 days before you get certified.

Now, but the elephant in the room that we still haven't addressed all day today, is what's happening to the LCFS market. Literally it's crashed from $200 down to 80 something dollars. And from that -- so anybody on the supply chain that mentioned is not getting credit because a credit is not only hard to get, but it's dropped down to you know 60 percent of what it used to be a year ago, and because of the massive amount of renewable diesel that's coming in.

So, the hydrogen market today is severely affected. And, and as far as economic is go, whether we are carbon negative, carbon neutral, the hydrogen market is driven by LCFS. And the other part is, a lot of people are talking about decarbonizing other sector. Well, power mixing with natural gas going into pipeline -- that sector does not get LCFS credit. So, they won't move forward, because there's no incentive to move forward until you have, perhaps, the PTC coming out, which may or may not happen.

There is a lot of challenges here for the hydrogen system. If you want to take it about and outside of mobility. And as far as mobility is concerned, I mean, there's a limit that we are very few trucks on the market. So, there's really no demand. Aviation, marine is all talk, so there's no certainty as to off taker.

So, for our producer, like Dave, our Plug

Power is lucky because they are it directly to their own customers and their own stations, so they are vertically. But for group like us, or Air Liquide, we need to see a bigger market demand. And that demand for green hydrogen, it's just not there for a producer to come out and build these plants. I, I spoken up, I let others chime in.

MR. BROPHY: Yeah, I would just add to the least controversial point today is that, we absolutely support completely rigorous and absolutely transparent carbon intensity source for the hydrogen production pathways. They don't really -- the colors are shorthand, but we really want a rigorous way of doing it that doesn't have somewhat arbitrary requirements in it, like exclusion of hydro and stuff like that. That's unhelpful.

When you're trying to -- it really, just should be absolutely neutral and completely rigorous in how it, how it scores the, uh, the pathway. I, I would say our focus is on the big picture. At Plug, we're about replacing fossil fuels with green hydrogen. By 2050, a complete replacement. We're going after diesel first. But, when we're done with these little we're going after natural gas.

At that scale, at that kind of, of energy usage, the only resource that you can, can really scale is solar and wind. And so, we're starting with that resource and, and that's the one we believe will scale. And that's not to say all of the other pathways that we talked about today are not excellent ways to make hydrogen. But, in the end game, it will be solar and wind and electrolysis that is the bulk of the hydrogen production, if we're going to seriously replace natural gas and oil.

VICE CHAIR GUNDA: Thank you all so much. I have so many more questions, but I'll, I'll pass it to Commissioner Monahan first.

COMMISSIONER MONAHAN: Well, I really appreciate this panel, and all the different projects that are directly producing hydrogen. And, I'm curious about the recommendation that Nick has made around the geographic correlation that, that eventually, I'm not sure how soon Nick is recommending this happen, but that green hydrogen tracking systems should have a physical link to ensure that the energy input is involved in a -- in the hydrogen, the -- versus the book-and-claim that we currently have in the LCFS.

How, in this panel, how -- I'm, I'm curious about the reaction of -- I'm guessing Plug Power would like that, but Air Liquide, in particular, around that recommendation. Dave, what do you think?

MR. EDWARDS: Yeah. So, I think, as, as Nick pointed out for the short term, we, we really only have the book-and-claim option, and we need to think about all resources that are available that can be plausibly tied in through those processes, whether that's electricity or, or renewable natural gas, for example.

But I think there is some merit to the regional tie-in, and how that brings value to the local investors, to the local society, to local community. It, it –– one of hydrogen's real strength is that you, you produce it where you use it, and you use local resources. And that amplifies that impact by doing that.

We're not ready to do that yet from an enemy sector perspective. And we would, we would greatly hamper what resources would be available for low-cost low-carbon production today. But, I think if we start aiming toward that as an outcome, we can start conditioning systems and, and policies toward, toward being able to do that. I think that would be a really intriguing idea.

MR. BROPHY: I would echo what Dave said. You know, while this California project has a direct connection, that doesn't always work everywhere. And,

and so we need flexibility at the start to be able to put together economic hydrogen plants that, that are viable that we can build. And so, flexibility at the beginning, but I think absolutely in the longer term in the medium term, we can aim for, you know, more criteria around how we, how we account for the hydrogen.

COMMISSIONER MONAHAN: And what, what's medium or long term? Like, what would be the timeline, time horizon?

