DOCKETED

Docket Number:	25-IEPR-04
Project Title:	Hydrogen
TN #:	266063
Document Title:	Transcript - 72925 - Integrated Energy Policy Report (IEPR) Commissioner Workshop on Firm Zero-Carbon Resources and Hydrogen
Description:	7.29.25 - Integrated Energy Policy Report (IEPR) Commissioner Workshop on Firm Zero-Carbon Resources and Hydrogen
Filer:	Raquel Kravitz
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	9/18/2025 11:37:12 AM
Docketed Date:	9/18/2025

STATE OF CALIFORNIA

CALIFORNIA ENERGY COMMISSION

In the matter of:

2025 Integrated Energy Policy Report (2025 IEPR)	)	Docket No. 25-IEPR-04
RE: Firm Zero-Carbon Resources And Hydrogen	)	

IEPR COMMISSIONER WORKSHOP ON

FIRM ZERO-CARBON RESOURCES AND HYDROGEN

CALIFORNIA NATURAL RESOURCES AGENCY AUDITORIUM

715 P STREET

SACRAMENTO, CA 95814

IN PERSON AND REMOTE VIA ZOOM

TUESDAY, JULY 29, 2025

9:30 A.M.

Reported by:
Elise Hicks

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P R O C E D I N G S

9:30 a.m.

TUESDAY, JULY 29, 2025

MS. NAKAGAWA: Good morning, everyone. We’re just going to give it a few seconds while people file into the virtual room.

Alrighty. Thank you for joining today’s Integrated Energy Policy Report or IEPR Commissioner Workshop on Firm Zero-Carbon Resources and Hydrogen. I’m Sandra Nakagawa, Director of the IEPR at the CEC. This workshop is being held as part of the CEC’s proceeding on the 2025 IEPR Policy Report.

Today, we are hosting a hybrid workshop meeting in person and via Zoom. For those of you in person, you can find restrooms and a water refilling station available outside of the auditorium if you turn to the right.

This workshop is being recorded and recording will be on the CEC website shortly after the workshop. To follow along, you can find the schedule and slide decks have been docketed and posted on the CEC’s IEPR website.

There will also be opportunities for the audience to ask questions of presenters today. After each panel, we’ll have a few minutes to take audience questions, but please be advised that we may not have time to answer all the questions that are submitted. Zoom’s Q&A feature is available for you to submit questions.

We also ask that in-person attendees who would like to submit questions log on to Zoom to access the Q&A feature. In-person attendees joining via Zoom should keep device volume at zero and mute themselves to avoid audio feedback. You can also upvote a question by clicking on the thumbs up icon. Questions that receive the most upvotes are moved to the top of the queue. For any in-person attendees who cannot access Zoom, please write your question on a yellow card, which can be found at the back table of the auditorium, and bring them up to me so I can read them at the appropriate time.

Attendees can also make comments at the public comment section, both at the end of our morning session, before we break for lunch, and at the end of the day. Please note that we will not be able to respond to comments given at public comment today. Those are limited to three minutes per person, with one person per organization allowed to comment.

We also welcome written comments. Instructions on how to provide those can be found in the workshop notice. Written comments are due by 5:00 p.m. on August 19th.

I'm now going to turn it over to Vice Chair Gunda for opening remarks from the dais.

VICE CHAIR GUNDA: Thank you, Sandra. Thanks for kicking off the workshop. My name is Siva Gunda. I'm one of the five Commissioners of the CEC. I'm the Associate Commissioner for IEPR this year, and also leading our resource planning activities.

In 2021, the SB 100 Report did a number of different scenarios to understand the value of zero-carbon resources, especially the zero-carbon firm resources. It was established in that, that, you know, with the inclusion of some of the generic zero-carbon resources in that, you could substantially reduce the need for overall resource mix. I think there's a number of advantages you have in terms of land use, the ability to diversify our resources, potentially having more inclusion of inertial mass-based resources on the system.

So as you think about the resource planning moving forward, the things that the SB 100 Report has really established is both the need temporal and technological diversity, and the importance of firm resources as we go into, especially over the next 10 to 15 years, as you have more and more deployment of intermittent resources.

So I'm really glad to be joined by Commissioner Gallardo today. And so for today's workshop, much of it is legislatively driven to both study the importance of zero-carbon resources, but also hydrogen, and thinking through emerging and rapidly commercializing technologies, and how to ensure that our planning and procurements take advantage of those resources.

I want to also thank Sandra, David, Liz, and Max for their leadership. A number of staff work on these workshops, and there's a lot of work that happens behind the scenes to make this happen, so a big thanks to all of them.

I want to give a shout out to our CEC presenters, Chie, Jason, Sammy, and Quentin. They're going to be presenting today. But also a big thanks to all the industry experts who are here to provide us with important information to take into account as we develop a pathway and a roadmap for inclusion of more zero-carbon firm resources on our system.

Again, as we think about, you know, the foundational North Star, just thinking about affordable, reliable, clean, and equitable resources, it's really important to think about in a proactive manner, you know, how do we include resources that allow for those qualities to manifest on the grid.

It's also really important, kind of, for us to think about is, as we talk about equity, the non-energy impacts or non-energy variables that we don't always put into our planning. So typically, we optimize around greenhouse gases and the most cost-effective, kind of, distribution of resources, but oftentimes we don’t have a good way to include the land-use impacts, water impacts, air quality impacts in the local communities. And, you know, the resources, studying of these resources, also have a lot of non-energy impacts which need to be really well understood. So looking forward to the conversation today.

And with that, I’ll pass it to Commissioner Gallardo.

COMMISSIONER GALLARDO: Buenos dias. Good morning, everybody. It’s wonderful to be here.

I’ll just give, first, a quick thanks to Vice Chair Gunda for his leadership on this Integrated Energy Policy Report, the IEPR, that has such a major impact on all of California, even if some people don’t know what the IEPR is, have never heard of it.

So I also want to give a big thank you to the team that put this together and enabled me to attend after explaining all the things that we’re going to go over today. I’m really excited about the topics, hydrogen in particular, because it’s coming up in some of the areas that I lead in terms of my portfolio.

So I’ll also add that this year marks the 50th anniversary of the California Energy Commission, so we’ve come a long way. We're doing so much. And the topics today will be part of our future moving forward.

So glad so many of you are able to join us in the room and remotely as well. Looking forward to it.

VICE CHAIR GUNDA: Thank you, Commissioner.

Before I pass it back to Sandra, I just also want to just say we have a number of people joining us virtually. And, you know, just always an important thing to note is the work we do here at CEC is only as good as the participation. And thank you for taking the time to help us be informed and move forward in the most informed and constructive way.

With that, back to you, Sandra.

MS. NAKAGAWA: Yeah. We also have Rajinder Sahota from CARB here on the dais.

Rajinder, do you want to make any opening remarks?

DEPUTY EXECUTIVE OFFICER SAHOTA: Yes. Thank you so much for the invitation to join you all today.

So, you know, I'm the Deputy Executive Officer for Climate Change and Research here at the Air Resources Board. I oversee some of the large planning documents, like the Scoping Plan, and then some of our large regulations such as cap and trade and LCFS.

For me, the workshop today really builds off of the AB 32 Scoping Plan that was adopted by our Board in 2022. It's jointly developed across all the agencies that are key in this space, energy being almost the center of the universe when it comes to climate policy.

On that note, we know that we need hydrogen. We know we need electricity. It all needs to be clean and sustainable. And we know that from the modeling in the Scoping Plan, hydrogen demand will be substantial for hard-to-electrify sectors.

And so when we think about hydrogen production, you know, we want to have options like renewable electricity for electrolytic and biomethane for SMR technologies. And we're also working in other spaces on hydrogen with our partners here and with GO-Biz, such as SB 1075, which will really call for a variety of technical analyses related to the scaling of clean hydrogen. And some of the CARB staff will speak to that today.

So our goal is to make sure we're sending the right market signals for investments to continue to scale this important energy type as we transition away in a thoughtful way and an affordable way from the fossil infrastructure and fossil fuels that we've been using for decades and decades.

So the planning efforts such as this IEPR allow us to hear from you all and staff across the agencies on any updates to the policy or technical space in this area. With that, I look forward to the discussion.

And thank you, again, Commissioner Gunda, for the invitation to join you.

MS. NAKAGAWA: All right. Thank you.

We're now going to go over to David Erne, Deputy Director from our Energy Assessments Division. David will be providing workshop kickoff and some background on the purpose of today's convening.

MR. ERNE: Good morning. As was mentioned, I'm David Erne. I'm Deputy Director in our Energy Assessments Division. And I welcome you all here today to join us for this workshop.

I also want to express our thanks for Vice Chair Gunda and Commissioner Gallardo, as well as Deputy Executive Director Sahota, for joining us on the dais for today's session.

Today is part of CEC's ongoing efforts to support resource planning by assessing clean energy resources and making that information available to all stakeholders, including resource planners.

California has made a substantial amount of progress on transforming its grid. In 2023, California served 67 percent of its electric demand from renewable and clean energy resources. From 2019 through 2024, we've had over 4 gigawatts of fossil retirements, as well as about 25 gigawatts of clean energy resources being added statewide. Incredible progress even just over the last five years.

The focus of that, however, has been primarily solar, wind, and four-hour battery storage. But we all know, as the Vice Chair mentioned, having a diverse set of resources and diverse portfolio is incredibly important. Because if we don't, it makes us vulnerable to supply chain issues like we saw during the pandemic, and certainly continue to see threaten the development of clean energy resources in California.

So we've also noted that it's an ongoing challenge for the utilities to source additional clean energy or clean firm resources.

(Off camera audio-video technical issue.)

MR. ERNE: That's okay. Are we good? Okay.

It's been a challenge for utilities to source this diverse set of resources, and having information helps them to be able to look at those technologies, understand how they can employ them for reducing their emissions, and supporting local reliability, which is particularly important for some of our smaller publicly owned utilities that have limited transmission, having those resources available to them.

So today, we actually have two -- kind of a broad set of topics about clean firm resources. We're going to have a morning session, which is focused on kind of a broad set, an overview of firm resources, and that will help support our, the requirements of SB 423. And then, in the afternoon, will be a deeper dive specifically on hydrogen as potential for the electric transportation sectors, and that supports our work for Senate Bill 1075. We put them together because there's overlap between the morning and the afternoon in terms of content, makes it easier to cover it, and also grabs the broader audience for these topics.

As I mentioned, this morning's session is going to be on a broad set of resources. We're going to start with a panel of utilities to talk about their interests and challenges associated with procuring firm zero-carbon resources. After that, we'll cover an update on our overview of those resources that will be in our IEPR this year, as well as having a panel of technology developers, industry representatives to talk about different resources that can be available and how they're maturing.

In the afternoon, we're going to focus on hydrogen. It's an evolving market, many levels of opportunities available in different sectors in the state, and trying to delve in on those. We'll have Bloomberg New Energy Finance give an overview of the hydrogen market in the U.S., and that will be followed by a series of panels.

One will have producers, developers of infrastructure, end users of hydrogen will give their perspectives. And that will be followed by a state agency review of work that's going on around hydrogen. CEC, the Public Utility Commission, and the Air Resources Board are all coordinating on our analysis on hydrogen to try to make sure that we can look at this topic and help provide insights to all stakeholders.

So with that, I will kind of wrap up my introductory comments. We have a full day, a lot of information. Hope you all enjoy it, find it informative, and just remind you that we'll have multiple opportunities for Q&A, as well as providing comments during the course of the day.

So with that, I conclude my opening remarks, and we will turn it over to Liz Gill, who will be leading our first panel.

MS. GILL: All right. Good morning, everyone, and thank you, David.

My name is Liz Gill, and I'm the manager for our reliability analysis branch here at the CEC, and I'll be moderating our first panel on utility procurement needs and challenges with a clean firm capacity. So we will kick off the panel with Kurtis Kolnowski, the Manager of System Planning Analytics at Pacific Gas & Electric.

Kurtis, go ahead and turn on your camera and unmute and begin your presentation.

MR. KOLNOWSKI: All right. Thank you.

So as Liz mentioned, I'm Kurtis Kolnowski. I've been with PG&E since about 2020. I've been working in this space ever since. My group is responsible for a lot of our CAISO system modeling. We lead PG&E's engagement in the CPUC's Integrated Resource Plan proceeding, which is what I'll be talking about today. But we also, since we have this CAISO modeling perspective, we also model gas-fired electric generation for our system, and that all flows down to decarbonization. So like the System Planning Group within PG&E, it's kind of centralized a lot of the planning. There's many planners throughout the company, but we're trying to be a central hub to help coordinate with the rest of the groups.

So let's go into the first slide.

All right, so PG&E, as a CPUC jurisdictional load serving entity, we participate in their IRP process. And I think the biggest reason this makes sense is the over 40-plus, over 40 load serving entities regulated by the CPUC. And if all of us, especially the ones in the CAISO or certain areas of the CAISO, if we were all to run our own IRP separately and come up with our own assumptions, pick our own preferred resources without any consistency, it would be a very difficult process to try and make some sort of consistent sense out of it.

And one of the things that the CPUC does is, in their IRP proceeding, they establish a common set of assumptions. They put forth a resource portfolio to start the LSE IRP planning process. And then at the end, they actually aggregate up all of the preferred portfolios from the LSEs into one bigger portfolio. And I'll cover this in a little bit more detail than I otherwise would since CPUC isn't here presenting the cover themselves.

So just a very high level. There are a lot of groups or organizations that participate. CPUC oversees the IRP process, like I mentioned, and they do a lot. I want to emphasize the consistent set of assumptions just as a really useful topic. Them and their consultant E3 do a lot of work to get a consistent set of assumptions that everyone can use. And that's things like what technologies are available, what do they cost, how do they operate, when are they available, everything under the sun.

And that's why for this workshop, it's important to engage in that proceeding to make sure that these technologies are captured and modeled there, because it's really the genesis of the whole process for planning and for PG&E and other entities.

Next, I'll note CEC plays a very large role in this process. We're in the IEPR, talking about IEPR proceeding right now. CEC develops the load forecasts that are used for the IRP process, and also provide a lot of technical work that we're looking at. So very, very big part to play. CAISO does an assessment of the transmission upgrades needed. So CEC sends load forecasts to the CPUC, who develops these resource portfolios, sends those to the CAISO, then assesses them for transmission upgrades, and then the cycle repeats every couple years.

CPUC develops a portfolio every year. The LSEs, like us, develop our preferred portfolios every two to three-ish years. Technically, it's on a two-year cycle, but I think just due to some timing issues, the whole cycle process was delayed. So we have an IRP filing coming up soon. The data center, question, clean firm are all going to be of a lot of interest to, I think, all of the entities.

And I'll just note that the final -- there are a lot of other intervenors and stakeholders that participate, like the environmental groups, customer advocates, people advocating for various technologies, trade organizations. There are many stakeholders involved in the IRP process.

Okay, let's move on to the next slide.

So there's really three pillars that I see when optimizing these portfolios or figuring out what the energy system of the future should look like here. These are very, very, very broad. You can use reliability in many different ways, local areas, system, all those. But in general, you want, where we're looking for portfolios to be reliable, sustainable, and affordable. And the question is: How do these balance out? Are there synergies between them? How do we get to a point where we're a reliable decarbonized system with also not breaking the bank?

And that's where these complicated simulation models come in. CPUC runs one called RESOLVE. There's others in the space, like PLEXOS or AVB, that do the same thing. But essentially, you simulate a big system, give it constraints that it needs to meet, so, say, serve this load to a one year in 10 reliability standard while meeting RPS, clean energy, and a specific GHG target. And then the model will actually go and optimize for that and pick the best resource mix.

And I'm saying all this as a lead-in because this is where we're starting to see the clean firm resources, the value of clean firm resources come into play, is where it can help with all three of these. So, like I said, reliability it's almost a non-starter. Like we have to make the system reliable. There are like safety and affordability issues we don't -- like if we -- if the power goes out, there can be monetary implications for like business and safety implications for customers during a heat wave, getting too hot. So like reliability tends to be like the minimum that we're looking for.

After that sustainability, there's CARB sets, targets in the Scoping Plan. The CPUC assesses various targets for GHG emissions. We're currently on a 25 million metric ton by 2035 trajectory at the ISO system level. But those are things that can be looked at.

And I think affordability is a newer one. Like it's always been there, but I have a feeling it's going to take a more front and center look in the future, just as we look at, with this diverse set of resource mixes, how we can serve the load most in the cheapest manner or the most cost effective manner possible.

Now I'll talk a little bit about the problem and then how clean firm can help.

So if you wouldn't mind going to the next slide?

This is the CEC's 2024 IEPR Planning Scenario Forecast. So all this data, you can just find it right on the CEC's website. This is what we would expect to be used in the next IRP to, essentially, the load that needs to be served by different generators when it needs to be built.

I will notice, this is much faster growth and higher growth than we've seen in previous IEPR cycles. And one of the biggest reasons for that is the data center forecast. It's been in the forecast for a while, but it is much larger and a much more prominent piece of the forecast. It's really driving the near-term growth.

In addition to that, electrification, the vehicles and buildings are the other big drivers. Between those three, you've got the vast majority of the load growth. And the reason why we're seeing clean firm be important to these is the help -- that these resources that can generate in any hour of the day or all hours of the day can -- will be generating when these new loads need the -- need the demand -- or have demand. You could also install solar and storage and try to shift the energy, but then you're incurring storage losses of 15 percent. Solar isn't the best resource in the winter.

But yeah, so data centers, very high utilization factor, pretty flat. They need a lot of demand in hours outside the solar period. I almost like to think of them as inverse clean firm generators because they're very -- like their load looks a lot like the clean firm supply.

Electrification, right now, most EV charging happens outside the daytime hours. We can see a lot of it overnight. There's no solar overnight. Clean firm will be generating overnight.

And finally, building electrification, which that's electrifying space heating, water heating equipment, potentially cooking and other appliances, that mostly occurs in the winter. And that's where solar has less value.

So these new loads that we're seeing come online could be well served by clean firm resources.

Do you have my final slide? And I'll just give a -- or I have a little visualization of what this -- or where the clean firm can show benefits. Next slide, please.

All right, so a little data, finally. What I'm showing here, there are two bar charts and then a line. The bars are capacity factors. That's the axis on the left. It's essentially, like for an installed capacity, what percentage of that for each hour of the month -- or how many hours a month or what percentage of that capacity is being utilized in a given -- or generated in a given month. And you'll see existing geothermal plants run around 70 percent capacity factor. The new ones we're seeing estimated around 90 percent capacity factor. It varies by month.

And then solar is this orange line. And capacity factors are in like the 10 to 20 percent range in the winter, up into the 30s in the summer. But it's not nearly as flat and isn't -- or it isn't flat across the day or the year.

On the right axis, we have the 2024 CAISO emissions. So if you look at these by month, you'll see that the spring when we have the lowest -- or the -- we have a lot of hydro and low -- pretty moderate temperatures, the emissions are pretty low. Summer right now, emissions are rather high, but surprisingly -- or not surprisingly, they're not that different from the winter. And as we add more solar and storage and move more load into the winters, I would expect this curve to shift even more and you'll see more emissions in the winter.

This is why I think looking -- I will echo what Commissioner -- or Vice Chair Gunda said earlier, that temporal and technological diversity is important. Adding clean firm to a resource where -- or a system where you already have a lot of solar and storage has additional benefits. It can fill in the gaps in those winter periods or the periods outside the solar hours and ultimately get you to a more decarbonized system. You can really add as much solar as you want in the winter. If it only has a 12 to 15 percent capacity factor, it's not going to do you a whole lot of good.

Other things I'll note, like you may see a couple months where the clean firm, like technology, the capacity factor, goes lower, mostly like March, May, and October. Those are the months most likely where there are maintenance or outages taken, or planned outages taken. When your load is low, you have the ability to schedule when a lot of that happens. So I know for the big nuclear resources and things like that, they schedule them outside the high-demand times as well, which is why you see that fluctuation there.

But yeah, I won't -- I'm not going to talk a whole lot about the challenges in procuring these resources right now. Mainly what we want, what I'm looking for is getting the technologies modeled correctly and consistently in the IRP. I think we'll see, with that high-load forecast, we should expect different results than we've seen in the past, just there's more need for new resources. So it will be interesting to see what resources pop up. It will be important to understand these barriers. I think we'll talk about/hear more about later in the day, though, like ways to get geothermal in the state or imported into the state, or other resources, too.

But, yeah, I'll say, just these resources, just in closing, the resources that -- or the load that is forecasted to come on over the next 15 years really hits the hours where a clean firm resource could have a lot of benefit. And that's a good reason to take notice right now and why this workshop itself is very timely.

So that's it for my presentation. Thank you all for listening to me talk your ear off.

MS. GILL: All right. Thank you, Kurtis.

Next up, we have Mandip Samra, the General Manager with Burbank Water and Power.

All right, go ahead and start your presentation, Mandip.

MS. SAMRA: Well, thank you so much. I really appreciate being here. So I'm also going to talk about our Integrated Resources Plan.

So previous to me becoming the General Manager, I was the Assistant General Manager of Power Supply, and I led the efforts on our IRP. So I'm going to talk about the role of clean firm resources in our IRP. So I just want to also focus on how we did our IRP before we go into it, so before I start talking about public outreach, we are regulated by the California Energy Commission.

We are a publicly owned utility. We have 55,000 electric customers. Over 70 percent of our load is our commercial customers. We are Hollywood, so a lot of the big studios are actually housed here in Burbank, and they are our biggest load using customers. We also have our city council that approved our IRP, and Black & Veatch developed the models. We wrote the IRP. Actually, I wrote the majority of the IRP.

LADWP is our balancing authority. We are not part of the California Independent System Operator, so we have very limited transmission. We could only bring in resources where we have contracts with LADWP to bring in those transmission -- or the resources via transmission.

We also don’t have any, you know, resource adequacy. When we do have capacity needs, our backstop procurement is LADWP. We actually do a contract with them every single year for backstop procurement for additional megawatts if we need it. So I just wanted to give that context.

In terms of our IRP, I do want to highlight that we did a major public outreach for this. We had nine meetings with stakeholders that represented every facet of our community, from low-income customers to residential customers to the studios, to environmentalists to some of the city leaders, as well. We had four large community meetings, which were open to the community. We had anywhere from 10 people to 100 people attend those, and we had those in four different locations to make sure that people were able to attend from different parts of the city.

We did a survey, and we’ll talk about the survey later. We had 952 responses, so that was pretty good compared to a couple of other places I've worked at where we had a couple of hundred responses.

We actually had 10 meetings with our board, so I would give updates every month in terms of what was going on. We also had a Burbank Water and Power board member as part of our stakeholder team.

We also had two meetings with City Council before we went for approval just to get updates on the IRP of where we were. This allowed for a very smooth transition to approval. I think between my presentation and approval, it was 15 minutes at City Council. So it was a smooth process because we had community output every step of the way.

So we did have a lot of data assumptions that we had to make. So this is back in 2023, so we did not include data centers during that time. But since that time, it was two years ago, we've actually had a lot of data centers come to us because Burbank has a lot of high reliability.

We're actually one of the highest reliable utilities in the state and part of the top five percent across the nation. We have high reliability. And even though we went through some rate adjustments, we are still one of the lowest cost utilities in Southern California. So high reliability and affordability are key reasons why data centers want to come here. So since then, we've actually had a few come talk to us.

And during that time, our natural gas prices were a lot higher than we forecasted, and our energy prices were correlated with the natural gas prices as well. That's just some of our data forecast.

Sorry, I'm just -- here you go

And then with renewable energy, back in 2023, the REC, the renewable energy credit, that we had forecasted, not the actual energy, was at $44.00. I think we were in compliance period for then, so there was a big push and a high demand for it. By the end of our IRP, it was actually $85.00. Those prices have since fallen, but we did assume those in our IRP forecast.

We're also part of the Intermountain Power Project, which is a coal facility now that transitions to a natural gas facility. The cost for that resource has also gone up. So everything that you see in the current update was not included in our IRP. Only the stuff that says April, May assumptions were included. So a lot of our costs have gone up since our IRP was produced, and I just wanted to highlight that.

The Intermountain Power Project is actually located in Delta, Utah, so it's not in California. It's adjacent to the Southern Transmission System. That is a transmission line that is 500 miles long that allows us to also bring in renewables.

And then, in terms of technology assumptions, we had to assume that our local reliable resource here, which is the Magnolia Power Plant, would be run by hydrogen by the time 2045 hit around. We also were looking into renewable natural gas, but there was nothing available, so we did not model for that.

And then with carbon capture and sequestration, we were looking into that as well, but we needed four additional acres, and that does not exist adjacent to our site right now.

We did include small modular reactors and also geothermal, which is not listed here, as part of our resource mix to get picked up as well. We were modeling this after the New Scale Project, which is the Idaho Lab Project at $89.00 plus an additional $25.00 for transmission. The project no longer exists, but there are other SMRs that are happening across the country and adjacent to where we have transmission, so we are still looking at those options, and you will see that when I go over our preferred portfolios that were picked up.

So these were the two selected scenarios. So most public utilities, when they submitted an IRP to the state, they selected one scenario. We actually selected two, and this is -- there’s a reason why. We actually don’t know what is going to happen in the future, we don’t know what technology is going to exist, so we wanted to have two viable paths forward.

So the first one was complying with SB 1020, which is, you know, getting to zero carbon a lot faster, but also including small modular reactors in the mix post-2030. This would be outside of California, adjacent to where we have transmission lines. So there are thoughts about the SMRs being built near the STS, where we have transmission, as well as an urban transmission system, and also possibly part of the Pacific DC intertie, which goes north-south, and Burbank has part ownership of that as well.

We also looked at LADWP's long-term transmission plan and focused on the buildout of new transmission and additional Power Purchase Agreements. And here, we really focused on geothermal and access to geothermal in the Salton Sea and at the Imperial Irrigation District. Part of the publicly available documents that are available at LADWP, when they talk about transmission planning, is a possible line that connects directly to the Imperial Irrigation District to get access to those geothermal resources.

So those were the two selected portfolios, and they were selected based on affordability and reliability. Sustainability was actually voted last in our ranking based on our surveys and based on the discussions we had with our stakeholder group.

And then, this is kind of how our scorecard worked. Our scorecard was developed with our stakeholders in mind, so this was a very democratic process. So affordability was number one, as well as reliability. Given that we do run -- the studios run off of our electricity and they really rely on us to have reliable power, that was one of the reasons this was selected.

Affordability was also key from our residential customers, in particular in our small business club stores. We were hit hard with the rider strike and the screen actor strike, so a lot of people that used to come into Burbank no longer do, so they're not really going out to the small businesses, and so they're really focused on keeping their rates low.

Environmental stewardship, we are still intent on meeting all the state goals. That fell to 10 percent because that was just the ranking that our stakeholders chose.

Lastly, was diversification. It is mandated by SB350 that you don't put all your eggs in one basket. So we had to look at portfolios that wind, solar, geothermal, batteries, and plus solar and other items. We couldn't just put everything in the solar basket for any other resources. We also looked at location of resources, making sure they're not all located in one area as well, and diversifying the size of these resources as well.

This is our scorecard result. So I will say, the next slide will show what we had to eradicate. So the one that was voted number one was a model run that we did with reduced demand. That was not going to happen, so we actually took that out of the mix. And we also took anything that had lower demand in it out, because after we had started the IRP, we actually had additional load that was added to our system.

So these were the selected scenarios based on their ranking and the scores, just so you could see them for perspective. So our first one, really says number two here, is the new transmission and additional PPAs, and the second one was meeting SB 1020 and, you know, adding SMRs to our mix, so that's why we selected those.

And then, in terms of projected rate increases, I'm going to tell you right now, these are a lot lower than where we're standing right now, but when we ran the IRP, these are the two additional rate increases year by year that we would have to do for 20 years. For the SMR one, it's about five percent every single year just on our energy charge. This does not include infrastructure. This does not include any technology upgrades that we're doing.

Just for our energy portion, it would be five percent, actually for at least 20 years. And for the new transmission and PPAs, at least four percent for our energy charge for perpetuity. We actually looked at this and pretty much go on for beyond my lifetime.

So that's just something to keep in perspective; in order to build a transmission, it costs money. And everything has only gone up. The geothermal resources that we did have modeled were in the $70.00 range. We can't see anything less than $100 right now. So these are significantly higher now than they were when we forecasted those. So it's really important to highlight the projected rate impacts, and we did talk to our city council about this as well.

So I'm having a little problem going on with the slides here, but this shows right here just a projected increase over time. So you can see just a portfolio cost dollar per megawatt hour and the total system cost. So the total system cost for new transmission and PPAs from year one, which is 2023, all the way to 2047 was about three and a half times the cost. And like I said, this is only -- this has probably doubled since that time, so that is just something to keep in perspective. This is a snapshot in time. But when we show this to the public, I mean, it is eye-opening that everything does cost money, and it isn't until 2035 that the transmission really were to be built that we could actually bring that in. So there's a delay on the transmission.

And now that we're looking at it, no new transmission has been built to date, so this is actually going to probably get delayed beyond 2035 if it happens.

Sorry, I'm just still having problems moving the slides.

And this is just the load mix for the new transmission and PPAs. You can see that geothermal is the one that we would start adding, and that is what increases over time.

You do see H2, which is hydrogen, for our Magnolia Power Project. We would bring that online in 2040. The reason we would bring that online in 2040 is because Burbank has a goal of going zero carbon or zero-carbon resources by 2040. That would require a large investment, close to $1 billion, to modify that project. That's what we're projecting.

The other items that you see in here are our hydro, which is our Hoover Dam project. So we still have that. That's still going on for the next 50 years.

Coal would be removed starting in 2025. That resource is actually shutting down in October of this year. We will no longer have coal. It will transition to natural gas.

Solar is still a big portion of our resource mix, but you do see that natural gas on the very, very bottom disappears by 2040 and transitions to hydrogen. That is all assuming that hydrogen would actually come online. We're not quite sure if that's going to happen and when it's going to happen, but we do hope that it does happen relatively soon so we could plan for it and really figure out what the cost is going to be for that as well.

This is the resource mix for the SMR1. The difference that you see here is you see that the nuclear comes in starting 2030. That is probably going to be most likely delayed. There are a few projects that are, you know, being built in the Pacific Northwest, but we are looking into those as well.

The one that we did model in here is no longer happening, but we are still focused on that. It is really important for us to focus on clean firm resources and small modular reactors, and geothermal happen to be those resources that we are looking into. We're probably one of the few utilities in the state of California that's looking into SMRs, but we've done a lot of research on this and we're also partnering with other entities outside the state. We're looking for partnerships with private companies as well since they're looking to do this as well.

We're looking at data centers. We're going to need a lot more resources to come in.

One of the things I did not highlight that we cannot model in IRP, but we will model in the future, is we do need another tie point to bring in additional resources to Burbank. We do have a tie limit with our transmission coming into the system. So because of that, we do have to start building that and working with two entities, which is LADWP, and also, possibly we have a tie in with Edison. But with Edison, it's a different balancing authority, so we're not quite sure how that's going to work out.

That's all I have. Thank you very much.

MS. GILL: All right. Thank you, Mandip.

Next up, we have Sara Elsevier, the Manager of Resource Planning with the Sacramento Municipal Utility District.

Sara, go ahead and turn your camera on and unmute, and you can begin your presentation.

MS. ELSEVIER: Hi, everyone. My video, for some reason, is not turning on.

MS. GILL: It's okay. You can go on without the camera.

MS. ELSEVIER: Yep. Okay. Sorry about that.

Hello, everyone. My name is Sara Elsevier. I have been -- I am the Manager of Resource Planning here at

SMUD, and I've been with SMUD since 2018, working on long-term planning.

Next slide, please.

We got a really good overview from the last two presenters on the process of long-term resource planning, so I think my presentation will kind of add to more of the details of the planning process.

Here's an overview of SMUD. I know most are very familiar with SMUD, so I will breeze through these, just that SMUD is a community-owned, not-for-profit electric company, and we don't have any shareholders, and that we make decisions that are in the best interest of our customers and community.

We are one of the cleanest utilities in the nation, 50 percent of our power supply coming from carbon-free resources, including hydro and renewables. And we are focused on a long-term goal of zero carbon by 2030, and I will get into that more in the next slides.

Next slide, please.

This timeline shows SMUD's environmental activities, which started in the '90s, just an overview of how active SMUD has been throughout the years. We had a customer PV program that started in 1991, for example.

In 2004, we established our Strategic Directive 9, which is an internal directive that sets internal goals for our internal environmental goals for us internally. The timeline also shows that we have been in compliance with RPS goals throughout the years.

And one of the major decisions that our Board of Directors made was in 2020, as you can see, they declared a climate emergency and set a goal of eliminating carbon from our energy supply by 2030. Staff put together a plan to achieve this goal by 2030, and as you can see, this plan is flexible and has ups and --

MS. GILL: We may have lost Sara's audio.

MS. NAKAGAWA: Sara, if you're able to re-join, that would be excellent.

Maybe we'll take a one-minute break and see if we can get Sara back online.

(Pause)

MS. NAKAGAWA: Yes, Sarah, if you can try to speak even when we aren't hearing you.

All right, we just heard from one of our colleagues. Her computer shut down and it's restarting, so we're just going to give it another minute or so. Yeah.

VICE CHAIR GUNDA: I think Catherine probably can do the voiceover or no? Do you want to just wait for a few minutes, is that -- okay. All right. Thanks.

We have an open mic if anybody wants to come and do some jokes.

MS. NAKAGAWA: So I guess this is a good time to remind folks that if you do have questions --

VICE CHAIR GUNDA: Yeah.

MS. NAKAGAWA: -- from the panelists, you can use the Zoom Q&A function. We actually have no questions right now, so yours will go to the top of the queue if you want to ask any questions to any of the panelists today. And if you see questions in there that you would like to have answered, you can thumbs them up and have the upvote feature there as well. So feel free, any audience members, if you would like to ask questions to the panelists.

VICE CHAIR GUNDA: Yes, Sandra, as we wait, maybe I can just ask a couple of questions.

You know, just kind of going back, so first of all, Mandip and Kurtis, thank you so much for your presentations. We'll make way for Sara when she's back.

So just, Mandip, on the survey results, can you just explain -- I mean, first of all, it's super interesting, you know, the kind of using the surveys to weight the scenarios. Can you provide a little bit of context on, you know, the community participation in it and, you know, the support? And also between the ranks one, two, and three, you know, the preferred doesn't include the rank one. Could you just expand on those two while we wait? Thanks.

MS. SAMRA: Yes. With our survey, I think it was 10 to 12 questions. They were focused on what people in our community really cared about. We actually sent a few bill inserts. It was on our website. I believe it was posted for about eight months. So we stopped. We kind of cut it off in early September so I could have all the data sets getting ready to go. We actually had a few more people respond to it, so I think it ended up being over 1,000, but I only included 952.

But we asked questions like, you know, what kind of customer are you; are you business, residential, et cetera? We had a mix of customers, so it wasn't anyone in particular. We also asked them to rank their priority. Do you care about customer programs, do you care about EVs, things like that. But most of the questions were focused on how much are you willing to pay for the IRP and the outcome of the IRP? The majority of our responses were zero. They didn't want to pay for any of the outcome.

And then we asked what was important to you, reliability, sustainability, affordability, and that ranking was very, very clear. So it came out with affordability was number one by a landslide, and then reliability, and then really almost dead last was sustainability. But with us, we are stewards of the environment, we really do care. We want to meet the RPS goals, but with our community, that was really not in their best interest for what they needed. They needed the lights on.

But we also went out with the community and talked to everybody, so we had a mixture of commercial customers and residential. It was a majority of residential customers that came with these, but we also had a lot of members of the sustainability community. We did have a couple of members from large corporations that support sustainability. Once we explained small modular reactors and how they work, they actually did not, you know, oppose it.

So not coming out and support is better than opposing it, so that's what we got. So actually, I really look forward to them. We went out a lot. So I was out there in the community pretty much every single week hosting meetings and inviting people to the office. I also had probably about 50 or 60 one-on-ones with members of the public to discuss the IRP as well.

VICE CHAIR GUNDA: Thank you, Mandip.

Sara is back?

MS. NAKAGAWA: Yeah, it looks like we do have Sara back, so we can check, Sara, if your audio is working, and you can pull up the slide deck again. Okay, Sarah, I saw a video there. If you want to unmute, then we can check the audio.

MS. ELSEVIER: Hi. Can you hear me again?

MS. NAKAGAWA: Awesome. Yes.

MS. ELSEVIER: All right. I'm actually -- hold on one sec. All right. Can you guys hear me?

MS. NAKAGAWA: We're getting some feedback. It sounds like there might be two devices going where you are.

MS. ELSEVIER: Yeah, I got off one.

MS. NAKAGAWA: That's much better. Yeah, we can hear you now.

MS. ELSEVIER: Okay. I'm sorry about that. I have no idea what happened. That was very strange. Hopefully, it won't happen again while I'm presenting. Okay, I really apologize. You can always count on technology to do this to you; right?

Okay, going back to the history of environmental leadership, I mentioned that our goal is a very flexible pathway to eliminating carbon from our generation supply by 2030.

Next slide, please.

Where we're headed, this is just an overview of our Zero-Carbon Plan that became our official IRP back in 2022. There are five main areas that we focused on when we put the plan together.

Repurposing our natural gas generation. There are many ways this can be achieved by replacing or repurposing our local gas generation. This is heavily dependent on reliability studies and are being updated as new solutions are proposed.

Increase the amount of proven clean technologies, the second area. These are technologies like wind, solar, geothermal, hydro, biomass, battery storage, and also customer and behind-the-meter solution.

We estimate that these two areas, these two pillars alone, could potentially get us 90 percent of the way to achieving our zero-carbon goal.

The third area is adopting new technologies and innovation projects where this new firm community sources come into play, kind of closing that last 10 percent gap of the pathway to reach our goal.

And expanding, definitely, expanding partnerships and pursuing grants and everything possible to keep our rates low and affordable as they have been.

And also, throughout this process, bringing our community along, maximizing our community benefits by creating new clean jobs and involving our community in every step of the way as much as possible.

Next slide, please.

Our ZCP Plan has, as folks from PG&E have already mentioned, we do have the same guardrail, affordability and reliability. And that's why the plan was designed to be a flexible plan, because our priorities are these two metrics, which is why there's more than one way to achieve the goal.

Also, we understand that achieving the goal also depends on factors external to SMUD, such as what we have all seen in the recent months, import tariffs, tax credits, renewals, policy decisions, and the economy in general can really impact achieving this goal.

Next slide, please.

And this is a snapshot of where we are and what our progress is to date. It's an overview of our progress. We've made great progress since developing the 2030 Zero-Carbon Plan. As you can see, we have completed several projects, solar battery storage, geothermal, and wind projects. In 2021, we brought over -- we have brought over 300 megawatts of renewable and energy storage projects.

In 2023, we added 100 megawatts of geothermal energy to SMUD's portfolio coming from Calpine's operations at the geysers. This past spring, our Solano 4 wind project came online. This project involved replacing 23 old turbines with 19 new larger turbines at our Solano wind farm.

And this year, the SloughHouse Project, which is a 50 megawatt solar project, will be coming online locally in the SMUD service territory. We also continue to support distributed solar and storage installation and launch and pilot other programs, such as virtual power plants, to reduce the use of our thermal plants.

As you can see, between 2026 through 2030 -- or 2025 through 2030, we have a number of other projects that are in the works and development phase. And we have so many more in the pipeline that we're planning to bring online.

Next slide, please.

With all the progress in improving clean technology, like solar, wind, and geothermal, we know that the absolute zero-emission goal can't be achieved without firm clean resources. As you can see, 90 percent of the goal potentially can be achieved with those resources, but we still have the 10 percent gap. And when you add in large data centers, electrification, load growth, all those challenges really highlight the need for a firm clean resource.

Next slide, please.

Our studies have shown that the need for clean firm resources is especially important during very prolonged low solar and wind production. We have, actually, an example from our own system back in January of 2022, SMUD's experience of a long weather event that limited our solar production to under 10 percent of its capability for a period of two weeks.

We need resources that can provide inter-hour balancing firming across days, weeks, and seasons, provide ancillary services and all benefits that our natural gas resources provide today. We have pursued clean firm resources even before our ZCP, but made it a priority to follow these technologies in the last five years and will continue to do so. We have focused on long duration energy storage, hydrogen, carbon capture and sequestration, and other technologies, and we'll continue to watch these spaces.

Next slide, please.

As an example of our pursuit of clean firm resources, we supported Calpine Sutter CCS Project application for a DOE grant back in 2023. This project plans to convert the existing gas plant to include carbon capture and sequestration. The sequestration site is on a nearby storage site and doesn't require any new right-of-way, transmission, or interconnection upgrade. SMUD's interest is potentially to take off some of the energy through a Power Purchase Agreement. The project entails our estimation at this point and any following.

That grant application was successful and Calpine was able to secure a $270 million grant. But unfortunately, in the last few months that grant was canceled. However, as we understand it, Calpine is still pursuing developing the project and SMUD will consider terms and conditions, hopefully in 2026, and it will be a public process and we'll bring it to board for reviewing of the terms of the agreement.

Next slide, please.

What are considerations and challenges?

Maintaining affordability and reliability definitely are the two main challenges. We talked about some of these factors, including weather volatility that impacts renewable resource availability like solar and wind and hydro. This highlights the need for development of firm clean resources. However, technology readiness is a challenge that many new technologies are facing. They're not viable or commercially available yet. The upward cost for developing projects, including proven clean tech and new technology resources, hasn't really been helping that technology readiness issue.

The other challenges are also -- and also an opportunity is the regulatory framework that will help enable long-term planning and investment. Clear and consistent recognition and definition across the state agencies and environmental policies will help many technologies like CCS.

Also, as we transition away from carbon-omitting resources, we need to be careful and ensure reliability metrics are maintained before we completely transition away. Things like parallel operation of new clean solutions to existing resources is a way to meet reliability requirements.

There are a lot of clean firm resources in the works and I hope as a lot of the new changes settle down and we understand their impact, we're able to move to a more maturity state for these technologies.

I think that's my last slide. I'm sorry I kind of ran through this slide, worried that my computer would turn into a blue screen again. Thanks for having me.

MS. GILL: All right. Thank you, Sara, and I'm glad we were able to get you back online.

Next, we will move to dais Q&A. So if our panelists, except for maybe Sara, can turn their cameras back on, I will pass it to Vice Chair Gunda to lead the dais Q&A.

And as a reminder, the Q&A is still open, will be open for the remainder of the workshop, in the Zoom Q&A feature. So if any audience members have questions for the panel, just a reminder that you can drop those questions in anytime.

VICE CHAIR GUNDA: Yeah, thank you, Liz.

And first, I want to thank Kurtis, Mandip, and Sara for the remarks, really helpful information. I wanted to kind of set up a few questions and see if Commissioner Gallardo also has some questions, and then we'll open it up for Q&A. Looks like we're about 10 minutes ahead of schedule at this point, so we have a little bit of time.

All right, so, you know, Kurtis, maybe, you know, just kind of looking at different questions and coming back, you know, the rest of the panelists can weigh into as you see fit.

So, Kurtis, just on the point that you made that was really helpful in terms of the match between the load shapes and the capacity factors of like, for example, data centers and kind of how they match well, and then at the same time, the mismatch of current electrification load profiles with some of the intermittent resources, just maybe take just the data centers because it's a common theme. I know we're doing a lot of to improve the forecasting and to put some, you know, expected loads in. But are you hearing from data centers in terms of what their needs and, you know, exact -- I mean, specifically to zero-carbon firm resources, whether it's coming from supporting the load shape, supporting the RECs, supporting the goals of the specific industry, tech sector?

MR. KOLNOWSKI: Yeah. So I personally haven't heard anything from the data centers. I know that we have a whole Task Force working on that problem, working with the data centers. I do know that like PG&E is interested in that from our perspective, like decreasing emissions and serving that load as effectively as possible. But I haven't heard anything from the data centers themselves around that.

VICE CHAIR GUNDA: Well, so, okay, so just going to maybe step into the reliability conversation a little bit. And I think from establishing the value proposition for zero-carbon firm resources, I mean, obviously the diversity and all is recognized, but just looking at reliability and affordability as two important guardrails, as both Mandip and Sara kind of framed. Could we just talk a little bit of, I'm going to have a long question, but tell me, you know, just kind of frame however you see fit.

So, one, just starting with that planning regime in terms of a 1-in-10 planning, is that adequate moving forward; right? So given that, you know, kind of the futures are constantly changing, the tails are kind of growing, is 1-in-10 paradigm still an enough planning regime? That's one.

And then two, in the current planning regime, do we think that we're capturing the variability of solar and wind well enough; right? So one, is the planning standard good enough? Are we even capturing the variability well?

And then that kind of bringing it to the third point of are we adequately capturing the local and flex capacity needs as it pertains to reliability?

So if I take those three, so is the planning regime good enough? Are the assumptions that have solar and wind, you know, adequate? And are we looking at local and flex adequately? If I look at all those three things, you know, it just points to me the real importance of, you know, the resources in terms of those firm resources that you can call on.

Could you all kind of just talk through specifically through the reliability, how you're thinking about the need for zero-carbon resources? I think, Sara, you give a really good example of, you know, two weeks, you know, in 2022 having less than 10 percent of the solar that you're kind of expecting on the system. Can you three comment from your perspectives?

I think, Mandip, from Burbank's perspective, you have a small enough region that, you know, you have some pros, but also some cons in terms of where you depend on, versus, Kurtis, you have a very large footprint, and then the ability that both could kind of get removed in the noise, but also can provide situational difficulties, especially in flex and local issues.

MS. SAMRA: Yeah, I mean, I could start briefly. We did plan for 1-in-100 event happening pretty much every other year. So since I've been here, I've been at Burbank since 2021, we've had hurriquakes, it was hurricane-like winds and an earthquake. We've had the firestorm and the windstorm that just happened. We had three massive heatwaves. These are all 1-in-50 and 1-in-100 events. So our IRP was forecasted having those every two years. And I think going forward, we're going to have to have those every year.

We also plan for having, you know, a heatwave two weeks every September. So that was forecasted in our load. We did not go back 30 years to look at what was happening. We only went back five to six years because things have changed so rapidly.

The other thing that we did, too, with solar and wind is we did go back historically to see how those units were running that we own or have PPAs with, so Power Purchase Agreements, so we modeled those for future solar projects.

We have one solar project in Nevada that's adjacent to a mountain, so it also, it gets exposed to shade. So one of the things that this has led to is any project that we sign, we actually go and look at the site, too, before we sign it to make sure that it's pretty clear, and we also look at weather patterns. So all that is taken into consideration.

We don't have the RA requirements because we're not part of CAISO. but having Magnolia Power Project, which is a combined cycle, resources mostly steam and natural gas on our campus, helps with our flex capacity. We actually can go ramp it up and down. In 2020, we went through major upgrades, tens of millions of dollars, to allow it to ramp up and down every five minutes.

MR. KOLNOWSKI: Would you like me to go next? All right, so three questions in there.

I'll start on the 1-in-10 planning standard first. My understanding is that's a pretty well-established in the industry. It doesn't mean planning for a 1-in-10 year. It means planning for one event occurring every ten years. And the assumptions that go into that would take -- encompass a lot more.