MR. BROPHY: For us, we would consider the medium term to be late this decade. So, from 2027 through the early 2030’s, as, as medium term beyond 2032 as longer term.

MR. EDWARDS: Yeah, I think I would agree with that. From a timeline perspective, all of the investments that you've seen today are likely to be in production for a decade or two or three, potentially, depending on markets and viability. And, and that requires some stability of, of, you know, regulation and investment clarity.

COMMISSIONER MONAHAN: It seems like Nick has something to say.

MR. CONNELL: Yeah, and I would say too, in regard to a timeline, it may vary. But again, if we look, can we benchmark —— like the European Commission, you know, they just released set by mass balancing by 2027, and giving a grace period for projects to get there. And so, some time of consideration for California, especially from a regional approach, would be a, a great way to start looking at that and road mapping, like, a long-term plan to get to mass balancing.

COMMISSIONER MONAHAN: And Sara?

MS. GERSEN: Thank you, Commissioner. Tying in the inputs to the hydrogen production is a really elegant way for identifying when electrolytic hydrogen is truly green. You know, having an equivalent of a bucket of one RPS renewable electricity source power the electrolysis.

But when you're talking about things like biomethane, there's really a double-edged sword when you're asking producers to use locally sourced biomethane. Because, your catalyzing the market for locally produced swine and cattle manure gas, often to the detriment of the local environmental justice communities, who see increased pollution in their communities when industrial agriculture responds to the incentive to produce more methane pollution by, surprise, surprise, producing more methane pollution, and doing so by using less sustainable practices for renewal management?

So, um, I -- I guess this also ties into the previous Commissioner's question about technology neutrality. Focusing on zero emission electrolytic hydrogen is the clearest way to ensure that not only is your hydrogen being produ-- produced through a path that's sustainable for the climate, but, it's -- it's the only way to ensure that you will avoid detrimental public health impacts on local communities.

COMMISSIONER MONAHAN: Great, thank you.

DR. DO: I wanted to second Sara's statement about the methane. Because, you know, my -- one of the position that is by, by CARB, is that methane has a greenhouse warming potential of 20 times CO2. But that is only looking at over a 100-year period. And we know the more important part is looking at over the next 20 years where methane has an 80-time GWP, according to the UN and IPCC, as part of the COP 26 and the methane capital regulation.

So, I think it's important that CEC is reviewing how you're looking at the impact of methane in terms of GWP versus CO2 over 20 years to be more consistent with the UN policy at the moment.

(Pause)

MR. FOO: Hey, this is Fritz. I actually had one technical question, and then maybe a broader question for everyone. The technical question is for Robert. You all mentioned that you heated the plasma up to 3,500 degrees. I'm curious what the energy source of that is? Is that electric, or some other gaseous source?

MR. EDWARDS: Yeah, it is electric, classified as an electric process. And, we then actually recover, and through a waste heat to power system, in order to generate the electricity we need to run the torch.

MR. FOO: And I just my second question probably for folks, in really just thinking about a tracking system of some kind. You know, do you see that ed-- everyone mentioned, kind of, carbon content and threshold. Is that, I guess more, you know, a legislative fix? Maybe, you know, a broader policy fix? I'm just kind of thinking through it. It's definitely a question that's being, kind of, thought through a lot of think tanks. But you know, what are -- what is, kind of, the main lever there that is needed? Is it -- is it really a legislative fix? I'm kind of curious as to what your thoughts on that are.

DR. DO: Well, from, from my standpoint, you know, we -- I have a similar form to a PTC that's been paused for clean tax is the, the main piece. In Europe, the discussion has to do with a CFD or contract with differences, which is the amount of CO2 savings that you're getting, and then you get a price on the CO2 itself.

So, whether it's LCFS or CFB, there has to be a premium paid to pull that carbon savings over green hydrogen, over brown hydrogen, over natural gas, over diesel. And that need to be across the board for all industries, whether you are using the hydrogen savings or CO2 savings for power productions, or reduction of the natural gas footprint, or home heating, or all the stuff that SoCalGas done.

There has to be a pay for that CO2 savings. And is it the carbon tax? Or, is it a part of LCFS or an RFS? I think that that has to be the trigger. And, you know, that's, I think, the 40X program that's proposed by the Build Back Better on the climate legislation, something similar like that is going to be the driver to incentivize producers, users, in, in terms of the hydrogen economy.

MR. FOO: Thanks.

VICE CHAIR GUNDA: Thank you. So I'll, I’ll as ask just one quick question to Brenor, and then, you know, hopefully we can pass it on given the time here. And I, I will also just say that I would love to follow up with a few of you to have some follow up conversations on, on thinking through. I'm, I'm still learning this area, and this is really helpful, this particular discussion.

So, Brenor, on your -- the 120-megawatt capacity that you talked about for the electrolysis project in California. What are -- how are you thinking about the interconnection agreements and the queue? Is there an opportunity for taking, you know, the, the large amount of interconnection queue that we have today to potentially marry with some of these, you know, projects, electrolysis projects, and then provide a pathway for both reliability, but also, you know, more advancing the deployment of the renewable

MR. BROPHY: That's a really interesting question. The genesis of this project was actually a first solar, solar project that was -- held Q positions, but it only held an energy-only Q position, and it turned out that was very challenged to get a PPA, because it didn't have deliverability.

And so, a marginal solar project became an excellent hydrogen project. So, hydrogen has what's enable this to go forward. And, and that's a, an interesting point, where the alternative energy delivery of -- through liquid hydrogen and trucks, as opposed through the grid, enables a renewable energy project to, to meet the economic hurdles that it's about to.

You know, the, the queue. Interpreting queue is, especially in California, is enormously complex. There are, there are many projects that the costs related to interconnections are -- can be very, very high. And there's a lot of complexity a lot of time. I think, certainly hydrogen, is a way that either in replacing the off-take of, instead of electrons you, you export protons. Or, as a way to enable additional economics for a renewable plant that would otherwise see curtailment or, or may not be able to get all of the electron off take that it would like.

All of those are opportunities where hydrogen can play. I think it's incumbent on organizations like Plug to really reduce the hydrogen part of that equation to practice, to build enough plants to get to a scale where, if pure renewable energy developers, solar and wind developers, can, can see a hydrogen solution that's, that's off the shelf. And also, enough of a hydrogen market, that there's a place for that product to go because just generating the hydrogen somewhere is -- it's not enough. You've got to have a path to market. And that's either through pipelines or through liquefaction or something similar.

VICE CHAIR GUNDA: And Brenor, just a quick follow up and, and I'll follow up of offline too. Just from a –– supporting the net peak period, specifically, the four to nine. Given, and obviously there's a part of it is to, you know, if you're really depending on solar, you don't really have an opportunity to potentially reduce load. But is there, or are there opportunities to support the grid with the kind of system you have during that peak period?

MR. BROPHY: Absolutely. So, this plant is a, a hydrogen plant in general. An electrolysis, electrolysis plant can be extremely load responsive, or demand responsive. About 80 percent of our load can be curtailed literally in milliseconds, if we need to.

This plant is designed –– if you do the calculations, 120 megawatts is actually 45 tons of hydrogen production capacity for a 30-ton liquefier. Frankly, what we're doing is we make hydrogen when the sun shines. So, during the peak of the day, we make additional hydrogen that we store, and then during the on-peak period of 4:00 to, to 9:00 P.M., or the gooseneck theory, the dark –– duck curve that we, we talk about.

We actually curtail the electrolyzer hydrogen production. And our liquefaction plant runs off storage, the stored hydrogen that we made earlier in the day when the sun was shining. So, in fact, what we're doing, is we're curtailing our load during that peak period. And, we're actually exporting some of that solar energy in the first half of the period when we still have solar. We're exporting it into that market because the prices are very high.

So, we are very responsive to time of use energy rates. And, we've designed this project to, to support California's energy grid by not -- by curtailing load at peak periods, and actually by enabling energy supply into the grid during those same periods, while still making absolutely steady 30 tons of hydrogen every day.

VICE CHAIR GUNDA: And thank you.

DR. DO: On the other hand, by -- to follow up on that, point. We're talking with some of the peak producers in California who are interested in taking hydrogen and blend it into their turbine during peak hours. But the challenge for them at the moment, is there is no premium for them to pay for the blending of hydrogen. Because now, power includes you know, 20, 30 percent hydrogen during this peak time. But there's no method to compensate the, the peak -- the peaker power plant for, for utilizing hydrogen and decreasing the carbon footprint. So, that's a regulation that need to be, to be discussed.

VICE CHAIR GUNDA: Thank you so much. I know we used up a lot of time. Thanks, Heather for facilitating the broader conversation. With that, do we want to go to the Q&A?