I agree with what Mandip said. Looking at more recent history can help with some of that. Like I know we've been working internally in some of our forecasting to look at more recent history, like for forecasting hydroelectric generation and things like that, because things are changing.

I would say that the 1-in-10 planning standard, like whether it's adequate or not itself is a determination that should be made through the IRP proceeding, but the assumptions that go into that are definitely something that we should be looking at, and things we may not be capturing. The impacts of climate change could make certain events occur more frequently, so they'd be occurring -- be more likely to occur every ten years, think solar profiles, the heat waves, cloud cover, everything like that. So even if the standard is correct, we should definitely make sure that the assumptions going into it are right.

One thing I will note about clean firm and how it can help with reliability, we actually have been looking a little bit at just this simplified slice of data tool. That's the way that the CPUC tracks RA program accounting. And one of the things that you need for that is energy sufficiency on a peak day. I think this is really important during a heat wave. Your day three of a heat wave, your batteries are going to be fully discharged from the day before. Y

You need to charge all those batteries to be able to start the load. You can build a lot of solar, charge in the middle of the day, or a clean firm resource that's generating overnight, in the morning, throughout midday. You have all those hours to charge your batteries, and we can actually see bigger shifts. Like if you add a thousand megawatts of clean firm, it may re-optimize the batteries to get even more benefit in certain hours where you really need it. So there's definitely work there on the reliability.

I sort of answered the second question on variability. I think that variability increases more under climate change. I know the CPUC is leading a big effort statewide to develop a lot of data on climate change impacts and how it could affect various things like hydro, solar load, things like that. So I would say that is definitely of interest.

And finally, local capacity. One of the things I believe the CAISO studies have found is just adding solar itself to any local area -- or sorry, storage itself to local areas isn't enough because you need to get the energy to those areas as well. So that's why gas plants in local areas are still a thing and still may operate above what you would expect normally. I don't know if like there are different clean firm resources that may support that more than others. Like I think geothermal resources are, you know, located in the northern and southern parts of the state, so they may not do the local thing themselves. But other resources, if they can be located in those local areas, could definitely help.

And I'll note just a little spoiler for our comments coming on Friday on the new IRP OIR, we are suggesting that the local area reliability get more attention as we go through it, because we do see that that may be the last bastion for gas emissions, if we can't solve the local area issues.

VICE CHAIR GUNDA: Thanks Kurtis.

I don't know if Sara has anything that you want to add?

MS. ELSEVIER: Yeah. So definitely, we have also found that it's a really good question to ask about the 1-in-10 being still a good metric for reliability. And we've been spending a lot of time kind of, as Mandip and Kurtis mentioned, looking at historical data and really focusing on our forecasting to make sure we are capturing some of these climate change issues that we're experiencing.

However, that's a work in progress. We are working with consultants and industry partners to kind of look at reliability as an overall issue, so 1-in-10 is definitely part of that process. But we are focusing on different tools and different metrics, looking at a loss of load hours, and things like that, that may not be captured by the 1-in-10 metric. We are continuing to kind of follow that standard, though, definitely.

And also for the local capacity, we are very closely coordinated with our transmission planning and operation team and our risk management team to really make sure we are following the minimum local capacity needs that these teams operate based on in our planning process. So making sure that we are meeting those requirements.

VICE CHAIR GUNDA: Thank you. I know Commissioner Gallardo has a question.

Rajinder, please let us know if you have a question as well.

I'll just -- if you have a short response to that so that, as so I don't monopolize all the time. In terms of -- so we talked about just the reliability, and I think there is a very clear need for zero-carbon firm resources on a variety of kind of fronts for reliability.

On the affordability, can both of you comment, well, can the three of you comment on this tension we have between the needs for investments and market certainty to achieve the scale and the cost effectiveness versus trying to do the most cost-effective solution today and kind of holding off on those investments? Can you just talk about how each of your companies or entities are thinking about how best to do this?

MS. SAMRA: I can start off on some of the infrastructure stuff that we're doing. So one of the things that we moved to was converting our 4 kV lines to 12 kV lines, which allows more electrons to flow on the lines.

That's a short-term solution since we're also looking to build up transmission adjacent to Burbank. That was a 20-year plan. We moved it up to 10 years, and we're trying to expedite that.

So that's one of the things that with low-hanging fruit, it's very costly, but in the long run, it's going to help us. So that's one of the things that we did with our budget cycle this year, we moved that up.

The other thing is looking, you know, looking forward. We're looking at SMRs, so small modular reactors, and we're really just partnering with, talking with the Department of Nuclear Energy. We go to DOE quite often. We also want to look at all different types of technologies. So we're really focused on thinking outside the box.

And with hydrogen, you know, with federal funding kind of kiboshing some of the hydrogen funding here, we now have to think outside the box what we're going to have to do with this Magnolia Power Project. We're doing more efficiency improvements here. What it does is increase megawatts, reduces emissions.

So I think as that technology comes to fruition, we're going to keep doing that. So that's one thing that's very costly that we're doing right now, because hydrogen is currently off the table.

MR. KOLNOWSKI: I can add a little commentary on what we're doing in the CAISO, so two things.

The first, there's a lot of uncertainty. Like you mentioned, Vice Chair Gunda, there is a lot of uncertainty in which resources will come online, what they'll look like. I think just a couple years ago, like in 2022, a lot of the IRPs had offshore wind in them. Now we're kind of looking beyond that. There's some issues around cost and the generation that are coming up. That may not be the goose that lays the golden egg anymore and now we're thinking, oh, is it CCS, is it nuclear, is it geothermal, biomass, something else?

So I like the way that it's currently being done. The CPUC has requested that the Department of Water Resources open a solicitation for -- I believe, it's up to 1,000 megawatts of geothermal. But they're very clear that it's not to be built or purchased at any cost. So there, like looking at these diverse resources, geothermal, offshore wind, other things, and getting a chance to compare the cost rather than building at any cost will be helpful.

The other thing I would note is the, well, the cost that we see today ideally won't be the cost that we'd be paying in 2035 or 2040. Number one, we want to see all of -- we should see all these technologies considered in the IRP in 2035 and 2040. I know right now, CCS is one that is not included in the CPUC's IRP process. I know they're working on it, but we should be making decisions that far out until we have all the resources accounted for.

But, yeah, the other thing is just we need to make sure we understand what the cost could look like in the future. My understanding is like it may be more expensive right now to do geothermal in-state versus like Utah or Nevada. Asking the questions why, how can we bridge that gap, or can we produce that cost by the time that these resources are ready to come online would be a good way to help with affordability there too.

MS. ELSEVIER: For us, a very maybe similar approach. Definitely we are monitoring the challenges with costs and definitely feeling it here. We are trying to focus on lower cost solutions that have bigger impacts.

For example, one of our gas units, our custodian's (phonetic) gas unit, we just implemented this, basically, upgrade on this unit to turn -- to change the minimum point from 300 megawatts in that unit to 200 megawatts. That would really have a huge impact in the operation of that unit. It's not completed yet, but it will be later this year.

So things like that, we are trying to invest in technologies and solutions that will keep us within our affordable heavy guardrail as these other more expensive solutions mature. And hopefully -- like I mentioned in my presentation, that all these changes have happened recently and in such big scale. So until all of this settles down and we kind of understand the impact, we are marching along and trying to take advantage of what's available and what we can afford in the meantime.

VICE CHAIR GUNDA: Thank you, the three of you.

I'm going to pass to Commissioner Gallardo.

COMMISSIONER GALLARDO: Thank you. I'll try to be quick.

So first, I wanted to say blessing to anyone who's sneezing. I couldn't say it during the time people were talking, but I know it's cold in here. If it gets too cold, let us know. We can see if we can make some adjustments. But anyways, just know that I send you a bless you.

Second, I did want to emphasize for our three speakers, I really appreciate what you mentioned about the struggles addressing the climate change issues. Our chair, David Hochschild, always says that it's hard to fight climate change because of climate change. The weather is just so erratic, so extreme, so it's hard to keep up with it, let alone get ahead of it. So just want to acknowledge that we appreciate all of the diligence you're putting into trying to affect change on that front, as are we.

Kurtis, I also had a question on the affordability. You mentioned, and it stood out to me, that it's become, it's always been important but it's become front and center.

And Mandip also mentioned affordability being one of the number one criteria for constituents.

But Kurtis, I was curious if you could speak maybe briefly on what is bringing it front and center.

MR. KOLNOWSKI: Yeah. Well, I think it's no secret that rates have been going up for various reasons for our customers. Not everything is within our control. Like if gas prices go up, the price of energy goes up. And I think it's becoming more front and center on our customers' minds, which means it's becoming more front and center on ours, too.

And like I guess what I'm wondering or looking to do on like how that could change is like, right now the -- like it almost needs -- it needs to be its own pillar alongside affordability -- or sustainability and reliability going forward. Like right now, we run the models and see which is the least cost, but there may be more effective ways to do it if we consider all of the costs, like transmission upgrades, interconnection costs, all that, maybe there's a cheaper solution we can find somewhere in there.

But, yeah, it’s really driven by trying to stabilize rates and keep the prices lower.

COMMISSIONER GALLARDO: Okay, thank you for that. It’s helpful to get the utility perspective. And then I’ll just do one for each of you, since we’re short on time.

Mandip, I was curious, you mentioned the geothermal agreements with IID. Would that be for existing power plants or new power plants? Are you able to share that with us?

MS. SAMRA: Yeah, we we’re actually, you know, based on LADWP’s transmission planning process and things that were brought up there, so it would be new projects. So, drilling in and getting new projects, you have the Salton Sea right there, and it’s all in Imperial Irrigation District territory. So just having transmission accessibility there would be ideal for us. And LADWP that’s on top of their list to do, so we’re really counting on them to do, and that’s what we model for.

COMMISSIONER GALLARDO: Great, thank you. I lead the Lithium Valley Vision, and so that’s constantly on our minds, the potential for geothermal lithium development out there, additional development too. Thank you.

And then, Sara, you mentioned the DOE grant that Calpine lost for the Sutter Project. But I missed -- I think you were talking a bit about the solution, could you -- but I didn't catch it. Could you state that again?

MS. ELSEVIER: I just mentioned that even though that grant was canceled, the other tax credits, I believe the 45Q is still in place, and Calpine is still moving forward with developing the project. So they are, I believe, in the front-end engineering phase. And we are -- I think our -- the timeline has shifted, obviously, with all the changes. As of now, they're in-service date or operational date is 2029. And I believe the terms and more details of the project and a potential contract for SMUD is coming in next year sometime.

COMMISSIONER GALLARDO: Okay. It's good to hear that you can still move forward. We know a lot of the federal changes are impacting everyone, so that's why I was curious.

And, Sara, I also wanted to highlight that I appreciated the considerations and challenges you had at the end. I think that type of information and insight is really helpful for us, so I won't ask you any questions about it so Rajinder can have a chance to ask questions, but thank you to all three of you.

VICE CHAIR GUNDA: Rajinder, do you have any questions?

MS. NAKAGAWA: No? All right. Yeah, then we will move on to our next panel. Thank you so much to Liz and all the panelists who are part of our utility presentations panel.

We'd now like to invite up Kent, Julia, and Harper to please take a seat up here at the front, in front of the dais here.

And then we will also be led by our moderator. She is the Electric Reliability Lead here with the California Energy Commission, and she will be kicking us off. But we'll just take a minute or so to allow our panelists to connect their laptops and get their video up and going here.

So, yeah, Kent, Harper, Julia, if you're able to come up, that would be great.

MR. YANG: All right. Good morning, members of the dais, panelists, and participants joining us online and in the room. My name is Chie Hong Yee Yang. I am the Electric Reliability Lead for the Reliability and Emergency Unit here at the CEC. Welcome to today's panel on Clean Firm Resources where we will focus on updates to the SB 423 firm Zero-carbon resources and featuring a discussion panel with various technology developers and trade organizations.

As California advances towards its SB 100 targets, clean firm, and dispatchable resources are critical for ensuring grid reliability and supporting renewable integration. We'll begin the session with a staff presentation on updates to the SB 423 Firm Zero-Carbon Resources Report presented by yours truly. This presentation will be -- will set the stage for our panel discussion by providing the latest findings and research framework, guiding the evaluation of these technologies. The insights from today's conversation will help refine and strengthen the findings in the upcoming IEPR update on SB 423.

Next slide, please. Let's do one more.

SB 423 directs the CEC to assess firm zero-carbon resources. The first report was published in March of this year, and future updates will be incorporated into each IEPR cycle. This ongoing assessment ensures that the state stays ahead and updated on the development of these emerging technologies, as well as the challenges and opportunities associated with them.

Next slide, please.

Firm zero-carbon resources are defined by their ability to deliver steady power, even during extreme events. They exclude standalone wind and solar, but include technologies like hydrogen storage, reservoirs, and natural gas with carbon capture. The key requirement is that these resources be dispatchable or have base load capability with the flexibility to operate for multiple days if needed.

Next slide, please.

This framework outlines how the assessment will be updated for future IEPR reports. It will incorporate technological advancements, policy updates, and market changes to ensure a comprehensive understanding of firm zero-carbon resource potential. Coordination with stakeholders and agencies remains a central part of this process.

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The key technologies that we're tracking include long-duration energy storage, hydropower, geothermal, bioenergy, hydrogen, and generation with carbon capture. Resources like nuclear fission and fusion are also explored as part of this assessment. They're highlighted in green due to challenges that are unique to nuclear resources, having a nuclear moratorium, and fusion resources being very early in their development.

Next slide, please.

Starting off with long-duration energy storage, we'll do a couple highlights here. Long-duration energy storage include technologies such as iron-air, zinc hybrid cathodes, and flow batteries. These technologies are in their early commercial or pilot stages, and they range anywhere from 1 to 10 megawatts. These resources are supported by initiatives like AB 209, CPUC's Central Procurement, and DOE's LDES Earthshot. While high capital costs and limited bankability remain challenges, these resources have strong potential during multi-day net peak events or periods of low renewable generation.

Next slide, please.

Conventional geothermal is already commercial. While enhanced geothermal systems are still at demonstration stages, innovations like the FORGE project, horizontal drilling, and reservoir monitoring are advancing enhanced geothermal development. Despite high upfront costs, site-specific geology issues, and long lead times, EGS has the potential to unlock more than 100 gigawatts nationwide, while with significant opportunities in California's Imperial Valley.

Next slide, please.

Bioenergy technologies include renewable natural gas with steam methane reformation, landfill gas, gasification, and methane pyrolysis. Emerging trends involve biochar production, modular biomass gasifiers, and co-firing with carbon capture for additional benefits such as net negative emissions. While feedstock supply chains and air quality pose concerns and challenges, bioenergy offers flexibility and the ability to utilize forest and agricultural waste.

Next slide, please.

Carbon capture is considered in the post-combustion combined cycle generation, which is already commercial, and these are point source capture technologies that use absorption, adsorption, and membranes. Federal 45Q tax credits, LCFS credits, and DOE combined carbon capture hubs support the development of these technologies, but these do come with high costs and exciting risks. Carbon capture does have a strong potential for industrial and power sectors.

Next slide, please.

We heard a little bit about small modular reactors today in the first panel. So small modular reactors, also known as SMRs, are pre-commercial or in their early demonstration stages. There's designs, such as the natrium sodium-cooled reactors, as well as the pressurized light water SMRs who are leading the development. Federal funding programs, NRC pre-licensing, and loan support help advance these technologies.

Although California's nuclear moratorium and waste handling pose barriers and concerns, SMRs offer modular scalability, potential for hydrogen production or co-production, and co-location with renewable energies.

Next slide, please.

This slide shows a couple of the cost curves that will be included in this IEPR update. These are sourced from the 2024 NREL Annual Technology Baseline, or ATB. The example that we have here is just the utility scale battery storage. We see that costs are forecasted to come down over the horizon, so we'll keep an eye out for that.

These baseline forecasts and many developers may already have curve costs that are actually ahead. So we'll hear from a couple of the developers, and they may actually be much more advanced, and the cost may be much lower than what these curves show.

Next slide, please.

On this assessment, we see the need to continue investing in demonstration projects and early deployment of promising technologies. Some solutions require broader coordination with additional import capabilities needed to access firm zero-carbon resources outside of the state. Coordinating with permitting authorities is important as these technologies are new to the market. These efforts are critical in accelerating the commercialization of these firm zero-carbon resources.

Next slide, please.

Thank you so much for your time. That concludes my update.

We will now move forward with our panel discussion. Our panelists represent leading technology developers and trade organizations. They will share their perspectives on the state of these resources, the latest advancements, and what policy and market mechanisms are needed to scale them effectively.

With that said, I would like to introduce Jason Houck. He represents Form Energy.

Jason, if you could please unmute and show your camera? There you are.

MR. HOUCK: Hi, everyone. Thank you so much for having me today. I'm grateful to have this conversation and to be here. I'm Jason Houck. I'm a Policy Director at Form Energy, and I'll tell you about the 100-hour duration iron-air battery we are bringing to the market.

Next slide, please.

So we're commercializing a technology that is a reversible rust battery and has a duration of 100 hours. So that means we can discharge our battery at rated capacity for 100 hours. And we call this class of energy storage multi-day storage. The chemistry is rather simple. We're taking, when we discharge the battery, we're taking metallic iron, and we are converting that into rust or iron oxide and releasing electrons. And when we charge the battery, we're taking low-cost energy and reversing that process. So we're turning iron oxide or rust back into metallic iron.

It's a very stable and safe chemistry. It's been known for a very long time. It's just never been commercialized before because it's not great for vehicles. It's not intended for small-scale applications, but it's perfect for the electric grid where what really matters is low cost, safety, scalability, and bringing technologies to the grid that are durable and can last over time.

Iron-air chemistry is inherently very low-cost because iron itself is incredibly abundant and available on every continent on Earth. It's also very safe. There's no mechanism for thermal runaway in our battery, and the water-based electrode we use also acts as a fire retardant. Iron itself is scalable. We're benefiting from the existing scale of the iron supply chain, and that also helps us ramp up our supply chain very quickly.

Next slide, please.

As an example of how fast we're moving, this is a photo of our manufacturing plant in a town called Weirton, West Virginia. We broke ground on this plant in 2023. We began production of our batteries in 2024. We already have about 400 people employed at that site today, and we'll continue to grow that. The batteries we're making are made right here in the U.S. Our supply chain is almost entirely domestically sourced.

You know, why West Virginia? Well, this

particular site was once the site of one of the largest steel mills in the country. And, you know, there's incredible access to the resource, just the physical infrastructure and the workforce with the skill sets that we need to work in manufacturing, and specifically with iron-based products.

I'll just point out that to get a better sense of what our technology looks like, on the bottom below the factory image on the left there, there's a picture of our iron anodes, so that's the part of the battery that really is most active. We'll put several of those anodes into the cell. That's the second image on the bottom left. Those cells are about three feet tall, three feet wide. We'll bundle about 36 cells into a module. That's the third image on the left. Modules are about the size of a small car, and those will be deployed in enclosures. And those enclosures will look, from the outside, very similar to any other energy storage or battery energy storage projects in the grid today. And that's what the rollout of the factory is, the enclosures filled with those cells and modules.

Last image, please.

We've announced a number of commercial projects across the U.S. And I'll note that in the coming months, we're going to be deploying our first and delivering our first batteries to our first utility customer, which will be Great River Energy, a cooperative utility based in Minnesota. That will be a true technology pilot of 1.5 megawatts, 150 megawatt hours.

We're also incredibly grateful to have received a grant from the Energy Commission to help us deploy our first project in California, which will be at PG&E's Mendocino Substation in Redwood Valley. That project is slated to be online next year, in 2026. We're grateful for the support from both the state and PG&E to advance this project forward.

The rest of these projects will all be in the next year plus. We're basically on the cusp of commercial -- our first commercial deployments and then rapidly scaling, you know, to much larger projects.

And I'll note that we have 14 gigawatt hours of project energy capacity announced. To put that in context, California doesn't yet publish energy capacity of all the batteries that have been deployed in the state, but it's probably roughly around 60 gigawatt hours. So these initial projects alone are about a quarter of stored energy capacity that California has on its grid.

I'll leave it there and I look forward to the conversation. Thank you.

MR. YANG: Great. Thank you, Jason.

We'll move over to our next panelist to introduce himself. Kent Leacock represents Mainspring Energy.

MR. LEACOCK: Good morning. I will say, Commissioner Gunda and Commissioner Gallardo, I'm Kent Leacock. I'm in charge of public affairs, regulatory relations, and government relations for the western half of the U.S. for Mainspring Energy, a California-headquartered manufacturer of unique technology called a linear generator.

Next slide. Thank you.

The meat of the linear generator is two 125 kW compression technologies that take these oscillators and squeeze whatever the air fuel mixture is, whether it be ammonia, some sort of methane, any kind of waste gas, natural gas, or hydrogen. The technology is completely fuel flexible without any modifications. Through power electronics and software, the technology can react instantaneously to the change in energy density of a different fuel. So for example, if you're zero carbon on hydrogen, but your hydrogen supplies fall short, it could instantly switch over to natural gas as a temporary bridge or even propane if necessary.

The technology is dispatchable, which allows it to partner well with microgrids. We have a number of projects where we are with a solar microgrid in one instance and a battery microgrid that you'll see in another. We have projects where we're going to be completely islanded with solar, where we do peak shaving, firming, a variety of applications with this technology. It's a very versatile technology that has now been proven for a number of years.

Next slide, please.

First example of the technology in deployment, and I believe some folks are going to be visiting this location from the CEC in the near future, is the Napa Sanitation District project where we're taking digester gas and generating electricity. And, in fact, we're allowing the Napa San to accept more types of waste gas and -- I mean more types of fuel to generate more waste gas where they can turn around and power their facility and power their digester. In fact, this was the first waste gas project that we did, and it has enabled additional waste gas projects. So you're taking methane that was previously potentially being vented, capturing that, and generating electricity.

In one instance, down in Southern California, we are now slated to do a project at the Toyon Landfill in the middle of Griffith Park, where they will be exporting electricity, renewable electricity, to the grid.

We're also doing a project with Monterey Wastewater Treatment Plant, as well as Silicon Valley Clean

Water, where once again we'll be taking wastewater gas and generating electricity either for grid or facility and/or both. Some of it's yet to be determined.

You can go to the next slide.

This is a unique project. This is a microgrid project with batteries. And the interesting thing is that this was a speed-to-power solution for electric truck charging. A fleet of 100 trucks owned by Maersk shipping diesel trucks that they had purchased electric trucks, drayage trucks, to completely convert their fleet. They were told by their utility that it would take three to five years to get them the power that they needed, and in under 12 months, led by Prologis' Mobility Division, along with batteries and linear generator technology fed by SoCalGas, we were able to get this up and running as the largest charging microgrid in the U.S. at the time it was launched over a year ago.

And the interesting thing is the reason that technology was chosen is because Maersk and Prologis have aggressive carbon reduction goals. And the ability for the technology to accept hydrogen blends and hydrogen in the future without changing a thing other than the connectors that are different for hydrogen was a good selling point for them as an affordability option in terms of stranded capital for deploying those assets. So that's up and running right now, charging up to 96 trucks at over 300 kW simultaneously.

Next slide, please.

This is a project that's in development right now. It's a combination of firming, as well as allowing for data center growth in a rural community in the Midwest. They had a data center that was coming online that they couldn't meet the load, and so they decided to do a project where we would be providing a little bit more than 30 megawatts of power to help their un-firm power provide firm power to the data center, which is what data centers need. And this is one of a number of projects that we are providing firm power for a data center and/or islanded prime power for a particular data center that was constrained in the timeline that they would get power from their utility.

As you are all probably aware with data centers, time is like of the essence, I mean, if you're falling behind, if you're a month behind schedule energizing your data center. So this speed to power solution is one that is gaining traction across the U.S. And once again, our fuel flexibility is giving them comfort that at some point in time, when, not if, but when hydrogen becomes available at scale and is affordable, then they can convert to a zero-carbon operation.

Next slide, please.

So those are examples of real-time projects, and this is one that we'll be launching next year. And this is a hydrogen project. That's why I'm referencing it to give the guys this afternoon a little bit of a lead in. This is Verdagy, an up and running electrolyzer down in Moss Landing. Verdagy has their corporate headquarters there. They have a manufacturing facility, as well, in California. But currently, that electrolyzer has just been producing hydrogen as a proof of concept for them, but they've been venting it. So now they're coupling that hydrogen production with a linear generator, and they are going to be turning around and powering their facility, to some degree, and the electrolyzer.

The use, the electricity usage is beyond the capability of one linear generator, but this is an ability for them to show the ability of their electrolyzer to operate 24/7 in an automated fashion and the ability of the linear generator to then in turn take that hydrogen, produce electricity 24/7. So it's a unique opportunity for us because right now hydrogen is so expensive that for us to purchase hydrogen and run our technology 24/7 would be cost prohibitive. So this is a really good partnership for Mainspring, Verdagy, and California to get an opportunity to really see the ability of hydrogen in generation.

Thank you.

MR. YANG: Moving right along to our next panelist, we have Julia Levin with the Bioenergy Association of California.

MS. LEVIN: All right. Good morning. I'm going to unmute myself. Okay. Good morning, Commissioners. Julia Levin with the Bioenergy Association of California. Thank you so much for this workshop and the attention on firm power. You understand better than anyone how much we need it and how urgently we need to ramp it up.

We strongly support all forms of firm power, but I'm going to talk just for a couple minutes about why bioenergy provides additional benefits even beyond other sources of firm power, but we need it all. So I want to be very clear about that. And we needed it all yesterday for all the reasons that staff and others have said, reliability, affordability, resilience, diversity, et cetera.

So the Bioenergy Association of California has about a hundred members, including many private companies like Mainspring and others, they're really on the cutting edge technology-wise, utilities, as well as a lot of public agencies, cities and counties that have to divert organic waste from landfills, air districts, water and wastewater agencies, et cetera, and then research institutions, tribes, and others.

Next, please.

We focus on all kinds of organic waste for all different energy and uses, but the common denominator is organic waste. And this is where bioenergy provides significant additional benefits beyond other forms of firm power. Most importantly, it reduces short-lived climate pollutants. And climate scientists are really clear that this is by far the most urgent thing we can do to address climate change. In the energy sector, it is the only thing we can do that makes any difference to the climate for the next several decades. And I want to say that again, because most people still don’t seem to realize this. Everything we’re doing to reduce fossil fuels, while critical, makes zero difference to the for a long time, and we don’t have that much time left.

People are dying now every single week from climate disasters all over the world, including in this country, including in this state, from wildfires, floods, extreme heat, et cetera. When you reduce short-lived climate pollutants, you benefit the climate right away.

And in California, methane and black carbon, the two most common short-lived climate pollutants, are entirely from organic waste. While, 87 percent of methane emissions is from organic waste, more than 90 percent of black carbon is from wildfires, pile burning of forest and ag waste, and diesel. All of those emissions could be virtually eliminated by converting organic waste to energy and using it in place of diesel instead.

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So in addition to reducing short-lived climate pollutants, bioenergy is also unique among generation resources because it can provide carbon negative emissions, in some cases, even without CCS. So that is a correction to one of the earlier staff slides. According to Lawrence Livermore National Lab, bioenergy with CCS could provide two-thirds of all the carbon negative emissions we need to reach carbon neutrality by mid-century. But many sources of bioenergy, like dairy biogas, or diverted organic waste from landfills, or forest waste that would otherwise be burned, can be carbon negative even without CCS. So this is just an enormous and critical opportunity to meet our mid-century goal of carbon neutrality.

Next, please.

So in addition to short-lived climate pollutant reductions and carbon negative emissions, the Air Resources Board, the legislative analysts, and Lawrence Livermore have all found that investments in bioenergy are actually the most cost-effective of all of the state's climate investments. Each and every year, the Air Board issues a report to the legislature that shows that very, very clearly. And that's because bioenergy uniquely provides a triple benefit for the climate. It reduces methane or black carbon, climate super pollutants upstream, it displaces fossil fuels, and it can provide carbon-reducing co-products like biochar. Then when you add those three benefits up, it becomes an extremely cost-effective climate solution.

Next, please.

So in addition to the climate benefits of bioenergy, it is also a critical tool for reducing wildfires. And according to the PUC's recent report back to the governor on affordability, wildfires are by far the biggest driver of increasing electricity rates. So if we want to maintain affordable rates, we have to address wildfire. And one of the ways to do that is to use forest waste and other vegetation that's removed for wildfire mitigation for bioenergy production.

Unfortunately -- well, the good news is California has really stepped up efforts to do forest thinning and other vegetation removal. The bad news is the vast majority of that, as the photo in the upper right shows, is still sitting in piles in the forest. And CAL FIRE and the Placer County Air District have looked at those piles and determined that that actually increases wildfire risks, because you have these little fire bombs spread throughout the forest now in piles.

We have to do something with those piles, and by far the biggest opportunity is bioenergy production, which not only mitigates wildfire risks and impacts, but also helps protect water supply, which is why water agencies across the state now are really stepping up to invest in and support new small-scale bioenergy products that use forest waste.

Next, please.

So in addition to all these other benefits, I want to address air quality. There is no question that there are emissions from biomass combustion, but according to the Air Board, CalEPA, the entire statewide association of local air districts, open burning is significantly worse. Bioenergy cuts particulate matter, black carbon, methane, other air pollutants significantly compared to pile burning or wildfires.

And this graph is based on combustion biomass. When you get to non-combustion conversion, gasification, and then use it in a linear generator or other non-combustion technology, you can virtually eliminate emissions, which, again, compared to pile burning or the emissions that would otherwise happen from landfills or landfill gas flares, which is what we do with half of the state's landfill gas, bioenergy provides huge net reductions in air pollution that are really, really significant, which is why one of our first members was the Placer County Air Pollution Control District.

So I'm going to stop there. Looking forward to the discussion. Thank you.

MR. YANG: And moving on to our -- introducing our last panelist, Harper with Fervo Energy.

MS. HARPER: Hi, everyone. Thank you so much for having me. It's great to see you, Commissioner Gallardo and Vice Chair Gunda. And thank you so much to the staff who worked on this workshop and this report, and also just committing to fact-based decarbonization through clean firm resources.

I am here representing Fervo Energy, and we are a 24/7 enhanced geothermal energy systems company that is currently delivering power to power data -- or to power a Google Data Center. And we're also contracted with California LSEs for 500 megawatts fully phased on by 2028, starting delivery next year.

If we could move to the next slide?

Enhanced geothermal systems, or EGS, essentially utilizes advances in drilling and fiber optic monitoring and applies those advances to geothermal reservoirs for the first time. And what this has done for the geothermal industry is unlock a huge amount of potential resources that were previously inaccessible. Because we're accessing new rock formations, and also have control over subsurface engineering using these techniques, we're largely able to vastly expand the resource potential across the West. USGS just released a study that in the Great Basin alone, using current technology and enhanced geothermal systems, we can unlock 135 gigawatts of resource just using current methods.

On to the next slide.

We're also as we scale, we're rapidly driving down costs and have exceeded and outpaced Department of Energy and NREL projections. One of the ways that we've been doing that, and I'll give an example, is by driving down the time that it takes for us to drill a well. Since we drilled our first well, Fervo has decreased the time that it takes for us to drill a well by 70 percent. This is important because about 50 percent of geothermal project capital expenditures come from drilling costs. And 75 percent of drilling costs are associated with drilling time. So those advancements are helping us drive down costs, and that's only one example. We've been driving down costs across our entire business.

It's our goal in the future as we scale to become not only the cheapest form of clean firm power, but just power on the market. And we believe that this is possible given the current technology that's been developed over the last decade.

Next slide, please.

And to ground this in some of the policy needs so that we can expand and bring clean firm power to California so that we can meaningfully decarbonize our grid, especially in overnight hours, these are a range of different policy recommendations. But I really wanted to highlight transmission here as being one of the key constraints at this time, and I think many other industries are facing transmission constraints as well.

Especially through interagency coordination here at the CEC, with the CPUC, with the CAISO, that type of coordination to drive transmission infrastructure buildout, especially cross regionally, is going to be critical if California is to meaningfully and truly decarbonize their grid 100 percent in all hours of the day. And especially, I think there needs to be more coordination on out-of-state and imported resources as well in the near term in order to meet short-term goals, especially as this resource expands across the West.

Thank you so much, and I'm looking forward to the discussion.

MR. YANG: Great. Thank you so much.

We'll now go into the discussion portion of this panel. Quick time check. We have about 10 minutes or so, so we'll go through a few questions and welcome the panelists to chime in on this first question that we have on tap.

So the first question is: How are recent changes in federal tax credits, incentives, and other policies affecting your technology's ability to gain traction in the market, as well as what additional policy levers or market structures would most help accelerate the adoption of your technology? So welcome any thoughts on this question?

MR. LEACOCK: Well, I guess as a company that is going to benefit from the recent change where the ITC, investment tax credit, was re-established, we have to say that it's allowing a variety of customers, whether commercial, industrial, whether it's public agencies, wastewater treatment plants, landfill, whoever it may be, it's allowing them to get certainty for the next 10 years in terms of those tax credits, as well as, you know, saving a substantial amount of money in the purchase of our technology.

So it's helping spur the growth of our technology and projects are, you know, really looking to accelerate starting after January 1, 2026 to kind of keep going. You know, this is a tax credit that was already in existence, so it’s re-established it and given our pool of potential customers certainty in their path forward.

MS. LEVIN: Yeah, I think all of our technologies fall in the category of other in the Big Budget Bill. And so we received a full extension through 2033 and then a phase down of the investment tax credit until 2036, so 10 years, which is super helpful. Actually, as Kent said, better than what we’ve had in the past, which have been very short-term extensions.

I mean, I’ll just say personally, I would have liked to have seen extensions for all renewables, but at least firm power did get those extensions and CCS and hydrogen as well. So I think for firm resources, this is the time to make a push when these tax credits are going to be available for the next decade.

MR. HOUCK: And I’ll just add that it’s pretty notable that this is one of the only subjects that’s had broad bipartisan support for three administrations now. And so I think, you know, why is that? It’s because the resources we’re bringing to the market are fundamental to energy security, reliability, and affordability.

So I think the really important question is next for state policymakers and ISOs around, well, how do we squeeze the most value out of the generation of transmission we have today in this world where it’s getting increasingly challenging to build stuff rapidly enough? And how do we proactively encourage the development of these new resources? And I know that's a big focus of today.

So I want to just offer just briefly, like maybe three policy levers that I think are worth focusing on, and we'd love others' opinions too. One is planning. Like we've got to start making sure that all these resources are included in every plan that we, you know, do about the future of the electric grid. And we've got to start planning for the reliability challenges that we're really starting to face and ask, what is the least cost way to solve both the state's clean energy goals and the reliability challenges?

On markets and reliability, we still think about single days; right? We've got to shift to think about realistic weather events. And, you know, and what does firm mean? Well, it means the ability to be dispatched continuously over those periods of risks, which tend to span multiple days.

And then procurement. And here, California is, no surprise, playing a leader in the recent procurement orders coming out of Commission, but it's important to start thinking about not just capacity power, but energy, you know, and how much energy do we need to really support the state's reliability and other needs in the system?

So I congratulate California on making a lot of progress to date, but I think that's really kind of where we need to continue to push in the next few years and take advantage of the incentives that are, at this point, pretty durable.

MR. YANG: Great. Those are definitely great thoughts around what would it take from a policy perspective to scale these technologies.

I have a follow-up question for Jason. You had mentioned how to value these firm zero-carbon resources. With respect to your technology, what market mechanism or contracting structures would best recognize the unique value of multi-day or seasonal storage? And what would help reduce the risk of early large-scale investments?

MR. HOUCK: Yeah, it's a great question. I'd say there's easy near-term things we can do, and some harder things that are going to take a few years. The easy things are, one, just give accreditation in existing resource adequacy programs to multi-day storage and other emerging resources, just to give developers clarity on how resources are going to be valued today. And also, clarify a pathway for developers to swap battery technologies, in particular, in interconnection without having to trigger lengthy changes. Those two things alone will help get, you know, new resources.

In the longer term, you know, I think it’s important to start making sure that realistic reliability risks are factored into market design. And, you know, today, we still plan the grid in California and grids across the country about -- around the single-day peak. But we all know that those real reliability crises are around several days of hot weather, an atmospheric river in Southern California in the wintertime, or several bad things happening all at once, and those tend to last over several days.

And so, the real challenge is setting a clear signal for, you know, characterizing, what is that reliability challenge, not just short-term, but over the long run. What does it look like in different scenarios of weather and resource requirements? We have a lot of stuff that’s pretty old in California and elsewhere, and it may go away. And then, what performance, I think this is the key thing, what performance do we need out of new resources that can fill that gap?

And I think once we answer those questions, the procurement piece becomes easier, because then we can say, we need, you know, this kind of performance. Let’s let the technologies compete to provide that at a competitive cost. And so I hope that’s where California -- I know there’s been a lot of progress in that direction, but I think that's really where we need to spend a lot of our attention in the coming few years.

MR. YANG: Thank you, Jason. Those are great insights.

Shifting a little bit in terms of what are some of the biggest barriers some of these technologies are facing, I do have a question for Harper. What are the biggest barriers relating to permitting or transmission access with regards to geothermal projects, and how can policy help address these challenges?

MS. HARPER: Yeah, absolutely. And I feel like this feeds a little bit into the federal conversation we were just having.

Enhanced geothermal systems, while it's been proven and it's scaling, we're in what's called the valley of death, which is, you know, common. You know, it's an ominous term, but it's this big gap between when a company has, you know, a venture or a technology has venture-backed capital and when it needs to move into full deployment. And that is really a great space where policy can come in and help launch a technology from being just in the research and development stage into more the research, development, and deployment stage. And like we were saying earlier, we need this energy now, and we needed it yesterday. Load growth is growing rapidly. Load is already growing rapidly, and load growth is projected to continue on that trajectory.

So I would say, related to barriers in California, I think there's a lot of opportunities to streamline permitting practices. And I'll highlight specifically for growing geothermal in California some of the challenges related to CEQA in the broader western market context.

The fact that California has a specific and different regulatory scheme for developers to learn, understand, and move through for a project does put them at somewhat of a competitive disadvantage compared to other states who all work in NEPA. And for that reason, it is difficult for technologies that are scaling to attract the financing and capital needed to deploy in a state that has a unique regulatory scheme. And when I say unique, I would also link that to the term uncertain. And in, you know, financing, in the financing world, uncertainty comes at a price point.

So really what you're talking about when you work to streamline permitting practices in the state is directly saying we want to make power generated in the state more affordable. So that all is very much linked. And I know we're in an energy affordability crisis as well. So really decreasing uncertainty has direct affordability benefits.

And then on the transmission side, I would say the biggest barriers right now are related to inter-regional transmission and sort of the western wide transmission connectivity, especially related to imports. The planning around imports is not as predictable as it needs to be for both developers and also offtakers to work ahead of time to really match the level of planning and planning horizons that California has set in their goals. So I think aligning those timelines together, the transmission planning timelines with our clean firm SB 100, SB 223 timelines together is going to be critical to meet California's goals.

MR. YANG: Thank you, Harper.

We're going to take another sort of spin here and go towards a more distributed question. And this question is for you, Kent. What incentives or interconnection policies are needed to expand the deployment of linear generators, especially in those sort of distributed applications or even off-grid applications?

MR. LEACOCK: Well, I think that the main thing that we would look for is, I'd say, kind of technology neutrality in procurements, in grants. I think that, you know, at times there have been, you know, kind of dedicated silos for funding. And I think now is the time when, especially with wanting to grow hydrogen, that looking at clean fuels as, for example, long-duration energy storage on the -- for the grid that can then double also as distributed generation when coupled with, say, for example, electrolyzer, I think that that's -- the policies need to be all-encompassing. They need to be able to allow all the different technology choices a seat at the table because, you know, some technologies are dispatchable. Others aren't. They can't respond to, they can't respond quickly to changes in the grid and what the grid needs. You know, they can't respond within seconds to dispatch signals that CAISO might send out.

So, that would be -- I think, is the biggest, you know, or policy, you know, thing that we think would benefit our technology and others as well is a more kind of open acceptance of all the options that California needs.

MR. YANG: Thank you for the insights, Kent.

Doing a quick time check. I think we're out of time for the discussion panel. I wanted to turn it over to Vice Chair Gunda for an opportunity for remarks and questions from the dais.

VICE CHAIR GUNDA: Thank you, Chie. And thank you so much for the panel and this really helpful information. I monopolized most of the time last panel, so I'm going to start with Commissioner Gallardo first.

COMMISSIONER GALLARDO: You're allowed to monopolize. You're leading this. No, but I appreciate it. Let's see, I think I have quick questions for everybody.

So, one, congratulations on all the work you're doing, everything you're advancing. It's really exciting to hear about all these technologies. I don't, I'm not deep on all of them, but very fascinated by everything.

Jason, I wanted to tell you I'm jealous of West Virginia. I would have loved for that factory to be in California, but definitely understand, you know, why there might be some barriers to being in California.

I also wanted to congratulate Form Energy for the, I believe it's 14 gigawatt hours across the United States. Significant and just impressive. And also acknowledging that you mentioned the CEC funding, so that's good to get that type of feedback, too, when our grants are able to support and support well, and maybe where there are gaps where we can do better on those grants. So we do want to make strategic investments, even though sometimes we'll have limited funding, or especially when we have limited funding.

So, Jason, I think those are just comments for you, not necessarily in question.

And then Kent, it stood out to me, the Napa Sanitation District. I heard you say that staff might be visiting soon. So I'm going to check in with staff to see if I can join that. It sounds really exciting. And I think seeing it firsthand can also help me wrap my head around how it all works. So very interesting.

And then you gave an example of a shipping port, but I didn't catch where that is, or one of the case studies.

MR. LEACOCK: Yes, Los Angeles.

COMMISSIONER GALLARDO: Okay.

MR. LEACOCK: So, that's Maersk Shipping down in the Port of L.A. And those are drayage trucks that, you know, they eliminated 100 diesel and went to electric that run Long Beach, Los Angeles to that facility run by Maersk Shipping that then goes out to the railyards, takes the containers, you know, to rail and/or to other distribution points from the port area.

COMMISSIONER GALLARDO: That's exciting. You said 96 trucks in the fleet?

MR. LEACOCK: Up to 96 simultaneously.

COMMISSIONER GALLARDO: Simultaneously. Yeah, that's incredible. Okay. Let me see here if I have anything else.

Oh, the Verdagy?

MR. HOUCK: Commissioner Gallardo, if I may just --

COMMISSIONER GALLARDO: Oh, someone else?

MR. HOUCK: Sorry, Commissioner Gallardo, I wanted to briefly just note --

COMMISSIONER GALLARDO: Okay.

MR. HOUCK: -- I did mention the West Virginia, but we do have a presence in Berkeley too. So we employ about 200 people at our Berkeley offices doing engineering work. So I have a large footprint in California and intend to continue growing that.

COMMISSIONER GALLARDO: Okay. Thank you. I think that may have been delayed.

Jason, were you responding to the first comments I made?

MR. HOUCK: I was. Sorry. Apologies if there's a delay.

COMMISSIONER GALLARDO: No, it's okay. We just didn't hear everything. I think you were talking about the workforce.

MR. HOUCK: Ah, sorry. I was saying that we do have a large presence in Berkeley, California, where we do all the engineering work for our technology, so -- and that has also been supported by CEC R&D funds. So I just want to acknowledge that we are in California, as well, and intending to continue to be there for a long time doing a lot of critical engineering function that goes into our technology.

COMMISSIONER GALLARDO: Excellent. Thank you. I think that was addressing my jealousy. All right.

And then, I was asking Kent about Verdagy. I'm sorry if I'm pronouncing it wrong.

MR. LEACOCK: You know what? That's not my company. I don't know if it's Verdagy -- Verdi -- Verdigy, Moss Landing.

COMMISSIONER GALLARDO: Got it. Okay. So are they established already in Moss Landing?

MR. LEACOCK: Oh, yes. They've been producing hydrogen, as I mentioned, and venting it for quite some time, and so this will be good.

And the other thing that I didn't mention was that we're also going to be participating in a CEC-funded science experiment down in Southern California at Cal State Long Beach, where they will be blending hydrogen. GTI Energy is the project lead. So they'll be utilizing a linear generator with different blends of hydrogen to produce electricity on the campus of Cal State Long Beach and help them eliminate some diesel generators. And that will be, once that kind science experiment is done, it will stay in place and run the campus. So they'll be doing different hydrogen blends, as well as some synthetic fuels.

COMMISSIONER GALLARDO: Mm-hmm.

MR. LEACOCK: And South Coast AQMD is also a participant in that project to be looking at the emissions profile at various levels of hydrogen blending. And then, also, we're going to go straight pure hydrogen as well.

COMMISSIONER GALLARDO: Okay. Excellent. Thank you for the clarification.

Julia, I'm interested in visiting, also, one of the sites here just to better understand, you know, how the technology works. So I just wanted to make that comment. This is an area where I don't know too much.

And then, Harper, it's good to see you again. I feel like after that Geothermal Rising event, I keep hearing your name and Fervo keeps coming up. We were just at Berkeley National Labs, and we talked about Fervo and their investment in Fervo as an entrepreneur, so glad to see you here. And you talked about the drilling costs, and that's what we've heard too. That's a major barrier.

And I'm just curious if you could talk a little bit more on what else could we do to help with those types of barriers, if anything?

MS. HARPER: Yeah, absolutely. In terms of cost, one of the areas where states can be particularly helpful is in providing low interest debt financing for projects. And we've seen that be incredibly useful in the past. Drilling is a very expensive endeavor. So the magnitude of grant funding to support drilling operations is really just quite large. So that is really why I point to the financing side there.

COMMISSIONER GALLARDO: Mm-hmm.

MS. HARPER: There's also opportunities for tax support, property tax remittance. You know, Fervo, we have lease positions in California around the Salton Sea, and, you know, there's a lot of potential across California to deploy the technology. It's, again, just the question of the place that EGS is in scaling and where the next right places are to deploy it as cheaply as possible so that, again, we can drive down costs and make our product in the market economically viable. So, yeah, there's a few different mechanisms.

And I think, also, on the transmission side, transmission is expensive and takes a long time to build. And that is also, you know, transmission costs are also built into and considered in PPA pricing too. So I do think that that's really a place where the CEC and CPUC and CAISO together can push a major difference that will have tangible impacts, you know, in the 5- to 10-year time horizon.

Yeah, and also, it's great to see you. I really appreciate both of your engagement on geothermal, and it's been really wonderful to share these spaces with you.

COMMISSIONER GALLARDO: Excellent. Thank you.

MS. LEVIN: Commissioner, can I --

COMMISSIONER GALLARDO: Go ahead.

MS. LEVIN: -- can I also answer that question in terms of barriers? I think some are common to all of our sectors. I think the most important thing, I hope, will come out of the SB 423 Report is a recommendation to have actual procurement targets, enforceable procurement targets for firm power, and maybe even within that dispatchable power because there's a subset of firm power that's even more critical. There's a reason we haven't been able to shut down most of our natural gas power plants. And until we really significantly ramp up firm, and especially dispatchable power, we're not going to be able to shut down the gas plants, although we should also be looking at opportunities to decarbonize those plants.