MS. RAITT: Sure, thanks. So, Peter Chen is on the line to moderate the Q&A. Go ahead, Peter

MR. CHEN: Thanks, Heather. So, I have a question here from Willem Hazenberg, it's directed to Dr. Do. So he asks: "Bloomberg indicates that hydrogen is not a good choice for passenger cars, whereas SGH2 is betting on customers who are particularly committed to mobility. So how do you view the mobility market?"

DR. DO: Well, we, we see the mobility market leaning a lot more toward heavy duty. And in, in Europe, we are developing three projects working with large-scale heavy-duty stations that being rolled out throughout Germany and, and in the Netherlands.

And so, that's where we see it. And of course, working also, at the Port of Rotterdam is where we're developing projects as well as the Port of Antwerp. Those are the two hydrogen hubs of Europe. And we are proposing to provide that hydrogen for the decarbonizing the port as well.

So, there's heavy duty equipment, there's drayage truck that they are using. They are also using green carriage for the movement of containers and, and for marine transport. So, I think that the Europeans are leading the way for heavy duty mobilization ability that are far, far ahead than what we're doing in California at the moment.

MR. CHEN: Thanks. Moving on to the next question it's from Bjorn Paulsen. So he asked: "If there's any consideration of underground storage of green hydrogen as a means for long term energy storage?"

MR. EDWARDS: So, this is Dave from Air Liquide. I can, I can at least start the conversation. We own and operate the, I think the world's largest underground storage in the, in the Gulf Coast of the United States. It's in a salt dome, it's about the size of a very large city building. It holds enough hydrogen to backup, for example, a nuclear power plant for a couple of weeks for example, if it were used for grid backup. Now, it's not.

The –– what we're using it for is for pipeline backup for our customers that are using industrial hydrogen. I believe the DOE has looked at California and identified geographically where locations would be ideal for underground storage. I'm not sure how far along the industrial side of investigating those opportunities looks at for power generation and backup, but I know that the, the processes are in place, the evaluations are in place, and the technology has been proven.

MR. BROPHY: Yeah, we certainly are looking at underground storage for the longer term. I think California is challenged to the extent that the underground geologic storage here is within depleted natural gas formations, which are a great place to put gas but not if you want to get it back at nine –– five ninths of purity to put it into a fuel cell application.

So, I think we're a little bit more challenged. But certainly, in the salt –– the salts geology of the Gulf Coast and some of the other places in Utah for example, geologic storage certainly is going to make sense.

MR. CONNELL: And I would just that HyDeal Los Angeles, one of our initiatives, we're looking at Delta, Utah, for our geologic storage.

(Pause)

MR. CHEN: Okay, I have one last question here from apprenticeship coordinator. I'm not sure if there's a, a name for this person, but: "Is there any data stating that using––"

MR. LUCERO: Dominic.

MR. CHEN: "–– bio––" Dominic, okay. So, Dominic asks, "Is there any data stating that using biomethane increases incentives or increases pollution?"

MS. GERSEN: I think that the best source of information on this is probably a study by the Union of Concerned Scientists, UCS, put out recently. I don't have it at my fingertips, so I highly recommend googling it. And they analyze the enormous revenue opportunity that dairies are seeing from LCFS credits.

And I, I think they found that these industrial agriculture operations could expect to receive almost as much revenue from the off gas from the nuclear network from these cows as from the, uh, the milk they produce themselves. Obviously, dairies have a strong incentive to produce milk if they're getting just as much revenue for manure gas. That's a pretty strong incentive.

And it's also just really important for folks to understand that methane from manure is not inevitable. It is the result of choice regarding how these industrial agricultural operations manage the manure, and whether or not they're going to take su–– sustainable and responsible steps to manage that manure in a ways so that it does not produce methane, or if they forgo those sustainable practices to take advantage of these revenue generation opportunities.

MR. CHEN: And I think that's all we have for the Q&A's. I'll turn it back over to Heather at this point.

MS. RAITT: Alright, thank you, Peter. And thank you to all the panelists. Commissioner, did you want to say something?

VICE CHAIR GUNDA: Yeah, thank you, Heather. I just want to thank all the panelists -- Sara, Brenor, Dave, Robert and Nick. Thank you so much for all the comments. Really appreciate you all, both sharing a diverse perspective, but also kind of putting some common threads and some challenges and some potential missed opportunities.

And so, Sara, I would appreciate some of the things that you mentioned about the studies if you could docket them if possible, that could -- really appreciate that. And also looking forward to having individual conversation with all of you to just kind of learn and think this through. Thanks.