I think that's true across all firm renewables, is we need something more binding than kind of vague IRP targets. Those are targets. They're not requirements. They're not being enforced. You can't go to the bank, to be honest. So our members can't go to the bank and get it, you know, financing based on what's in the IRP Program where they can based on the Low Carbon Fuel Standard Program or the RPS as a whole.

Specific to bioenergy, new projects are generally distributed generation. So their problem is not transmission, their problem is interconnection timelines. And I think this is also common for all resources. We are not going to meet the clean energy or climate goals if we don't accelerate interconnection by orders of magnitude. And at a point, if the utilities can't do it, we're going to have to look at an interconnection authority, like the Central Procurement Authority but for interconnection, because that is terribly broken for all new clean resources.

The area specific to bioenergy is, and this is where we really need more interagency cooperation, we don't monetize any of the other benefits of bioenergy. And so, consistently, the Public Utilities Commission has been pretty hostile to bioenergy.

They are about to end a program that is required by state law. Vice Chair Gunda knows this well. The BioMAT Program, which has no outs in the law, and yet they're unilaterally deciding to end the program because they think it's too expensive. But they're not factoring in carbon negative emissions, short-lived climate reductions, protecting water supply, mitigating wildfire, which is a direct ratepayer benefit. Until the state does a better job quantifying and monetizing all those benefits, including, in general, the value of firm power and renewable dispatchable power, the only alternative is going to have hard and fast procurement mandates, but really, we should be doing both in order to accelerate the procurement. All of these resources are valuable.

And actually, the last thing I want to say, and this is not a diss to long-duration storage, clearly, we need that as well, but it really troubles me when we put it in the same basket with generation resources. They are not the same and they should not be treated the same. Even multi-day storage, which is fantastic, still requires generation at a point. It’s still not going to get us through three weeks of El Nino rains or six weeks of bad wildfire smoke.

And in terms of prices, we have to figure out how to compare prices based on power across the whole year. And so even multi-day storage is not going to be that. So how -- I think the Public Utilities Commission, in particular, really needs to figure this out. Slice of day is not going to do it. RA doesn’t do it. We’ve got to look at what keeps the lights on for every hour of every year, no matter what.

COMMISSIONER GALLARDO: Thank you, Julia, for adding that.

I have to depart for about an hour and a half, so I apologize that I’m leaving before I get to hear your responses to Vice Chair's questions. But thank you again for all of the insight you shared. Much appreciated, and I'll be back.

VICE CHAIR GUNDA: Thank you, Commissioner Gallardo. Again, thanks to the panelists. I think I'm glad Chie and Commissioner Gallardo framed a lot of the questions. I think I feel like most of my questions were answered.

But I just wanted to give you, I just, you know, on the linear generator, Kent, I remember seeing the first demonstration and kind of thinking about the Prologis issue, and specifically looking at your solution. And it's been wonderful to watch, you know, you all deploy the technology. And I think especially with the idea of cutting down the interconnection timelines or pre-interconnection, it's been kind of interesting to watch the technology go. And I remember Fervo, the first presentation a couple years ago. And, you know, just, you know, again, congratulations on the success. Same, Jason, with you on the firm energy.

And I think, you know, Julia, I think I just wanted to thank you for your advocacy on an important sector of kind of the overall mix.

So I think, Kent, you mentioned this and maybe, you know, just have you provide some closing remarks on this, you mentioned about how each of these technologies have their own benefits; right? I mean, they all bring something to the table, extremely important as you think through the lens of the clean, affordable, reliable, equitable, but also the kind of impacts; right? I mean, we don't necessarily monetize, for example, what it could do to decarbonization goals if there is three or four-year delay in energization; right? I mean, that's not really monetized.

Or Julia, in your case, we don't really monetize the reduced fire risk, you know, with, you know, adequately using the, you know, forest biomass; right? I mean, how do you do that?

So just wanted to kind of get your thoughts on going back to Chie's question on, are we valuing the technologies adequately? Are we having a wholistic value of each of your technologies within our planning processes? And you all touched on barriers that are both common and unique. If there's one thing you would solve immediately, what would that be? I think I know the answer for each one of you, but I'll just start there; right?

MR. LEACOCK: Well, I don't know if I can come up with one thing immediately, but, you know, I'd say that the thing that I would solve for most quickly, and it's something that's kind of out of our control, is if you're going to, you know, you really want the zero-carbon future, then we have to enable hydrogen. We have to enable hydrogen at a scale, as well as fully value the existing, and to Julia's point, the existing benefits of bioenergy. And when I say bioenergy, I mean producing electricity from biogases, methane, from wastewater, from landfill, from dairy digester. Because once again, it's one of the tools, because what good does it do to transition a lot of things if you have methane being vented into the atmosphere and not doing something productive with it, including getting rid of it and then utilizing it to generate electricity?

I think the other thing is I believe that hydrogen as a clean fuel should start to looking at its many properties, including long-duration energy storage. My company recently joined the Long Duration Energy Storage Council, and one of the conversations we're having, embarking on, is the use of clean fuels as a form of long-duration energy storage.

And once again, in different circumstances, it can be another tool in the toolbox because of its ability to be dispatchable. If you couple it with an on-site electrolyzer that is, you know, producing hydrogen for other purposes, it can also then fuel tank storage that can be long-duration energy storage that can be replenished regardless of weather conditions. It doesn't have to worry about sun. It doesn't have to worry about anything. It can be self-perpetuating, and it's zero carbon.

So I think that that's really where, you know, we would -- once again, as I mentioned before, I think that we need to kind of embrace new, embrace newer technologies and hydrogen as a solution for, you know, for what California is trying to do, all the while also, you know, really getting the fact that bioenergy and the capture of, you know, biowaste gases is so important. Because if you don't do that, then all these other things you're doing, you're just, it's like, you know, you're just counteracting against yourself by doing all these clean things and just allowing, you know, the vent of methane and/or flaring, which can be equally as harmful.

MS. LEVIN: Not surprisingly, I totally agree with what Kent just said. I think if I was going to say one thing that would benefit all of us, it would be a procurement step up between here and 2045 that provides all of us certainty and a guaranteed market, and that's what took us from 10 to whatever we are now, 35, 38 percent renewables. We need that specifically for firm power.

And I really do want to underscore generation. Long-duration storage has a huge role to play, but generation -- long-duration storage is not the same as generation. We need something specifically focused on generation. And to Kent's point, I think clean molecules need to be recognized as having two critical benefits of the longest possible storage is clean molecules, biogas, biomethane, or hydrogen, as well as their ability to generate dispatchable power.

So really, two of the most critical needs for reliability, neither one of which is really recognized right now, the long duration, really long duration as in seasonal storage, and the ability to generate dispatchable power. So procurement, and then recognition of those other benefits.

MS. HARPER: If I could wish upon a star with this audience in mind, in addition to the other recommendations, it would be that the NREL ATB updates are immediately integrated into all planning procedures across California in a timely manner. Those NREL ATB updates are incredibly informative about the technology that's developing today, and our planning processes will build a grid that we'll functionally see come online in about 10 years. So that's really why the timeline there is so important.

I'll end with that. Thank you so much for all of your work on planning and integrating up-to-date inputs and assumptions so far. I think the CEC has really been doing a great job of working towards those goals already, so I appreciate it.

VICE CHAIR GUNDA: Thank you, Harper.

Jason?

MR. HOUCK: I'm not sure if you're able -- apologies if there's still a delay, but I'd say the one thing that I'd recommend is to focus on ensuring both reliability and cost under atypical weather conditions. If we plan for atypical weather well in a technology-neutral way and we model all these resources in that, then we will get a clear picture of what's the right portfolio of resources to solve that. Let's focus on the weather and making sure we're modeling it right.

VICE CHAIR GUNDA: Yeah, thank you, Jason.

Thanks again to the panelists. It's an amazing panel. I look forward to continuing conversations. I think there's a lot to do. And as I said on the previous panel, it's really important that you engage.

I kind of recognize two things. California does a lot of good things, but things also move slowly, so thank you for how you continue to kind of work on this and advocating for the things that you believe in, and I look forward to continue working together. Thanks.

Back to you, Sandra.

MS. NAKAGAWA: Alrighty. Thank you so much. We are now going to go to Justin Szasz, a CEC Energy Analyst, who’s going to be moderating our Zoom Q&A. If you’re in the room, please join the Zoom and submit your question via the Zoom Q&A or throw a yellow card at the back table and bring it up to me.

All right, Justin, over to you.

MR. SZASZ: Thank you, Sandra, and good afternoon, Vice Chair.

We have one question currently on the Zoom, and that is:

> “Do you think hydrogen will be economic in our lifetime?” And then the person goes on to say, “Many experts don’t think so, and the industry seems to be giving up on hydrogen. We have gone from dozens of hydrogen inquiries a month to zero, and we have demonstrated an engine burning 100 percent hydrogen.”

MR. LEACOCK: I think that there are some examples that may be touched on later this afternoon, as well as other developers that I’ve met in other states, including New Mexico and in Oregon, that believe that they will be able to produce green hydrogen at scale. And one particular, I don’t want to call them out, but one particular hydrogen developer feels that they’ll be able to produce hydrogen at a cost-equivalent diesel fuel, and that with what’s happening in the fuel market, they may ultimately be, and this is less than 10 years from now, be less expensive on an equivalency scale than diesel.

So I think it's very much possible, and we've even spoken to a couple of producers that are doing this on their own. They're doing it from private capital out of New York, venture capital out of New York and the Bay Area. And they aren't even relying on Washington. If Washington does end up helping them, sobeit. You know, if they get opportunities with California, sobeit. But their business model is based on, you know, scale and profitability of their technology.

MS. LEVIN: Yeah, I'll just say for biogenic hydrogen, we are seeing prices come down already as the market starts to get more comfortable with it. The Green Hydrogen Coalition put out a great report about a month and a half, two months ago, showing that they thought they could get prices down, maybe not quite to where diesel is, but pretty close within a number of years.

But I think, like all clean technology, we have to scale up first, and so we have to be willing to take some amount of risk, do the best we can, and get most of the way there. For biogenic hydrogen, this also goes back to the need to monetize the other benefits that it provides, like reduced flaring, reduced wildfires, reduced methane emissions, et cetera. And then we can definitely get it to parity.

But I would flip the question around and say, well, how do we reach our goals without hydrogen? We can't mine our way. Globally, we just can't mine everything that would be needed to do it all with batteries. We're going to have to make hydrogen work, so it's not whether or not, it's how quickly can we do it.

MS. NAKAGAWA: Alrighty. Thank you, everyone.

I'm now going to turn it over to Ryan Young, our Deputy Public Advisor, who's going to begin our public comment session for this first half of the workshop.

MR. YOUNG: Good afternoon, everyone. I will take public comments. One person per organization may comment, and comments are limited to three minutes per speaker. If there are several parties interested in commenting, we may reduce the time.

We'll start with those in the audience that would like to comment. I have not received any blue cards today, so if you would like to make a public comment, please approach the podium.

Seeing none in the room, if you're using the online Zoom platform, use the raise-hand feature to let us know you'd like to comment. We will call on you and open your line to make comments. For those on the phone, you're going to use -- dial nine -- star nine to raise your hand, and star six to unmute your phone. You will unmute on your end, and then we will speak.

The first comment is from Caity Smith of XGS Energy. Your line should be unmuted. Go ahead.

MS. SMITH: Hi. Are you able to hear me now?

MR. YOUNG: Yes, we can hear you. Thank you.

MS. SMITH: Excellent. Welcome. I'm Caity Smith. It's C-A-I-T-Y S-M-I-T-H. I'm the Director of Stakeholder Engagement for XGS Energy.

XGS Energy is a California-based company developing an advanced closed-loop geothermal technology that can deliver clean firm power anywhere there's hot rock with no consumptive water usage. XGS's single-well pipe-in-pipe system efficiently circulates a working fluid in a sealed loop, eliminating interaction with the geologic formation and expanding access to geothermal energy beyond traditional resource areas.

We appreciate the CEC hosting today's workshop and the thoughtful analysis in the SB 423 Report. As the report highlights, clean firm resources are essential for decarbonizing our electric grid while maintaining reliability.

To meet California's long-term clean energy goals, it will be important to have a robust mix of renewable energy resources that complement one another. Advanced geothermal will play a critical role in addressing this need. In California, there's an opportunity for new technologies to both enhance output from existing geothermal fields and unlock development in new areas that have been historically out of reach for conventional hydrothermal.

We encourage the Commission to act on the SB 423 Report recommendations and help accelerate deployment of clean firm resources, including advanced geothermal, that are critical to a reliable decarbonized grid.

XGS will be submitting written comments that include more detail on the points that I've raised briefly here.

Thank you again for your leadership on this critical issue and for the opportunity to contribute to this important conversation.

MR. YOUNG: Thank you for your comment.

We're next going to hear from Adam Jorge of Sonoma Clean Power. We're going to unmute your line, and you should be able to unmute yourself and provide your comment.

MR. JORGE: Okay. Good morning, Vice Chair Gunda, Deputy Executive Officer Sahota, presenters, and staff. I'm Adam Jorge, A-D-A-M J-O-R-G-E. I'm the Senior Decarbonization Policy Manager with Sonoma Clean Power Authority, and I very much wish I could be there in person today. I’m unfortunately out of weather and just didn’t want to expose anyone. So, some high-level comments.

Clean firm resource development and expansion continue to be some of the most critical challenges to grid reliability, rapid electrification, accelerated decarbonization, and expanded access to predictable, affordable energy. So we’re really grateful to see this work discussed so meaningfully today.

And I wanted to take a moment to really emphasize the value of geothermal resources in this mix. As highlighted in PG&E’s presentation this morning, the high-capacity factors associated with new geothermal resources, which are estimated to be around 90 percent, and the suite of next generation technologies offer a way to generate renewable power affordably and reliably while bringing economic benefits and clean jobs into California.

In recent years, Sonoma Clean Power has built up its geothermal expertise and built out a team supporting our Geothermal Opportunity Zone initiative, aiming to add about 600 megawatts of next generation geothermal resource within our service territory.

And as a community service aggregator and public power provider, we’re working with a wide range of stakeholders to find solutions to some of the most significant barriers to geothermal development so that we can maximize its benefits to our customers. And we think that the state is making some excellent progress. We know there's more to do to maximize the value of any future clean firm resources, including alleviating key transmission constraints through robust transmission planning and build-out to ensure that renewable power is both built in and deliverable throughout the state.

So thank you to the presenters on both panels this morning for raising this as a critical issue. And thank you to Harper for highlighting Fervo's incredible work on EGS and for the clear policy recommendations. So we appreciate all of the Commission staff, presenters, partners leading this critical and intersectional work.

We happily offer our expertise, partnership, and resources to organizations working in this space, especially to our government partners, so please reach out any time.

So thank you all very much.

MR. YOUNG: Thank you, Adam.

We're next going to turn to David E. Park. David, we're going to unmute your line. Please go ahead. David, you should be unmuted. You might want to unmute on your end. Okay, we'll come back to David.

MR. PARK: Sorry about that. I just figured it out. Hello, David Park with the Hydrogen Fuel Cell

Partnership, D-A-V-I-D P-A-R-K. I'm the Industry Affairs Director for the Hydrogen Fuel Cell Partnership.

First of all, I would like to thank CEC for your leadership in California and in setting really world-leading energy policy. California has long set the standard for visionary energy leadership, and the Energy Commission has been at the center of that success.

Hydrogen can help carry that legacy forward as a versatile energy carrier. Hydrogen strengthens grid resilience, enables long-duration energy storage, and decarbonizes hard-to-electrify transportation and industrial sectors. Fuel cell electric vehicles, particularly in heavy-duty and high-utilization applications, deliver rapid refueling and operational flexibility while reducing nitrogen oxides and particulate matter in communities most impacted by freight and goods movement. Prioritizing hydrogen in California's energy planning will ensure that the state continues to meet its ambitious climate, air quality, and equity goals while building a robust future energy ecosystem.

You know, as you know, the Commission has been a member of the partnership, ARB and GO-Biz are, and we certainly would welcome you back to the fold.

Thanks very much.

MR. YOUNG: Thank you, David.

We'll next turn to Sarah Gerson. Sarah, we're going to unmute your line.

MS. GERSEN: Good afternoon. This is Sara Gerson with Earthjustice. And I had two points that I wanted to raise with the CEC and the other decision-makers who've graciously taken the time to be with us today.

First, I want to note that the ambitions that California has to achieve a zero-carbon electricity grid cannot come at the cost of addressing our air quality crisis. And there have been some technologies discussed today that are zero-emissions, some that are not. And our air regulators in California's most polluted air basins, which is also where most of the Californians live, have recognized that we cannot meet health-based air quality standards unless there is a widespread movement to zero-emission technologies across small and large sources alike.

So essentially what that means, bottom line, we cannot breathe healthy air unless we have zero-emissions sources exclusively powering our power grid located here in the South Coast Air Basin and the San Joaquin Valley. And I think it's important for the IEPR to recognize that you need to plan for these firm low-carbon power objectives in a way that is consistent with meeting the Ambient Air Quality Standards that the state also needs to meet.

The second point I wanted to raise was just a bit of curiosity about something I noticed on slide 9 of the CEC staff report on meeting the clean firm power goals. I saw that one of the technologies under consideration for bioenergy is converting biomethane to hydrogen through a variety of pathways.

And I was surprised that those pathways were something that the state thought merited consideration because there is such a limited supply of truly sustainable biomethane. And the CEC knows this. I know you've done a ton of reports that show it. And the idea of losing about a third of the energy in that biomethane in the process of converting it to hydrogen just to use it in an application where you could just use the biomethane directly just seems really wasteful and inefficient and unnecessarily complicated.

So thank you for your time and consideration.

MR. YOUNG: Thank you, Sara.

It seems like there are no other commenters on Zoom, so back to you, Sandra.

MS. NAKAGAWA: All right. Thank you so much, Ryan.

We are now going to take a break for lunch. The Zoom will remain on, but it will be muted, and we're going to plan to resume at 1:45 p.m. Attendees, you are welcome to remain on the Zoom, or you can log off and then log back on using the same link you joined for the first half of our workshop. Thank you, everyone.

(Off the record at 12:25 p.m.)

(On the record at 1:47 p.m.)

MS. NAKAGAWA: Alrighty. Good afternoon, everyone. Thank you so much. We are now going to kick off the afternoon segment of our IEPR Commissioner Workshop on Firm Zero-Carbon Resources and Hydrogen. I’m Sandra Nakagawa, Director of the IEPR at the CEC.

As a reminder, this workshop is being held as part of the 2025 IEPR proceeding at the CEC. It’s a hybrid workshop, and we are meeting in person here at the CNRA Auditorium, and via Zoom.

For those attending in person, restrooms in a water refilling station can be found just outside the auditorium if you turn right.

This workshop is being recorded, and a recording will be linked to on the CEC website shortly after the meeting concludes. To follow along, you can find the schedule and slide decks have all been documented and posted on the CEC’s IEPR website.

We’ll have a few minutes after each presentation to take audience questions, but we may not have time to answer all questions submitted. Zoom’s Q&A feature is available for you to submit questions. We ask that in-person attendees who would like to submit questions log into Zoom and access the Q&A feature. If you are doing that as an in-person attendee, keep your device volume at zero and mute yourself to avoid any audio feedback.

Folks can also upvote questions that are submitted via the Zoom Q&A using the thumbs up icon. Questions that receive the most upvotes are moved to the top of the queue.

For in-person attendees that cannot access Zoom, please write your questions on the yellow cards at the back table and bring them up to me and I'll make sure that they get read at the appropriate time.

Lastly, we do have a second public comment period at the end of the day. Please know that we will not be able to respond to the public comments, and those are limited to maximum three minutes per person, with one person per organization allowed to speak.

I'm now going to turn it over to Vice Chair Gunda for any opening remarks from the dais.

VICE CHAIR GUNDA: Thank you, Sandra.

Welcome back, everybody. We had a really good conversation this morning, thinking through zero-carbon firm resources and the opportunity for diverse mix for the state and the reliability and affordability benefits that they could bring to the conversation.

Looking forward to the afternoon. Now we're going to move into the hydrogen discussion and looking forward to the conversation.

Sandra, back to you.

MS. NAKAGAWA: Alrighty. We are going to go to David Erne, who's going to just give us a little recap of what we've covered this morning and set the stage for the afternoon.

MR. ERNE: Good afternoon, everyone. Welcome to our workshop this afternoon. In case you missed this morning, we had a really interesting conversation this morning about the broad suite of firm zero-carbon resources, covered a variety of those technologies and an overview. This afternoon, we're digging in a little bit more deeply in one particular area, and that is in hydrogen. So we didn't talk a lot about hydrogen this morning because we're spending half the day on hydrogen this afternoon. And that's the focus of this afternoon's conversation is hydrogen and its potential for both electric system and transportation, which is a request for us under SB 1075.

We produced an analysis for the IEPR two years ago, it was very high level, kind of simplified analysis. We've done a lot more work since then, working with our consultants, Guidehouse, to help us develop a more deep understanding of the potential for hydrogen power and transportation sectors.

This afternoon, what we’re going to do is we’re going to start off with a presentation from Bloomberg New Energy about finance, about their perspective on the hydrogen market and what that’s looking like in the United States.

We’ll follow that with two panels. One panel will be providing an overview on hydrogen production, transportation or storage infrastructure and end uses, so give us a perspective from the developer and the industry standpoint.

After that, we’ll have a panel of agency representatives from the CEC, the Public Utility Commission, and Air Resources Board. The three agencies are working closely on our understanding and our analysis of hydrogen and its potential for California. Both CEC and the CPUC -- or excuse me, CEC and CARB have requirements under 1075 to analyze hydrogen, and we’re coordinating those analyses and our inputs and assumptions to help expand upon the opportunities for the state. So that will be the second panel of the afternoon.

So we have a lot of content to cover. I won’t go much further on that, but what I’ll do is kick off the first speaker, who’s going to be Payal Kaur from Bloomberg

New Energy Finance, who will give us an overview of the hydrogen market.

Payal?

MS. KAUR: Thanks, David.

Hi, everybody. Thank you so much for having me. I'm a hydrogen analyst for BloombergNEF covering the U.S. clean hydrogen market, and today I'm going to go over some of the key trends in the U.S. and how California comparison fits into the picture.

So on my first slide, you'll see a scorecard.

So the next slide.

Yeah, so you'll see a scorecard here that our team created to show the different key points within the hydrogen value chain and where they're at on a scale of five. And today I'm going to touch on supply, policy, investment and demand, but I'll give you a brief overview of what we've scored them.

Supply is rated the highest because there's been a lot of announced supply, not just globally, but also within the U.S.

In terms of policy, the U.S. has seen a good amount of policy in terms of subsidies come out, tax credits and grants, but the issue has been there's been a lot of uncertainty and it's taking longer for those incentives to actually come to fruition.

The midstream is also rated two out of five just because there hasn't been as much progress in creating pipelines and storage for clean hydrogen.

Now investment and demand are both rated the lowest out of one because there's a lack of offtake for clean hydrogen and because there's also a lack of offtake, there's a lack of investment. It's harder to get final investment decisions for these projects because of the uncertainty in the policy environment, and because of the lack of demand.

And so I'll start off by talking with policy. And if you skip to the next two slides, you'll see I have a snapshot of our hydrogen subsidies tracker. So we have a tracker where we track all the federal subsidies available throughout the global markets, anything from your tax credits, grants, auctions, et cetera. And currently, or at least back in March, the U.S. fell second to the EU and its member states with about $90 billion in subsidies available.

Now that number is likely to be even smaller now because that $90 billion, specifically that teal color you see, that color is supply, is comprised of the 45E and the 45Q tax credit pool. And now given the new deadline to qualify for 45E, that value is likely to be much smaller now, about $30 billion less. And of course, projects in

California can apply for these incentives.

Now, the effect of what this uncertainty has done to the U.S. market is evident today. In the next slide, or the next couple of slides, you'll see that we've created a scenario to demonstrate the effect of the uncertain policy environment in the U.S.

And so what we did was we took a look at the seven largest markets that have movement with clean energy -- or clean hydrogen. And the U.S. is actually only comprising of 1.2 percent of the global clean hydrogen production capacity that took FID last year. And when you're looking at California, only one project is contributing in that of the U.S. amount.

Now, on the next slide, you'll see there's another barrier to the U.S. from the policy side, and that's tariffs. So back in April, our team analyzed what the impact of the tariffs that were announced on April 8th would have on the green hydrogen market, specifically on the levelized cost of green hydrogen. And I know that the tariffs have changed since then, but I kept this slide in here just to demonstrate the fact that having tariffs is just going to increase your levelized cost of green hydrogen, which is already more expensive. And so you'll see additional costs in your electrolyzed equipment, solar and wind equipment, and on EPC and other factors that get baked into your LCOH.

And then on the next slide, the most recent, not necessarily a barrier for blue hydrogen, but more so for green hydrogen, was the finalization of the One Big Beautiful Bill Act. So let me just talk you through this chart.

So existing guidance here is referring to the amount of green hydrogen projects BNEF had forecasted could qualify for the 45E tax credit prior to the OBBBA. And then the House budget bill is what was proposed and passed by the House. And then the past Senate budget bill is what was eventually passed and is now the OBBA.

So the final version, there is a decrease in the amount of projects that we had forecasted to come online just based off the forecast from last year. This number, which is around 700,000 metric tons, is actually likely to be even smaller as we're currently revising our supply forecast for this year. But it's a little better than what was proposed by the House budget, the House budget bill.

So the question remains now is, okay, we're having about 700,000 metric tons, possibly, most likely less than that amount that could qualify for 45E. What is the total supply available right now? And so what does that actually mean in terms of numbers?

So in the next couple of slides, you'll see the chart for the announced clean hydrogen capacity within the U.S. And so overall, the U.S. has announced around 16 million metric tons of clean hydrogen to come online by 2030 and beyond. N/A on this chart means projects that haven't just publicly disclosed when they expect their project to be Commissioned. But the top four states are Louisiana, with about four and a half million metric tons, Texas at around 4 million tons, West Virginia at three point two and California at one. The remaining amounts for the rest of the U.S. is around two and a half million metric tons of this split.

So when we look at the split between green versus blue hydrogen, so green is your hydrogen created through electrolysis, blue is hydrogen created using natural gas and thermochemical processes, the trend in the U.S. as a whole is more blue hydrogens now to come online than green hydrogen. But in California, the trend is reversed, where about 89 percent of the planned production is for green hydrogen and the remaining 11 percent is for blue.

Now, the driver between this big difference between blue and green hydrogen in the U.S. mainly has to do with costs, which you'll see in the next couple of slides. So right now, our team is working on updating our blue hydrogen levelized cost update, so I don't have a chart on that.

But what I can say is blue hydrogen is generally about 50 percent cheaper than what it costs to produce green hydrogen. And we were able to model out three different states in the U.S. Earlier this year, we published a report on our levelized cost of green hydrogen. And this first slide you're seeing is the cost of green hydrogen in Texas. And focus on the blue line, because that's where the costs are today. And this is assuming you're using off-grid renewables. And these are unsubsidized costs. And this is a best-case scenario where you're using -- your solar and wind are located in a really optimal spot within Texas.

So if your electrolysis is running at 80 percent utilization rate, the lowest LCOH you can have is around 750 in Texas. And that's mainly because Texas is modeled to have really good wind and solar renewables. Whereas on the next slide, you'll see the comparison to Utah, where their LCOH is a bit higher. It's around $9.00 per kilogram. And we had also modeled out New York. And it's even more expensive than Utah. So I would actually assume that California would fall somewhere between Utah and Texas just based off of renewables performance.

And so how does this translate to demand?

So in the next couple of slides, you'll see the chart for demand, where globally only six percent of offtake has been signed, and of the six percent, two and a half million tons is for supply, is supply contracted from the U.S.

So where does California fall in terms of signed offtake agreements?

Roughly 108,000 tons of offtake signed for supply in the U.S. are from California. And California falls in third place in terms of which states have the most contracted supply. They're behind Texas and Mississippi.

Now, if you're wondering, well, where is this going on the next slide, we have a chart that's showing globally what the trend is in terms of the type of product that is assigned for offtake and what the end use is. And so globally, most of the contracted volumes are going to either green ammonia or green hydrogen. And this is largely driven by the European market.

In the U.S., 1 million tons of the contracted volumes are actually going to blue hydrogen or blue ammonia of the 1.6 million tons are contracted supply that's remaining in the U.S. And what I mean by that is this 1 million tons is only accounting for the supply in the U.S. that's contract for domestic use and is not counting the U.S. supply that's being exported.

And so we can narrow it down to understand what's happening in California. Most of the contracted supplies, actually, for blue hydrogen or its derivative, blue ammonia. So out of the 108,000 tons of offtake signed in California, about 78,000 tons is for blue hydrogen or blue ammonia, and the remaining 30,000 is for green hydrogen or ammonia.

So this is interesting, given the fact that California has over 80 percent of its announced supply targeted towards green hydrogen and the remaining amount is for blue, whereas the offtake, the trend is different. So it seems like there's more demand for the blue hydrogen, blue ammonia product in California right now than there is for green hydrogen or green ammonia. And that's partly due to the uncertainty that there has been around the policy landscape for green hydrogen incentives.

And in terms of where these contracted volumes are going, they're going to be used within fertilizers, power and heat, and road transportation.

And on the next slide, you'll see a table where we've charted out the key end use sectors for green hydrogen globally, and you can kind of use this to compare it to what California is targeting. I heard David say earlier that you're targeting to use it for power and heat and transport, and they fall more towards the lower end of the table. And that's because your existing use sectors are where most of the demand is coming from today, which are your oil refining sectors, methanol and ammonium. Those are commercially ready sectors that already have an established use for hydrogen.

Steel and shipping are more of your emerging use sectors globally that are getting more demand. And this varies by where you're located. For steel, it's really being driven by the fact that certain markets have mandates for their sectors to decarbonize, such as your steel sectors. The U.S. does not have such mandates for steel. And then aviation power are towards the bottom of that table.

And so on this final slide, I know I went through this a bit fast, but I want to make sure I covered a good amount in these 10 minutes. We've gone through supply, we've gone through policy, demand and investment. We've taken a look at how what's happening in the policy realm is not only just pushing what's happening in the clean hydrogen industry, but its uncertainty is also hurting it in certain instances. And if you're taking a look at the trend between blue and green hydrogen right now in the U.S., it seems if you're doing blue hydrogen, you're in the right spot. There's more demand for it right now. The costs are much lower as well. And there's a lot less uncertainty around it.

Thank you. I don't know if we have some time for questions.

MS. NAKAGAWA: Thanks so much, Payal. If you're able to stay on for our next panel, it would be great to do combined questions with you and our next set of panelists.

I'm going to introduce Jason Orta, one of my colleagues at the CEC. Jason is a Gas System Modeler. And he's going to be moderating our next panel on hydrogen.

MR. ORTA: Great. Thank you, Sandra.

So this panel this afternoon is going to be an exciting one. It does build upon this morning's sessions as we will hear perspectives in -- across the hydrogen value chain from production to uses in microgrids, transportation and storage of hydrogen, and including a project here in California.

So the panelists joining me today will be Jeremy Hayward, who's the President of Redding Rancheria Economic Development Corp., Wladimir Sarmiento-Darkin, who's the Director of National BD and Clean Hydrogen with Linde, Shailesh Topiwala, head of Hydrogen Business Development with Bosch, Matt Franzen, Chief Operating Officer with H Cycle, and Craig Klaasmeyer, who's the co-founder of Kaizen Energy.

Our first speaker on this panel will be Jeremy Hayward, who will talk about what's going on at the Redding Rancheria. And he represents the Redding Rancheria

Economic Development Corp.

MR. HAYWARD: Thank you so much, Jason.

So as I stated earlier, my name is Jeremy Hayward. I'm President of Redding Rancheria's Economic Development Corporation, and we are looking to build a biomass to hydrogen facility in Red Bluff, California.

Next slide, please.

So Redding Rancheria's story, what we're trying to do, we're trying -- why we're trying to do this, and the tribe's culture of being stewards of the land, I'll kind of go through this for a minute.

So reduced fuels on the forest floor, obviously that's a huge issue here in California and affects my tribe every fire season. We've had tribal members' homes burned down. We've had one tribal member's home burned down twice and team members' homes, you know, burning down here in the community. I don't have to go on and on about this. I know you guys know all about the fires here. So reducing fuels on the forest floor, reduce chances of wildfires, reduce CO2 emissions and provide clean energy is what we're trying to do.

Why we're trying to do this is fires are more prevalent. Communities are being destroyed. Looking forward to the next seven generations, my theory and the reason that we got into this was we want our children to be able to enjoy the same landscape and forests that we have today and the future and their children and their children-children -- children's children. Sorry. So looking forward to the next seven generations, really important to my tribe. And it's kind of how we were all brought up around here was to take care of this place.

And then energy availability, we know that with all the data centers coming into the country and EV cars coming online and all those things, it's really straining the power grid here in California. We already experience these rolling brownouts and the PSP shutoffs and all that stuff. So we want to make sure that there's more energy available here in California.

And then just again, tribes' culture of being stewards of the land in the next seven generation mindset was taught to me and my family at a very young age by my great grandfather.

Next slide, please.

So biomass to hydrogen. Large wildfires are destroying our communities. We've had the Carr Fire, the August Fire, Dixie Fire, Park Fire, Camp Fire, Palisades Fire and many, many more. We have two or three very large wildfires every year here in California, and they're destroying our communities and destroying our forests. Our goal is to go after dead, down and diseased trees and utilize those as a better biomass to hydrogen facility.

The fuel building up on the forest floor, so this kind of relates back to a story of how we got into this. Me and my brothers, we ride mountain bikes and we ride in all the mountains right here around Reading. And one of them happens to be Mount Shasta, which is our favorite place on the planet. And there was a lot of fuel building up on the forest up there. We had -- there were some people that came and did some cleanup work, but the fuel is still there. It's just now piled up a couple of years later. And so, you know, we saw that and realized that there needed to be change in forest management and the way that we treat the fuels on the forest floor.

And then energy sovereignty, taking control of our energy production. So tribes over and over again are having to be at the mercy of whatever utility corporation it is that they're working with on trying to get more energy to the reservation to be able to expand homes, expand economic development, build, you know, expand our casinos and things like that. And it's really difficult to get some of these energy companies to agree to bring more electricity to the reservations. So we want to take control of our energy sovereignty.

Job creation, it creates permanent jobs in rural communities.

Limited power available. We talked about that already with electric vehicles, data centers and so on.

Next slide, please.

So our project, we're looking at developing a pyrolysis or working with a developer of a pyrolysis system operating in an oxygen free environment, utilizing a thermochemical decomposition of organic material into a syngas. It will be self-powered by our syngas and a microgrid, so we'll use the syngas to power the entire facility.

The hydrogen purification by pressure swing absorption, so we'll purify the hydrogen from a 65 percent hydrogen-rich syngas to a 99.999 percent hydrogen-rich syngas. We'll use two inch minus the size of the chips that will run the feedstock to our facility. Again, the hydrogen percentage with the three nines at the end. I'm sure you guys all know this, but three nines are very important if you want to create sustainable aviation fuel. And we are planning on being a carbon neutral project at worst, carbon negative at best.

Next slide.

So the process, we have our feedstock biomass preparations that will receive and store the biomass, grind it up into two inch minus, make sure moisture contents what it should be to go through the system. Then we run it through a high temperature pyrolysis system. It outputs about a 65 percent hydrogen-rich syngas and biochar, then it goes through a thermochemical decomposition where the syngas is now sent over to the pressure swing absorption, creating a 99.999 percent green hydrogen.

Next slide.

So biochar being the only byproduct of our facility, we wanted to make sure that there were good uses of biochar. And we started talking to the Biochar Coalition here in California and they educated us quite a bit on what biochar can be used for and what we should be looking to use our byproducts for, so water retention, enhanced nutrient availability, improved soil structure, increased crop yields, carbon sequestration, reduces soil acidity, absorbs pollutants and can be used as an additive for livestock feed.

So all that being said, hopefully you guys have heard, and if not, please look it up, the Trillion Tree Initiative was a good showcase for biochar. So what they did was the Sahara Desert was expanding year over year and just increasingly getting larger and larger, and they wanted to figure out a way to stop that expansion. So they used biochar rings and planted around vegetation on one side of the desert. And not only did that vegetation stop or did the -- sorry, did the desert stop expanding, but that vegetation started growing into the desert, which shrank the size of the Sahara Desert rather than it expanding year over year. So I think that's a good, good example of what biochar can do.

Next slide, please.

Renewable and sustainable.

So renewable, there's 54 million dry tons of biomass available annually here in California. Biomass from multiple sources, so ag waste -- oh, sorry, that's not biomass. So feedstocks can come from multiple sources for a facility like this. You can use ag waste, MSW tires, biomass from the forest, construction waste, all types of different things.

Sustainable, economically viable and operationally predictable, competitively priced with other energy sources, green hydrogen production without high energy costs uses less water and energy than other methods of hydrogen production.

Next slide, please.

And then benefits of our product, so we utilize carbon capture, creates permanent jobs in rural California, reduces fuels on the forest floor, hopefully saving some of these mountains around here that our children enjoy for the next generation. Less smoke from fires. I don't know about you guys or those of you that live here in

California, but my children breathe in smoke from these fires every single summer, and I would like to make sure that that's reduced.

Green energy or gas, so you can create energy out of hydrogen or you can create fuel for the transportation industry.

Safer communities, utilizing the biomass from the forest here around our communities.

And then the seventh generation mindset, really just trying to figure out how to live every day considering that we are trying to sustain this place for the next seven generations and beyond.

Next slide.

Okay, EVM and forest management. So we own a forest management company called Essential Vegetation Management, and we have three very experienced partners that we partnered with on this endeavor. We have master stewardship agreements with four national forests all around us, so we have Shasta, Trinity, Modoc, Mendocino, Lassen, and Siskiyou, so five master stewardship agreements.

Traditional ecological knowledge. So, you know, roughly 200 years ago when tribes were no longer allowed to manage the forest here in California, we had traditionally been using fire to manage the forest, clearing out the areas that got, you know, over or too much vegetation, helping some of the seeds pop so that we can grow new plants for food and things like that. And that has gone away for the past couple hundred years, and there has been an effort to revitalize TEK and utilize the tribe's knowledge about forest management to try to get some of these forests healthy again. So we're planning on working with TEK and trying to figure out how to support the national forest utilizing that.

We have a bunch of Caltrans contracts right now everywhere from San Diego all the way up to Siskiyou County and a bunch of counties in between.

We do vineyard maintenance for vineyards in Napa County.

Biochar utilization and reforestation. We are working with a few national forests right now and trying to show them the benefits of biochar and how we can utilize it for reforestation.

And then these three partners that we partnered with were instrumental in writing the Save Our Forest Act, so they put a lot of time and effort into that. And really, really great partners. They have the same mindset and forward thinking that the tribe does.

Next slide, please.

Rate increases related to fire. So, I don't know about you, but I'm pretty sure everybody here in California has seen rate increases for insurance due to fire. My homeowner's insurance has at least doubled within the past four years, and I'm sure a lot of you are all experiencing the same things. At some point in time, if we keep this up, Californians aren't going to be able to afford to finance homes anymore, having the requirement of having to have fire insurance. So rate increases are a big thing right now.

Also, rate increases for electricity. You know, our insurances are going up, our electricity costs are also going up, and this is really steaming Californians at the time.

Next slide, please.

Challenges with this project. So this project absolutely has not been without challenges. We've had a handful of them and are still working through some of them.

So restrictions on funding for use of biomass source from federal lands. I've been told at the last panel that I spoke on that this is being worked on and there may be a solution, but 57 percent of California's forested land is owned by the federal government and we cannot utilize that biomass for certain funding that we've received for our project, so we're looking for a solution for that. We believe that even though that these forests are owned by the federal government, we still need to maintain these forests here in California. They're still in our communities, they're still in our backyards, they're still places that we take our children to. So we absolutely need to include biomass from federal lands.

Infrastructure is not ready yet. When we started getting into this project, our main goal was to support the transportation industry and sell hydrogen to, you know, fueling stations and things like that, and it just hasn't come to fruition. In fact, last I checked, there's fewer fuel hydrogen pumps here in California than there was when we started this project. So we've slowed down a bit and are waiting for the rest of the industry to catch up so we can start seeing some of these fuel pumps come available and re-evaluate the project after some of this infrastructure is put in place.

Cost of transportation of biomass to the facility. This is an ongoing challenge for us. We're in the middle of having a feedstock study done right now to figure out how much feedstock is available within a certain distance of our facility. We have to keep the cost of biomass to the facility under $44.00 a ton, and if we can't keep it under that, then it's not a feasible project, or we'll have to raise the price of hydrogen, one of the two.

Funding uncertainty. So with this new

administration, obviously everybody’s had challenges with all their green energy funding going away and not completely certain of what’s going to stay around and what’s going to be stripped. So we’re just kind of waiting and seeing where the dust settles so we can figure out what funding we can go after to get this project off the ground.

That being said, California has been very, very gracious with supporting hydrogen and helping get a lot of these projects going. So, you know, I think the main reason most of these projects are still moving forward is because of the state.

And then interconnection agreement challenges. So once we realized the transportation industry wasn’t going to work out, you know, quickly, we started reaching out to different utility corporations and talking to them about interconnection agreements and things like that. And it is just a nightmare to try to get any of these utility corporations to agree to buy energy from us at the moment.

So those are the challenges with the project. And like I said, we’re still working through some of these and waiting for funding to hit and figure out what’s going to be available once that’s all done and over with. We’re waiting for infrastructure to be committed to so we can start seeing these pumps installed here in California.

And like I said, the first point here was utilizing biomass from federal lands. And I've been told that there is a solution for that. So, I'm excited to hear what that solution is.

Next slide, please.

Capital stack. So Department of Conservation from California have awarded us a $500,000 pre-development grant. And that's what we worked off of for the first year of getting this project going. CEC -- actually, I got that wrong. It wasn't CEC that we got that money from, it was the Forest Service. So we got a wood utilization grant from the Forest Service for $300,000. We're working on amending that right now to cover our feedstock study.

The tribe spent over $1.5 million so far of our own money trying to get this project off the ground, securing land and doing different studies.

DOE Direct Loan Program, they have a direct loan program that's specific to tribes. And we're in Phase 2 of the direct loan program with DOE, again waiting to see where the dust settles on that funding to make sure that it's still going to be available and get to the finish line.

And then leveraging the ITC, if it's still available, we have no idea if it's going to be available or not, but hopefully, being able to leverage the investment tax credit for that.

And then looking for additional grant funding, so we're always looking for additional funding to help get this project off the ground and make sure that it's able to happen.

Next slide, please.

All right, so I have a question slide on here, but I think they asked me to wait until the end, so I'll wait until the end for questions.

Thank you guys so much for listening to my presentation. And if anybody wants my email or anything like that, just let me know. I'll put it in the chat.

MR. ORTA: Great. Thank you, Jeremy.

So we're going to transition a little bit from, as Jeremy shared, the process of developing this project and the challenges. We will hear from Wladimir Sarmiento-Darkin from Linde. Linde is a company that specializes in various aspects of the hydrogen value chain from production, application, storage, transportation, and fueling.

Wladimir?

MR. SARMIENTO-DARKIN: Thank you, Jason.

Thank you, everyone, for the opportunity to talk to you today. Let's see, I have a couple of slides here to introduce Linde to the audience in case you haven't heard about us. And then I want to talk more about our vision for kickstarting the heavy-duty mobility market for California; right? And these visions also apply for expanding the market, but I kept the presentation based on the kickstart part, so time-constrained. But you will see the similarities between this approach and what we are discussing with ARCHES and how this should be implemented for new projects and to grow the market.

But let’s start with the next slide, giving just a quick view of Linde.

Linde, we have been around in business for over 140 years. Actually, California was one of our first hydrogen production sites in the United States in the 1960s, so we’ve been doing hydrogen for a while. We operate in more than 100 countries. And last year, we had a revenue of $33 billion globally.

We have two big divisions. One division that is the Gas Division that is in charge of distributing, manufacturing and selling -- manufacturing, distributing, and selling the molecules. And another division, that is the Engineering Division that makes the equipment for these plants. But our Engineering Division also makes equipment for third parties. We make big facilities that we sell around. It’s a world-class EPC division.

Next slide, please.

On hydrogen in particular, we have about 150 hydrogen sites around the world. We operate all kinds of hydrogen production technologies. So from steam methane reformer, that's what we have in California, to electrolyzers that -- we recently opened a 35-megawatt site in Niagara Falls, New York, to ATRs. We are building several of those as part of our blue hydrogen projects, partial oxidation units. You name it. We have been operating all kinds of technologies, and we have proprietary technology for most of them, including our liquefaction systems, which are also using Linde proprietary technology.

We have the largest network for liquid production in the United States, and that's why we have been always a big proponent of utilization of liquid hydrogen as a distribution mode. Because hydrogen -- liquid hydrogen, you can move it around easily, so you can back up faster and easier, you know, lots of molecules in any region.

As I said, we have 170 tons per day capacity. So yesterday, we produced about more than 100 tons of hydrogen. So when we talk hydrogen, we talk about what we have done in the past, not what we plan to do in the future. Also, that is included, but we have an experience in doing this. So I always, always ask, how many tons did you produce yesterday? And then we'll talk more about hydrogen; right?

We have a large pipeline of hydrogen in the Gulf Coast in the United States and in Europe. This pipeline in the Gulf Coast is about 500 miles, and it's attached to one of our hydrogen caverns, storing more than 6,000 tons of hydrogen, which makes the system in the Gulf Coast, you know, I think one of the largest in the world and the most reliable one due to the capacity that we have stored.

Operating more than 80 electrolyzers today, and we have two new plants of electrolyzers, one in Leuna, Germany, and one in Niagara Falls, New York, where we are expanding our experience with ITM technology.

Next slide.

I just want to show you quickly where our plants are. Five locations across the United States. The yellow triangles, let's concentrate on those. Those are the production sites. And as I said, one of them is in Ontario, California, which is in the outskirts of L.A. That plant has been there for more than 60 years. And then we have another four sites located in Texas, Alabama, Indiana, and New York.

As I mentioned before, we had 6,000 metric tons of storage cavern in our pipeline system in Texas, and we produce all kinds of carbon intensities through the network. We have the green hydrogen in Niagara Falls using hydropower from the Niagara Falls, and electrolytic. We have green production in Ontario with renewable natural gas available, and we are working on two big projects that were announced last year for blue hydrogen in Texas area.

So moving on, I just want to talk briefly and quickly about -- to the next slide about liquid hydrogen. I know a lot of you have heard stories about boil off. I just want to use this opportunity to briefly say that the boil off is not a major concern, really, if you know what you're doing. And as I said, we have been doing this for a while.

Our customers, before, you know, the refueling systems were installed in California for heavy-duty mobility, the temporary systems. Before those were installed, we haven't had any issues with boil off before that. We understand boil off should be less than 7 percent, less than 10 percent for sure, and these are the numbers that we have seen across our refueling stations. We have installed more than 200 of those worldwide. And you should have less than one percent in the distribution, less than one percent in the storage on the site, and less than five percent in your system. That's what we guarantee in our refueling stations anyway.