MR. CONNELL: Thank you Commissioner

(Pause)

MS. RAITT: Okay, well, if we're ready, then we can, I think, move on to public comment.

(Pause)

So, this is Heather. So, it's -- if you would like to make a comment, please use the raise hand function in zoom, looks like a high five. We will be limiting comments to one person per organization, and three minutes per speaker. If we have lots of comments, then we may need to limit that to 1.5, one and a half minutes per speaker.

Let's see.

(Pause)

So. First Person is Colby Morrow. Colby, go ahead and you can unmute your phone and make a comment.

(Pause)

Go ahead.

MS. MORROW: Sorry that --

MS. RAITT: There you go.

MS. MORROW: --tending. thank you, sorry about that.

(Pause)

VICE CHAIR GUNDA: Colby, we can hear you now. Please go ahead, if you can.

MS. MORROW: I'm so sorry. --on my part. I, I d-- I was trying to make sure I was mute-- it's my hand. Sorry. Can you hear me?

MS. RAITT: Yes. So, you don’t need ——

MS. MORROW: Okay. No pro—— no. I didn't have anything, sorry about that.

MS. RAITT: No worries. Thank you. Alright, we will move on to Robert Perry. Did you have a comment? Go ahead and unmute your line. You can go ahead.

MR. PERRY: Yes. Can you hear me?

MS. RAITT: Yes, go ahead.

MR. PERRY: Okay, great. Fantastic series of presentations and panels. I come away from this with a much clearer idea of where the state of hydrogen production and implementation is.

My only, my only comment is, you know, we really need to focus on hydrogen in all aspects of the supply chains, both centralized and distributed applications. I think there are situations where large scale electrolysis offshore, adjacent to the offshore wind farms that are slated to be developed would be —— would grant a lot of flexibility, all the way down to the commercial industrial zone within cities, which have a high potential generation capacity. And introduction of electrolysis as a shared facility within a center of these commercial industrial sites which are prone to be more open, receptive, to using medium heavy-duty vehicles that are, are fuel cell based.

We, we really need to look at every possible level of, of application because the introduction of electrolysis just confers so much flexibility. And, it really allows us to, to max out the amount of generation that a site can put out. So, that's just the extent of my comment, and I want to thank everybody for the event today.

MS. RAITT: Thank you. Next is, Arndt Lutz. Go ahead and unmute you line, and you may comment.

MR. LUTZ: Hi. We heard from Brenor how Plug has to use time of day, time of use rates, and to optimize the different electricity schemes to, to make the green hydrogen, or the, you know, zero carbon hydrogen economical. Why, why is it so difficult for the CPUC to just, you know, introduce a hydrogen production rate for anyone in the state that wants to produce hydrogen?

And the follow on question to that, or it's not a question more of a comment, is that permitting also needs to be streamlined for hydrogen projects in the state of California. It's, it's just way too complicated to get hydrogen projects permitted. Thank you.

MS. RAITT: Thank you for that. If anyone else wants to make a comment, please use the raise hand function to let us know. And, I see one more. And I'll just also mention that if you're on the phone and you want to comment, just press star nine and that will effectively raise your hand.

So next is Donald Taylor. And, go ahead, Donald. Unmute –– you can unmute from your end.

(Pause)

Donald, did you have a comment? Do you need ––

MR. TAYLOR: Can you hear me? Can you hear me now? I'm sorry, I thought –– okay. I muted and then unmuted. Okay.

So, you know there's some discussion about biogas, and I just wanted to indicate that –– like an opportunity to like, Air Liquide and the Apex landfill there in Nevada. Those are fairly rare opportunities. I mean, in California, okay we've got 80 landfills. But it really, the biogas rarely enters on my radar as a source. I mean, I made a lot of money in landfill gas through the years. But really, the amount of resource there is really small. I don't, so I don't really think of that as very much of an issue for hydrogen production. I mean, early on, it's easy for some projects, and it makes a lot of sense. If I was Air Liquide, probably done the same thing.

But really, if you look at biomass, not biogas, for example, in California, just the amount that we dispose in those 80 landfills is about 80,000 tons a day. And if you use just the bio fraction of that we're disposing, that will produce about 3 million tons a year of hydrogen. I mean, the conversion rate -- if you take a ton of biomass, you can make about a megawatt of electricity. But if you convert that to hydrogen with 60 percent efficiency, which is, you know, fairly modest, you're talking about probably 200 pounds of hydrogen per ton of hydrogen. So, I mean from a -- per ton of biomass.