So I just want to make a quick note, just saying boil off for liquid is not an issue, and we should use the opportunity that we have the largest network in the U.S. to facilitate the distribution of hydrogen for every state, but especially California, where we have one plant that can be backed up by several other sites in the United States.

So the next slide, we're going to start discussing how we see the market and how we see the market can take off for heavy-duty especially.

So next slide, please.

So we have seen California in the past have treated the hydrogen market as a compartmentalized sector, basically, and give providing funding and policies for the different portions of the market. You're treating the market as a production size, refueling stations, infrastructure, you know, and the vehicles, and, you know, some power applications.

And that has been the traditional approach. It's a very complex tax. You know, actually doing like this makes it more difficult. And you have incomplete information just because you are treating only one component in the whole system. So you don't really know how much funding or how much help you need to put on the refueling -- on the infrastructure side compared to on the hydrogen production side or in the vehicles. So there is no -- other than the parity versus the immediate competitor, you know, like say diesel, right, so you have to pay for pretty much all the refueling station just to make it similar to diesel, or have to reduce the hydrogen cost to make it similar to diesel to replace it in a truck.

So there is no complete information. You don't know how to connect all this unless -- next slide, please. Can you go to the next slide? -- okay, unless you treat the system like a component of a project, and then you do a matrix approach to this. Now you take, you know, components, each one of the components in your system and make a full project that will work as a system, you know, coordinated, and now you know what to -- what you are targeting; right? And then you can get all the players of that project to work together from the beginning to define what are the key characteristics of the project that will make the project successful.

And as I said at the beginning, we are talking about this with all the players in the state, and especially ARCHES, which we are part of it, as a way to assign funding and make sure that the competitiveness is there; right? And I just want to talk briefly in my next slide, please, on what is the key metric that we think has to be the guidance for assigning resources. And I want to show the impact on the total cost of ownership, which I think we think is the key metric for heavy-duty markets.

So next slide.

So in this case, you know, we have here a total cost of utilization ownership analysis for a 50-truck scenario and of Class A trucks. We are -- I mean, the assumptions are on the upper right side of the slide. But, you know, we start the analysis of the total cost of ownership, TCO, basically with diesel, which is a little bit less than $1.50 per mile. And again, a lot of assumptions, but this is just for comparative purposes, and I hope you take it that way.

For the cost of ownership, we are assuming, you know, basically three major components, which is the cost of the truck, which includes the maintenance, the fuel, and then the HRS. And then we are quoting here, on the left side of the slide, we are quoting what are the tools that the state has put in place. California has a wonderful framework, regulatory framework in place to help this market take off. And all the tools are at hand now to make that happen.

So when you compare the total cost of ownership of a diesel truck versus a hydrogen truck with no incentive, this is what you get. You get $1.50 versus almost $4.00 per mile in the case of hydrogen. But now you have the different incentives in the state to start mitigating that extra cost. You take off about $0.60 in the cost of ownership with a LCFS, you know, hopefully recover it with a new regulation in the order of $100 per metric ton. It's still around $0.50, but it's trending upward, so everybody should expect that to be a reality in the future, hopefully.

And then you see how the CapEx subsidies coming from the Carl Moyer or EnergIIZE Program can shave about another dollar per mile and making -- you can see the total cost of -- I'm sorry, the cost of refueling of hydrogen in the bottom side of the bar. So we go from an initial $20.00 per kilogram that you need to charge in order to recover all the investment in your capital, in your capital in your refueling station and your hydrogen production side to $16.00 to $9.00 once you have the HRS subsidies established. And then you get the HVAPs in the picture, you shave another $0.40.

And that's where you will be, you know, if you don't have a better LCFS, probably around $1.70, $1.80, which is a small increment versus the diesel versus what we were seeing at the beginning; right? So with this, if the LCFS goes even beyond, you know, back to the values in 2021-22, then you'll be a parity.

And then what we are saying is the tools for making this happen are already in place. And the capacity of production to do something like this, 50 trucks, and it's exactly -- it's present, so the capacity is there. You know, we have one plan. There are other producers that have other sites. But the capacity is there to do this.

So we think just by focusing on the dry metric, in this case, TCO, and getting projects evaluated as a whole, not as a piece of your separated pieces, you can actually maximize the of the regulatory framework that already exists in the state, making the competitiveness of the technology possible, which is -- which has to be, according to us, the final and ultimate target, just to make this self-sustainable; right? That is the goal of all this. So the state and the federal government intervenes, put the subsidies in place, and then pack away, and the whole thing will run forever because it’s commercially viable.

So just to finalize, my next slide, please, just want to say that, just to summarize, TCO, we think, should be the metric to deploy the resources in the heavy-duty market. A collaborative interagency effort in order to allocate these resources based on the TCO with microsystems in mined projects will be necessary. You know, we are -- we have a plant in South California that can be used for the short-term seeding projects. Again, there are other sites that can also work with the state in making this happen.

And the same approach can be utilized for ARCHES big picture, you know, now 800 trucks, now including a new facility production hydrogen, now 10 stations instead of 1, but the same approach based on the total cost of ownership, competitiveness, and parity with this; right? We got to get, obviously, operators like Pilo (phonetic) Trillion and others involved in this and work with all the OEMs that have offerings today for hydrogen refueling -- hydrogen fueling -- fuel cell, I'm sorry, vehicles.

And then we should approach the fleet owners with the numbers in hand, like saying, okay, now this is what you will be expending by using this truck. And as you can see, it's actually competitive versus your current alternative, which is diesel. And we can make that happen today. You just have to commit to get these trucks in the road. And then just start the discussions to instrument the projects that everybody's seen the details, obviously, but we think this is totally possible. And that's why we remain optimistic in the future of hydrogen for mobility, heavy-duty especially, and in California, you know, mainly.

So, thank you for your time. I'll be happy to answer and take your questions when the question session starts. Thank you.

MR. ORTA: Thank you. Thank you, Wladimir.

I just want to do a time check before we continue. This panel is scheduled, the presentations are scheduled to include at 2:50 and it's already 2:40. So we have a pretty long agenda with a lot of good information, so let's try to finish this on time.

So our next presenter is Shailesh Topiwala from Bosch. And let's -- so please bring up Shailesh. Thank you.

MR. TOPIWALA: Good afternoon, everyone. Thank you for this opportunity to address this group. So, again, Shailesh Topiwala from Bosch, Director for our corporate and business development activities and responsible for several parts of our hydrogen portfolio.

Next slide, please.

I'll give a very brief highlight on Bosch. You probably have some touchpoint with Bosch, but you know, we're a privately held multinational conglomerate, over approximately $100 billion across four key sectors, from mobility solutions to industrial technology, consumer goods to energy and building technology. And, you know, there are several key megatrends that are shaping our activities from electrification to defossilization, the vehicle transformation, power chain transformation in the mobility sector, the application of AI and IoT technologies that really impact a lot of our portfolio. And we're very proud to state that we have been CO2 neutral at Scope 1 level since 2020 for a company our size and our breadth. It's a pretty significant achievement.

Next slide, please.

So you guys know the challenges, but what is our motivation? You know, California has its targets for clean electricity, 60 percent by 2030, 100 percent by 2045, including carbon neutrality. And in the energy ecosystem and domain, 2045 seems like -- it may seem like a long way away, but it's really around the corner. You know, the challenges that have already been mentioned around, you know, the severe weather events, air pollution, the goals on decarbonization, dealing with decentralized energy systems, et cetera, these are all key factors.

But we also have solutions at hand. You know, leveraging flexible systems, modularity, scalability is key to solve the grid bottlenecks. You know, how do we complement renewables effectively to address, you know, ultra-low emission goals and in the end, deliver reliable power cost-effectively, whether it's stationary power for the grid or for end uses, or powerful mobile solutions?

So these are the drivers that we all have to think about, and one of the key motivations of Bosch's engagement in the hydrogen ecosystem.

Next slide.

I wanted to share this information to give some context of hydrogen. You're supposed to memorize all the colored dots here, just a little joke there, but what that shows is all the offtake of hydrogen across North America, obviously U.S. focused, and the different colors of the dots are the different end uses, the diverse end uses. And when you look across this, you have this distributed landscape, also, of where the offtake is. And then from targeted low-volume use cases all the way to large industrial applications.

While we do have some hydrogen pipelines, as was mentioned before, in certain areas, we don't have a national hydrogen pipeline network, which creates a challenge in delivering the hydrogen to all of these endpoints. And this is where, you know, these factors create an opportunity for electrolytic hydrogen production. You know, this decentralized demand results in a high cost of delivery for hydrogen from centralized production sources.

So these smaller scale offtakers can definitely benefit from a localized production model; right? So electrolyzer systems that are smaller scale can be deployed adjacent to or very near to the offtake. This approach addresses some real industrial applications and uses and new demand centers from growing mobility and station power applications, the hydrogen trucks, buses, clean backup power systems, all of these types of applications.

And then underlying all of this is, of course, corporate sustainability targets that we believe will remain a consistent driver for the deployment of cleaner and greener solutions in the hydrogen ecosystem.

Next slide.

So what is Bosch's role? Where are we focused across the value chain from production, storage distribution to use?

We do have a bit of a history here, but let's start on the use side, where Bosch's portfolio encompasses PEM technology in the context of our fuel cell. We've commercialized our PEM fuel cell for mobility. We have over 7 million miles and growing of real performance. So that's a key-plus to prove we can deliver at scale and then actually deliver the value to start challenging incumbent systems.

We're also commercializing combustion technology for both mobility and stationary heat and power applications. I think we have to take an all-of-the-above kind of view of where hydrogen can be used, fuel cells, combustion technology.

In the midstream, we're really focused on bringing reliability to hydrogen refueling stations and systems with a two-stage cryopump system, the lack of which has been a key hindrance for the mobility adoption.

On the production side, which is a key point that

I'm focused on, we're industrializing PEM stack technology to deliver really repeatable stack volumes to known and capable industry system integrators, so creating some optionality there. We're also working on addressing value-added purification, hydrogen gas detection, and hydrogen compression topics with some other portfolio offerings.

Next slide.

So let's dive deeper into two key areas and I'll wrap it up.

So when we think about refueling, as was mentioned before, you know, there's topics, you know, at different levels, but boil-off has been a key challenge. Really more important than that has just been the reliability of the refueling stations; right? So when a truck pulls up, a /car pulls up, you need to know that the pump is working.

And so what Bosch has focused on over the last few years is with our partner, FirstElement Fuel, is really to design a package, a modular package that really addresses that. And with our cryopump system in this footprint, we really have near zero H2 loss through that value chain of delivering hydrogen. We also address all formats. So making it a bit future proof so we can deliver liquid to 350 bar, liquid to 700 bar, Cassius (phonetic) format, or liquid to liquid, which really creates a nice ecosystem. So when you put a system like this one into the field, you can address all different offtake types in the mobility sector.

The other key point is refueling times. You know, we've gotten that down to 10 minutes, which is a key. And then one of the most important things is the footprint. The footprint is significantly smaller, up to a quarter or even a sixth of the size of a traditional infrastructure of this type. So reducing site construction time because it's a modular container type approach that we can deliver, and the time to deploy. Obviously, all of that drives down cost. And the lower the cost, the better the overall levelized cost of hydrogen at the delivered point. And the one thing we're most proud of is increasing the reliability over 10X; right? Our maintenance cycles are over 4,000 hours, and all of this comprises the high level of safety in the system.

So we believe this is going to be a game changer. We're launching into the market in California and Texas as a first step as we speak and have a solid pipeline of activity.

Last slide.

So on the production side, our main focus is electrolytic hydrogen using PEM technology, which has been around for a little bit, but not as long as alkaline, which is over a century of experience, PEM a couple of decades. But, you know, the market has developed in that sector really with vertically integrated suppliers, which certainly has its benefits, but also some limitations. We believe by adding Bosch's competencies in high volume manufacturing, precision manufacturing, leveraging these competencies, we can deliver really a very reliable, repeatable, and scalable stack, which can then be leveraged by a number of system integrators that are already active in the energy and industrial gas domain.

And so by giving these integrators, you know, the heart of the system that's very robust and reliable from Bosch, they can then apply their competencies, provide optionality to different end uses in developing either containerized systems or larger plant solutions for electrolytic hydrogen production.

And so that kind of ties up, you know, the opportunity set. We are active in the California market, working on, you know, systems as small as, you know, half a ton to a ton a day of production, all the way up to 50 tons a day that we're working on, and of course also aligned with ARCHES. But our integrator partners such as Neuman & Esser, Nikkiso, H2B2, AKA Energy Systems, just to name a few, these are the types of integrators that already have experience in the hydrogen ecosystem, and they can now leverage those competencies with Bosch to deliver some optionality in project design, again, driving down costs, and then the lower the cost, the better the adoption rate for green and clean hydrogen.

So with that said, I'll conclude for the sake of time. My last slide is just my contact information. I'm happy to answer questions when we get to that point.

MR. ORTA: Thank you, Shailesh.

Our next speaker is from H Cycle, which is a developer of hydrogen projects, and that speaker is Matt Franzen.

MR. FRANZEN: Yeah, good afternoon, and thanks, Jason. I understand we're short on time, so I'll get through this as quick as I can.

My name is Matt Franzen. I'm with H Cycle. I really appreciate the opportunity to join in this discussion. I'll share a brief overview of H Cycle and how we're navigating the complex intersection of waste, energy, and policy, three forces that are deeply interconnected and critical to the success of the emerging hydrogen market in California.

Next slide, please.

First, let me tell you a little bit about H Cycle and our mission. H Cycle was founded to address two urgent and interconnected challenges with a single scalable solution. The first is the growing waste crisis. Not only around the world, but particularly in California, we're faced with mounting pressure to divert organic waste away from our landfills so that we can avoid emitting large quantities of methane. The second is the increasing demand for clean fuels, especially in hard to decarbonize sectors like heavy-duty transportation and industrial processes.

From the beginning, California was our main target market. The state offers a rare convergence of policy leadership that drives policy not just in the United States but around the world, market incentives, and then also support, regulatory support for the environment, both on the waste diversion side and on the hydrogen side.

On the waste side, California has implemented SB 1383, which mandates a 75 percent reduction in organic waste to be diverted away from landfills. On the hydrogen side, the state has aggressively advanced its zero-emission vehicle targets, particularly across freight and across public transit fleets. These mandates have also been backed by significant funding and programmatic support from the state.

When you consider all these converging drivers, California provides the environment for us to develop, build, operate commercially viable facilities that transform organic waste into clean carbon-negative hydrogen.

So next slide, please.

So the way that this process works, it's actually very similar to what Jeremy at Redding Rancheria is doing, except we are focused on municipal solid waste.

And I think, go to the next slide, please.

So we begin by receiving 385 tons per day of pre-sorted organic waste. This waste stream is black bag trash that you've put out by your curb. It gets moved to a MRF, which is a material recovery facility, where they take apart those bags, they recycle what they can. There's an organic stream that's left over. And then there's also a small portion of that that will still go to the landfill, and that would be like low BTU or no BTU value products like concrete or rocks, things like that. But we take this organic stream and we pass it through a waste preparation unit, where we shred it, we dry it, we condition it for conversion.

It then moves to our non-combustion thermal conversion unit, where we convert it into syngas. And so basically what we're doing is we're taking that solid waste stream and we're heating it up to 1,000 degrees Celsius in an environment without oxygen, so it can't ignite, there's no combustion, and we're basically turning that solid into a gas. And once that gas is there, it's very easy to separate those molecules. And you're left with a syngas stream, which is basically a mixture of carbon monoxide and hydrogen.

That syngas is then run through the hydrogen production unit, which utilizes proven industrial technologies like water gas shift and pressure swing absorption to extract and purify the hydrogen, where we get to that point with the four nines purity. And then we also are left with a pure biogenic CO2 stream. So from 385 tons of waste, we're able to produce up to 25 tons per day of carbon-negative hydrogen.

And like Wladimir mentioned, at this volume and that scale, we believe liquefying is the only way to transport that much, to bring that much hydrogen to market. If the market is not ready to absorb 25 tons per day, which it's not today, we also have the flexibility to take that syngas and self-generate power on site. That's enough power for us to run the full energy needs of our facility. And then we're also able to sell the remaining renewable energy back to the grid, creating a secondary revenue stream.

Next slide, please.

So kind of focusing in on the waste dilemma that California is facing, at current waste generation levels, and assuming no new landfills are built, the state will fall short of its landfill capacity in 2040. That will happen even sooner in some specific markets. So if you have a landfill close by that's closing, you would have to transport that waste even further, further increasing the cost and carbon intensity of moving that waste around the state.

And while SB 1383 mandates a 75 percent reduction in organic waste being delivered to landfills, the implementation of this has lagged, and we are behind those goals. Many of the approved pathways, like composting and anaerobic digestion, they're limited on the feedstock that they can intake, meaning that they can't process all of organic waste. And so that opens the door for a diversion technology like ours, where, one, we have the lowest carbon intensity score, and then, two, we're able to accept a wide range of feedstock.

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And then, on the adoption of hydrogen, it's critical to reducing the emissions here in California. For the mobility sector, particularly the heavy-duty transit, hydrogen remains one of the most scalable and impactful tools for decarbonizing that sector. The problem right now is that adoption hinges on a reliable supply at a cost that's competitive with diesel. And when you look at the chart on the left, and you look at the carbon intensity of diesel, regardless of the production method, whether it's gray, blue, or green, switching away from diesel to hydrogen is an immediate reduction in emissions and improved air quality for those communities.

At H Cycle, since our process diverts organic waste from the landfill, and it avoids that methane emission, we get credit for that methane emission, and that's how we get to that negative carbon intensity score. And what that means is that we remove more emissions on a CO2-equivalent basis than what our process generates. And then, if you look on the far side, with the addition of carbon capture, we have the ability to further improve that CI score.

And in closing, like, I think what I'll do is I'll just pass it along over to Craig now with Kaizen Energy to save some time here.

MR. ORTA: Great. Thank you, Matt. Let's go ahead and do that, pass it on to Kaizen Energy.

MR. KLAASMEYER: There we go. Thank you. I'm Craig Klaasmeyer. I'm co-founder of Kaizen Clean Energy.

The prior panelists have largely addressed the supply side of hydrogen. At Kaizen, we're on the other side. We're creating demand for hydrogen, and we're using it as an energy carrier for distributed power generation.

Next slide, please.

So at Kaizen, we are making a 200-kilowatt off-grid power generator. It’s a containerized unit requiring no site improvements; drop it off, and we’ll have it commissioned in a day. The system’s low-cost, we can produce power at half the cost of a diesel gen set, and it provides energy security. So fuel stored on-site will run this system for 12 days continuously.

Next slide.

The easiest way to think of us is as a clean replacement for diesel generators, anywhere diesel generators are used for primary power, you can replace it with a Kaizen system for a lower cost and without the pollution. Applications that are attractive to us include EV charging, particularly as a bridge power until grid upgrades can arrive, and industries that are electrifying, such as the construction and agriculture industries are both very attractive, as well as industries that are already very big users of diesel gen sets like events, concerts, movie studios, et cetera.

What all these applications have in common is going to be large power demands and interim deployment. That’s really kind of Kaizen’s sweet spot.

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So there are a lot of hydrogen fuel cell power solutions available. What do we do differently?

First, we use methanol to transport hydrogen to the customer site. Methanol is a liquid at ambient conditions, which makes it a cheaper and easier way to transport than hydrogen itself.

Second, we store hydrogen at the customer site as methanol and produce hydrogen on site -- on demand. So we don't store any hydrogen actually at the customer site. It helps make permitting easier, and it also brings our cost, because diesel -- excuse me, methanol tanks are much cheaper than hydrogen storage.

And finally, we're unique in that we're the only scalable distributed generation solution that doesn't produce NOx, which is clearly a big issue in California.

Next slide.

A few notes on methanol. It is new to most people, but it's actually been a future fuel for like 30 years now, so we're actually hoping its time is now.

But first, it's the lowest-cost hydrogen carrier, and this comes from the Department of Energy. It's low-cost because it's the densest carrier of hydrogen. And second, as I mentioned, it's a liquid at ambient conditions, which makes it much cheaper to transport and store.

Second, its safety characteristics are like that of diesel and gasoline.

And finally, it's widely available. We don't need to create a fuel infrastructure like hydrogen to get it to customers. The distribution center already -- distribution infrastructure already exists.

Next chart.

Just quickly, how does it work? So this is the cutaway of the container. To start, we use a mixture of methanol and water as fuel. We actually get a third of our hydrogen produced from the water that we add at site, which reduces both our fuel costs and our carbon intensity.

The first step is reforming the fuel mixture into hydrogen, and that's going to be the gray box up front. That's our proprietary hydrogen -- excuse me, methanol-to-hydrogen reformer. The hydrogen that's produced is immediately consumed by a low-temp PEM fuel cell. In our case, we're using a standard 200-kilowatt reference design from PowerCell, which is a Swedish maker of fuel cells. And from there, the power goes to some nickel-zinc batteries. We use nickel-zinc because there's no threat of thermal runaway, so it's much easier to permit, and it's also much safer. And from there, we output the power, either as 480-volt three-phase into a customer's existing charging network or a skid-mounted charger that we can provide or, you know, any other application the client needs.

Not pictured here is going to be an above-ground fuel tank. They'll hold roughly 50-megawatt hours of usable energy. That's enough to charge 500 delivery vans from that one fuel tank, so quite a bit of power stored or energy stored on site.

Next slide.

So this is our proprietary hydrogen generator. It's a very simple design. It only has two moving parts, and the rest of the system operates through pressure differentials. The first stage is that we vaporize the methanol-water mix at a temperature substantially below where NOx forms. The vapor gas enters the radical core where hydrogen and associate gases are produced. And then the final stage is that the hydrogen is purified by a series of palladium membranes to produce an ISO-grade hydrogen.

The entire system is going to be a stainless steel construction, keep costs down, and we can do this because it operates at a much lower temperature.

I guess finally, we license both the technology and the design from one of our shareholders. The technology has been around for 20 years, and the design that we're using has over 20,000 operating hours on it, so it's been around for a while. This system is a metronome. It produces 230 kilograms a day from a six-foot by threefoot footprint and produces the hydrogen just like clockwork.

Next, please.

You know, in terms of costs, our levelized costs, we produce power for $0.35 a kilowatt all in, unsubsidized, and then $0.25 a kilowatt hour with LCFS. So even unsubsidized, we're going to be cheaper than both diesel and propane generators, and obviously without the emissions.

Next. Next slide.

You know, our local emission profile is great. We emit no NOx, and Kaizen is the only scalable off-grid solution that can say that. We also don't emit any particulate matter, SOx, or any of the other criteria pollutants. And CO2 emissions are 30 percent lower than diesel using a gray methanol and can be near net zero using a biomethanol or an e-methanol.

Next slide.

So we have been operating units for the past two years, and we're excited to be deploying our first Californian unit in the next month or so. This system is going to be going topside of a vessel operating in the San Pedro Bay outside the Port of Long Beach, and it will be replacing a diesel genset on a vessel that does environmental remediation of tankers in the bay. It will be a great demonstration for our systems, and we look forward to getting it in the field and being able to show it off to everyone.

Next slide.

So I've been talking up to now about power generation. Our methanol-to-hydrogen reformer is equally capable of hydrogen fueling. We can scale with fleets from 200 kilograms to 1,000 kilograms a day, all from a very small footprint that can slot in just about anywhere.

Next slide.

We can put hydrogen in the tank, operating expenses for less than $7.00 a kilogram unsubsidized, and we can do all this because we've basically taken all the transportation costs of hydrogen out of the system.

Next slide.

So to wrap things up, we offer California an interim distributed generation solution that doesn't emit NOx, provides unmatched energy security, and does it at a lower cost than diesel gensets. You know, we appreciate the support. We look forward to working together to reduce criteria pollutants and, you know, look forward to questions.

Thanks.