So, the amount of resource available from biomass in California is tremendous. Biogas is, you know, you're talking about dealing with manure is a local problem, and landfills is a local problem. It isn't really, I don't think, a major source in the long term. And I understand the long-term view, these various methods.

We haven't talked about ocean production of hydrogen, wind to hydrogen and electrolysis ocean water, which is probably one of the big ones. So, you know, there are just various other sources that we need to consider, biomass being one of the big ones. Biogas, I don't think that's really on the radar, in my opinion.

But, I do appreciate the time to make the comments. I'm sure everybody’s ready to go home. Thank you all so much for the comments, it’s been really great. Thank you.

(Pause)

MS. RAITT: Okay, one more –— one last call for comments, so raise your hand or press star nine if you're on the phone.

I see one more hand up. Mikhael “Mik” Skvarla. Go ahead. I’ll –— let me unmute you.

MR. SKVARLA: Hi, Mikhael Skvarla here, on behalf of the California Hydrogen Coalition. Again, I want to express our appreciation for this long day. We’ve heard a lot of varying perspectives on different production pathways and uses, and the rest.

Ultimately the market will decide its consumer uptake and adoption. It's how the businesses decide to utilize energy, resources for their certain processes. But what we do know, is in the pathway to carbon neutrality we need to provide, kind of, a set of guidelines and allow the market actors to conform.

You know, it's the role of the government to ensure that everyone's playing by the rules that are set. And if the path to the decarbonization is, is, you know, applied equitably across multiple industries, giving everyone the opportunity to transition, we will ultimately see what is taken up and what is not taken up.

And so, I don't think it's an argument of this production type versus the other production type. They'll all likely be used in various sectors of the economy. And we look forward to continuing to work with the CEC through the IEPR process, and their other regulatory proceedings, to ensure that hydrogen has a fair seat at the table. And, we want to ensure that when we are critical of hydrogen as a energy carrier, that we apply that criticism equitably across other energy resources.

Nothing is without a consequence. That goes for electricity, goes for the production methodologies of renewable electricity. The cradle to grave on all of these things is important, which is why I think you've heard pretty unanimously across the hydrogen sector, and folks presenting here today, that a carbon intensity score and pathway is one that is most important for this industry.

We know that CHC has introduced legislation on a number of occasions to pursue that, and we'd gladly work with any of our ENGO colleagues to achieve that goal, ultimately, creating parity between hydrogen and the grid as we move forward.

With that, I thank you and look forward to following up directly with some of the Commissioners and staff.

(Pause)

MS. RAITT: Thank you. I don't see any more hands up. So, I think we are done with public comment.

VICE CHAIR GUNDA: Thank you, Heather. So, I just want to thank our team, Heather, and your team for an extraordinary day. And, all the staff that helped think through organizing today. You know, just ––Jane, Kevin, Rizaldo, Peter, Jennifer, Carey, as well as David, who already left. So, just a, a big thanks for you for providing this presentation.

But I also want to thank Commissioner Monahan and Commissioner McAlister’s offices for shaping the conversation today, and, and providing their input on, on how best to structure today's workshop. So, thank you all. I really encourage both the participants, in terms of panelists, as well as attendees to please submit comments.

At the end of the day, we want to provide a venue to begin to coalesce on key agreements, key opportunities for continued agreement, development –– but also clear actions on what we should be doing moving forward. So, thank you all. With that, I will adjourn.

Heather, I need your head nod.

MS. RAITT: Sure. I, well, can I just make one announcement? I just wanted to put a plug in for all the passionate people that are still on the line. We are — the Energy Commission is accepting nominations for the 2022 Clean Energy Hall of Fame awards, and we encourage folks to, to participate in that. It's a great way to recognize local leaders for their contributions for achieving clean energy future.

And so, the information for nominating anyone on that is on our Energy Commission's web page. So, I just wanted to put that plug in. Thank you.

And, and then just finally, again, comments are very welcome. Written comments are due July 12. And thank you everybody for being here and participating.

(Thereupon the Workshop was adjourned at 4:48 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 17th day of August, 2022.

PETER PETTY
CER**D-493
Notary Public

TRANSCRIBER'S CERTIFICATE

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

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

IN WITNESS WHEREOF, I have hereunto set my hand this 17th day of August, 2022.

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Myra Severtson
Certified Transcriber
AAERT No. CET**D-852