MR. ORTA: Thank you, Craig, for presenting for Kaizen, and thank you to all the speakers on this panel for some very informative and enlightening presentations.

Because we are a little bit behind on time, I will transfer control of the meeting to the dais for discussion.

VICE CHAIR GUNDA: Thank you, Jason. I'm just checking on time, so we have -- you know, we're running a little close to the time here, but I do want to squeeze in a couple questions if we can --

MR. ORTA: Sure.

VICE CHAIR GUNDA: -- starting with Commissioner Gallardo. Would you want to go?

COMMISSIONER GALLARDO: Well, bravo to all of you for the technologies, all the advancements you're presenting. I'm really grateful to you sharing your insight. I am going to limit it to just a couple questions instead of questions for all of you or each of you.

So one of my team members, this question is for, sorry, let me see, Linde. Are you Wladimir? One of my team members was asking about the benefits of storing hydrogen in caverns. So you showed us an example. We're just curious if you could speak more to why you would use a cavern for storage.

MR. SARMIENTO-DARKIN: Well, yeah, thank you for the question. A cavern is, whenever the geological condition exists, it allows you to store hydrogen at pressure without having to make the investments to do so. Building the tanks to store gas hydrogen at high pressure is expensive. So whenever you have a geological formation that allows you to do that, you can take advantage of Mother Nature and save a lot of capital costs in doing so. So that's basically the key advantage.

Unfortunately, they are not as frequent as you may want. So there are only a few places where you can use them in the U.S.

COMMISSIONER GALLARDO: Okay. Thank you.

And then the next question is for Shailesh from Bosch. There was a graph you showed, and I think I saw a multitude of data centers as an example of end use applications. And I'm just curious if those are being powered up by fuel cells? Is that what that was?

MR. TOPIWALA: No, that was a graph of just multiple end use offtake, a data center being one, but refineries, it was just to show a map.

But to address specifically data centers, as we all know what's happening, you know, the scale up for AI and the hyper growth there and the need for clean energy, we see the application, potentially, of fuel cell powered systems for backup power. You could even -- and then for prime power, you know, combustion technologies, these large turbines, air-driven turbines that can run on hydrogen can be used to do base load power, especially, you know, considering that many of these data centers will now have their own islanded power gen facilities going forward.

So just something to think about, but I'm sure the industry will be, you know, working towards solutions that can meet the need and scale up the appropriate different technologies, combining them to address the data center needs. We already see any announcements in the press, so --

COMMISSIONER GALLARDO: Okay. Thank you. And congratulations for that 10-minute truck refill. That's exciting.

MR. TOPIWALA: Yeah, it's important. Thank you.

COMMISSIONER GALLARDO: Absolutely.

And then, Matt, I was just going to congratulate you, too, for thinking about how to more than one problem with a solution, so really appreciate that dual purpose. I'll turn it over to Vice Chair Gunda, unless, Matt, did you want to respond with more of a comment?

MR. FRANZEN: No. Thank you.

COMMISSIONER GALLARDO: All right. Thank you.

VICE CHAIR GUNDA: Thank you, Commissioner Gallardo.

Yeah, I also want to just thank the panelists. You know, there's a lot of good information. Let me kind of just construct a couple of 30,000-foot level questions, maybe, you know, starting with Jeremy.

Jeremy, thank you again for your presentation. You know, one of the things when we think through the hydrogen, I think there’s a lot of concerns around community impacts and, you know, the general, you know, hydrogen being, you know, a pathway for potential extension of fossil. You know, that’s a criticism that we often hear. So it’s kind of really interesting to hear from you specifically as you represent, you know, kind of, you know, the support. You know, what kind of, you know, support do you see for hydrogen within, you know, what you represent? Jeremy, are you still there?

MS. NAKAGAWA: This says Jeremy had to leave.

VICE CHAIR GUNDA: He had to leave? Okay. No problem. Thank you.

So the other question, maybe more broadly to the panelists, you know, just what I see is, you know, one of the things that we often forget is how expansive the usage of hydrogen today is, especially in certain sectors. And, you know, generally, the infrastructure that exists for transporting, you know, whether it’s, you know, oil and gas industry or others, could you just help explain, you know, from an industry perspective, where do you see the biggest barriers for hydrogen? Is it moving from grey hydrogen systems to more of an electrolytic green hydrogen systems or, you know, just the scale or the geographical diversity of where the use cases are? Can you just kind of frame on how you see both the market opportunity, but the barriers in terms of, you know, knowing that there is a pretty good scale of hydrogen usage today to the future in terms of different sectors and categories?

Maybe, Shailesh, given that, you know, you've raised kind of the opportunity across a broad class, it may be helpful if you can start off with that.

MR. TOPIWALA: Yes, certainly, and I think other panelists can chime in.

You know, the existing footprint of hydrogen use is significant and it's there. And I guess one key thing is I think we need to be mindful that the energy transition is not going to be easy in short term. You know, we already see the exponential demand just from the data center market; right? This is on top of our energy system today. And so for us to think that we're going to do this short term overnight, do everything, and meet the growth demands, I think it's a challenge in itself.

So I think the way to look at this is to say, can blue hydrogen, can carbon capture play a significant role to address existing infrastructure or existing demand centers to start to decarbonize as quickly as we can? Yes, it's still fossil based but, you know, we have a fossil energy system and, you know, that's the fact.

As we add on new energy demand, this is where we need to look at and say, well, can we go cleaner and greener, right, as a first step instead of extending fossil basis. So I think that's the mindset that at least I try to approach it with in discussions.

And I see that, you know, I think there's a lot of debate, liquefied versus gas, transport of hydrogen, and I think the answer is both. I think clearly there's, and I see Wladimir has his hand up, we'll definitely chime in on the liquid case, and I think it has all its merits. But as I mentioned before, you have so many -- so much offtake that's smaller scale, where it will just initially not be cost effective, as cost effective to deliver a liquid form. And can you address those with smaller solutions, smaller footprint, production centers, potentially? To be seen; right? I think these are concepts that are playing out. Different stakeholders are starting to test that model and deploy some systems.

But I'll pass it on to Wladimir or whomever else wants to make a comment.

MR. SARMIENTO-DARKIN: Thank you, Shailesh.

I just want to say, I think, you know, apart from the distribution, you know, just to address the question, what are the challenges, I think the main challenge is regulatory framework; right? I think that is a key indication for the industry, the signal to move forward and all that. And as I said in my presentation, I think California has a nice regulatory framework in place already.

So, to me, one of the key challenges is to get everybody to work together on the same objective, and I go back to the TCO as a critical point. It's difficult for this. And every time you go to a hydrogen presentation, you hear about the egg and the chicken and the egg and the chicken. And we, at this point, know where all the eggs and where all the chickens are. We just have to get all of them and, you know, somehow organize them; right? And I think that's the critical challenge today.

We have a technology that works beautifully. I'm talking about the heavy-duty market, and I will make a quick comment on the other technologies, but we know the product works. These trucks are wonderful. And, you know, to Matt's point, they reduce to zero the point emission versus diesel. So when you compare a diesel truck with a fuel cell truck, the comparison is emissions versus no emissions. It doesn't matter what kind of hydrogen you have in that truck; right? And as Matt mentioned, just the fact that you're using even gray hydrogen is reducing the

CO_2 emissions, which I think are important, but secondary to the point reduction, because the ports communities or the communities around the ports are not suffering from the CO_2 that these trucks emit. They are suffering from the particulates and NOx and the noise that these vehicles emit, which are completely 100 percent at risk with the hydrogen, no matter the origin; right?

And I think in terms of the other applications, it’s more difficult. I think the market will need more development on those sides, but I think in mobility, heavy-duty especially, we are so close to make it happen. It’s just about getting the proper coordination in place. And I let my fellow panelists to talk more about it.

Thank you.

VICE CHAIR GUNDA: Thank you, Wladimir. And if anybody else want to comment, I’m also just rushing because of time, but if anybody else has any other comment, if not, I’ll pass it back to Sandra.

MS. NAKAGAWA: All right. Thank you so much, everyone. Thank you, Jason, and thank you to our panelists.

While, we did have plans to have audience Q&A at this time, because we are running over 10 minutes behind, we are going to move to our next panel. So Max Solanki will be moderating this. Max is one of my colleagues at the CEC.

VICE CHAIR GUNDA: Sandra, just on the Q&A, I think I only see a couple of questions. Do you want to just take --

MS. NAKAGAWA: Yeah --

VICE CHAIR GUNDA: -- a couple questions quickly?

MS. NAKAGAWA: -- we can take a couple.

VICE CHAIR GUNDA: Yeah.

MS. NAKAGAWA: I'll turn it over to Ning then.

Ning, if you're able to jump on and moderate a couple of these questions we have in the Zoom Q&A, that would be great.

MS. ZHANG: Okay. Thank you, Sandra.

Hi, everyone. My name is Ning, and I am the monitor of this panel's Q&A section.

Actually, we have three questions in the chat, and the first question is from John, and his question is that,

> "I'm curious to hear the panel's thoughts on the challenges and the cost of large-scale hydrogen storage, which is particularly important for green electrolytic hydrogen to play a role as a seasonal storage resource in the power sector, to tie back to the conversations on reliability and the claim for resource earlier today.

"For context, E3's ongoing work with the CEC is finding that California has extensive potential resources for geologic storage in the form of deprecated fossil fuel reservoirs, but they are still very expensive, and some end users would be unable to use the stored hydrogen without large-scale purification technologies that are currently very expensive."

So this is the first question. Can anyone in our panel help to answer this question? Thanks.

VICE CHAIR GUNDA: Do we know if the panel is still there?

MS. NAKAGAWA: We do have some panelists. Any panelists want to jump in on that one?

I thought maybe, Ning, do you want to read the next one and people can reread that first one, see if it seems like something they're able to answer. Yeah, go ahead, Ning.

MS. ZHANG: Thank you. Yeah, the question is a little bit long for the question.

Yeah, I will move to the second question. The second question is from Michael. I'm sorry if I pronounce your name now, please correct me. And the question is that,

"We see in this series to attract renewable hydrogen production including electrolytic energy rates are critical. The California Hydrogen Coalition has worked with MIT on modeling the economics around the CapEx and the OPEX of hydrogen production focused on energy costs. Will there be an opportunity to discuss some benefits such as the flexible load, grid management, and the needs such as time-matched renewables which are not offered in Western market today in grade access for hydrogen production in the IEPR process?”

That’s it. Thank you. And anyone can help answer this question.

MS. NAKAGAWA: I can speak briefly to the IEPR process. So today’s workshop is part of the 2025 IEPR proceeding. People are welcome to make public comment today and have written comments for about three weeks afterwards. We will also be releasing a draft of the IEPR this fall and welcome public comments there. So that can be another opportunity to discuss some of these other issues if stakeholders do believe that things like flexible load, grid management, needs of time-matched renewables, if there’s more discussion needed there.

Thanks, Ning. Let’s go to our last question.

MS. ZHANG: Yeah. Thank you.

And the last question is from Zach and his question is for Craig. And the question is that,

“Why the decision to vaporize the methanol or water mix versus utilizing a methanol fuel cell with direct catalysis platinum and palladium membrane?”

So, Craig, can you help answer this question? Yeah. Thank you.

MR. KLAASMEYER: Yeah, so it’s a lower cost, first of all.

Second of all, it’s scalable. There are a few direct methanol fuel cells out there, but as much -- the largest I’ve seen is 5 kilowatt units. As you said, we’re using 200 kilowatts now in our system. We’ll be quickly using 250. So it has to do a lot with cost and scale.

MS. ZHANG: Yeah. Thank you, Craig.

MR. KLAASMEYER: Thank you.

MS. ZHANG: And thank you for answering this question.

And, Sandra, do you need me to move back to the first question or like we --

MS. NAKAGAWA: It doesn’t sound like we had anyone on the panel that was jumping in to answer that one, so we are going to move on. Thank you so much, Ning. Thank you, panelists. Thank you, Jason.

We are going to turn it over to Max Solanki, Branch Manager of the Fuels Analysis with the CEC, who’s going to be moderating our final panel.

Max, over to you.

MR. SOLANKI: Thank you, Sandra. Can you hear me?

MS. NAKAGAWA: Yes, we can hear you.

MR. SOLANKI: All right. Good afternoon. Good afternoon, Vice Chair Gunda, Commissioner Gallardo, Deputy Executive Officer Sahota, panelists and attendees. I'm Max Solanki, Manager of the Fuels Analysis Branch at the California Energy Commission. We are now beginning panel six, Senate Bill 1075 analysis. This panel brings together Jea Broody of CARB, Sasha Cole of CPUC, Sammy Sallam of -- Sammy Sallam and Quentin Gee, both from the CEC, to present their respective SB 1075 analysis in support of the upcoming Integrated Energy Policy Report. The agencies have shared their analysis, reviewed inputs, and have had a collaborative dialogue as we align together on policy development pathways under SB 1075.

Speakers, please turn on your cameras as I introduce you and your session.

Our first speaker is Jea Boodry, who is an Air Resources Engineer with the California Air Resources Board. She will be presenting SB 1075 analysis overview.

Jea?

MS. BOODRY: Yeah. Thank you for the

introduction, Max.

Good afternoon, everyone. My name is Jea Boodry. I'm an Air Resources Engineer at CARB and one of the primary staff working on the SB 1075 analysis, and I'll be presenting on the agency's behalf for this panel. Today, we will present an overview of the work we've done so far in the SB 1075 process. I will provide an overview of the background on hydrogen in California leading into the current status of the report.

Next slide, please.

To start, let's discuss California's climate goals from a broad perspective.

The line graph on the left shows annual emissions from 2000 to 2022 and California's statutory greenhouse gas emissions reductions targets of 2020, 2030, and 2045. The greenhouse gas emissions inventory shows that California achieved the 2020 AB 32 target of returning to 1990 emissions levels several years early in 2014, and the inventory has remained below the target through 2022.

In 2016, the legislature called for a 40 percent reduction in emissions below 1990 levels by 2030. And recently, in 2022, the legislature established two goals to reduce the anthropogenic greenhouse gas emissions by 85 percent compared to 1990 levels by 2045 and to achieve carbon neutrality no later than 2045, meaning that for whatever emission sources exist at that point, there’s an equivalent or greater amount of natural or technological carbon sets.

Next slide, please.

Achieving carbon neutrality is our most ambitious climate goal to date, and it will deliver major benefits. The Scoping Plan lays out a cost-effective and technologically feasible path to achieve carbon neutrality. The Scoping Plan covers emissions across all sectors, requires unprecedented deployment of low-carbon technology and energy and harnessing of nature-based climate solutions.

The left half of this slide highlights key metrics in the Scoping Plan scenario, showing the scale of transformation called for within the next couple of decades. You’ll note here that the Scoping Plan identified tremendous growth in the supply of hydrogen as a key element in achieving emissions reductions and carbon neutrality. What this also infers is a substantial increase in the use of hydrogen. Displacing fossil fuel with renewable hydrogen is a key energy transition action.

The right half shows some key outcomes that would result from achieving the plan’s actions for clean energy, technology deployment, and natural and working lands management.

Next slide, please. Oh, sorry, next slide.

California will deploy a range of options to decarbonize our economy, including widespread electrification of vehicles and buildings, as well as development of clean electricity and fuels.

Hydrogen is especially important for end uses with limited options to substitute for fossil fuels. This includes pipeline blending or low levels of hydrogen blended into fossil gas pipelines to lower the carbon content of fossil gas, aviation and maritime shipping, industrial uses both for heating and as a feedstock to make chemicals, fertilizer, and low-carbon fuels, and transportation fueling, especially in the medium and heavy-duty sectors or in off-road equipment.

Our deployment of hydrogen will focus on a handful of key ideas. Low-carbon sources for hydrogen will be the focus of the state, mainly electrolytic hydrogen and biomass-derived hydrogen, which makes up the source for all hydrogen by 2045 in the Scoping Plan.

Federal funding is a key part of our current plans that we recognize that some recent and proposed actions affect our original vision for the role it would play. We hope the conversation today and our analysis will address some of that change and uncertainty.

Many methane end uses could be replaced by hydrogen, both reducing greenhouse gas emissions and improving air quality. And non-combustion options broadly will be prioritized to improve health outcomes of hydrogen in end use.

Next slide, please.

The 2022 Scoping Plan update modeled integration of low-carbon hydrogen in multiple sectors and anticipates that hydrogen fuel cell vehicle use in the transportation sector will serve as an important part of the state's transition to zero-emission vehicles, particularly for medium and heavy-duty vehicles, as mentioned on the previous slide.

The other end uses with less total demand make up the rest of the anticipated use. These uses include renewable hydrogen that is blended into the natural gas system to reduce fossil gas use in buildings, rather, to replace fossil fuel in certain industries and used to meet electricity demands.

I also want to recognize that the Scoping Plan was done at a point in time when the issues around hydrogen use were evolving quickly, so while I want to share the plans and projections in the Scoping Plan, we're actively growing our understanding. The SB 1075 Report is an essential part of that growth and will explore a wider range of end uses.

Next slide, please.

In the 2022 Scoping Plan update, hydrogen is an alternative fuel for liquid transportation fuels and natural gas, and the modeling estimated the annual amount of hydrogen needed to achieve greenhouse gas emission reduction goals from now out to 2045.

The modeling assumes that hydrogen is supplied by three methods: electrolysis powered firm zero-carbon electricity; steam methane reformation of biomethane; and biomass gasification with carbon capture and storage. The volume that each method could contribute as modeled is shown on the slide.

For the Scoping Plan, the electricity needed to produce the anticipated hydrogen supply was not captured in the modeling of the electric sector as a whole. Rather, the Scoping Plan includes an approximate number of off-grid solar that directly feeds hydrogen production and is not integrated with the broader grid. These model assumptions were strictly for the purpose of the Scoping Plan utilizing information that was available at the time.

The SB 1075 Report will build on that foundation, serving as the next step in CARB's understanding of the issues surrounding hydrogen production and growth and supply we expect in the coming years. This is an area of rapid development, and our work will provide a stronger basis that reflects the ongoing transition.

Next slide, please.

CARB is currently supporting growth of hydrogen demand through zero-emission vehicle deployment. We're active in supporting the development of zero-emission fleets across the state through the Advanced Clean Fleets regulation.

During the development of ACF, CARB staff evaluated many potential compliance scenarios based on market data available at the time and extensive engagement with equipment manufacturers and fleet owners. CARB evaluations anticipated potential for fuel cell electric vehicles in the medium and heavy-duty space, with fuel cells making up a large portion of this market. State and local fleets will still comply with these rules, which will support zero-emission vehicle adoption in the public sector under the mandate that all new vehicle purchases in state and local fleets must be zero-emission vehicles by 2027.

In July 2023, CARB also reached an agreement with the major manufacturers of heavy-duty engines and vehicles referred to as the Clean Truck Partnership. The manufacturers in the agreement agreed to comply with the Advanced Clean Trucks regulation and the requirement to only sell zero-emission vehicles beginning in 2036, thereby committing to work with CARB to achieve our state's ambitious clean air goals.

The Innovative Clean Transit Regulation, adopted in 2018, encourages proactive planning for future zero-emission vehicles by requiring agencies to submit rollout plans to CARB. This also gives CARB a clear view on planned battery electric and fuel cell bus rollouts that transit agencies will rely on to meet the regulation's requirements.

And finally, CARB has a suite of education and incentive programs that help maintain and accelerate zero-emission vehicle market development. These include our Clean Truck and Bus Voucher Program, or HVIP, Clean Off-Road Equipment Vouchers, or CORE, School Bus Replacement Grants, and the Zero-Emission Truck Loan Pilot Program.

While CARB actions are expected to continue supporting demand for fuel cell trucks and buses, the most critical supply-side development will be growth in the availability of low-carbon hydrogen for transit agencies and fleets across the state. This is also a critical step in these organizations' planning, and it is important for public and private partners to work to support efforts that increase the availability of low-carbon hydrogen.

Next slide, please.

As we're discussing on this panel, SB 1075 directs CARB, in consultation with other partner agencies, to conduct a broad range of technical, market, and policy analysis that will support hydrogen production and use across many sectors of the economy, including those that are most difficult to decarbonize.

Next slide, please.

Moving on from the foundation laid by the Scoping Plan and other actions California is taking to implement hydrogen, let's discuss a little on the work done for SB 1075.

This slide shows the specific analyses that the legislature has directed CARB to include in the SB 1075 evaluation of hydrogen production and uses in California. To support this work, CARB awarded a research contract to E3 last year, and work began in July 2024. Our report will paint a picture of what the state of hydrogen in California could be in the short and long term. We'll be analyzing potential feedstocks, hydrogen transmission and distribution methods, possible end uses, air quality and health outcomes, safety and related standards, economic development and job creation, and policy recommendations.

It is important to keep in mind that this report provides recommendations on these topics. There are no regulations or programs that are guaranteed to come out of this report.

Next slide, please.

Throughout the process of developing the SB 1075 Report, we'll be holding two types of meetings. We'll hold daytime workshops where we'll be sharing preliminary results, which includes presentations done by CARB and contractors supporting the efforts. The first of these workshops was held in February, discussing E3's technical work on production, transmission, transmission and distribution, and end uses for hydrogen. We plan to hold another workshop to discuss the results on all topics. At the workshops, there will also be opportunity for public comments so that we can receive feedback from stakeholders who are available during the daytime.

We'll also hold community meetings where brief presentations will be made to share information about the SB 1075 work underway. This will be more high level and focus on collecting input from community members. These will take place in the evenings to accommodate those who can't attend the daytime events. We've held three such meetings so far, one in Oakland, one in Harbor City in South L.A., and a virtual meeting. We're planning on hosting another meeting on August 6th in Lancaster, so next Wednesday.

Next slide, please.

Our updated timeline for the report is shown here. Most of our work this year will focus on community meetings and workshops in parallel with work on the report. We’ll release the draft report for public comment in Q4 of this year and expect the final report in early 2026.

Next slide, please.

Thank you all for your attention during our presentation, and I’ll pass the microphone to Sasha Cole to discuss the CPUC’s work on hydrogen.

MR. SOLANKI: Thank you, Jea, for your presentation.

So our second speaker is Sasha Cole. Sasha is a Senior Analyst. Can you hear me?

MR. COLE: Yes.

MR. SOLANKI: Okay. Sasha is a Senior Analyst on the Renewable Gas Team at the California Public Utilities Commission. He will present hydrogen related activities at the CPUC.

Sasha, take it away.

MR. COLE: Thank you, Max. You can go to the next slide.

So just to follow up with Jea, the CPUC was assigned a consulting role on the 1075 Report, so we’re not really the main authors. We’re not. We’re just consulting, and we don’t generally produce reports like this, like the IEPR. We’re more consumers of this information. So I want to give a little context about what’s going on at the CPUC, and then a few notes about this.

It’s going to be a fairly short presentation. Apologies to people that cut their presentation short in the last session, because I think we’re going to make up some time. Oh, sorry, I was looking at the wrong screen.

So first of all, there’s really two large projects that are going on. There’s some smaller stuff, some pilot projects, but the two big projects that come through my shop at the CPUC have been the Angeles Link project, which I think people know about. It’s the SoCalGas’s proposal to build a hydrogen, a pure hydrogen pipeline network in Southern California to deliver clean renewable hydrogen from the inland areas where it’d be produced out to the areas, the industrial areas around the ports of Los Angeles and Long Beach.

We had an application in February of 2022, that’s 22-02-007. Decision later that year, 22-12-005, so that was in December, allowed SoCalGas to record up to $30 million, around $30 million in a memorandum account. A memorandum account means that it’s not a bouncing account. It doesn’t mean they’re guaranteed recovery. It just said record the cost, and we will discuss later and make a decision later on whether you can recover these costs and rates.

It required SoCalGas to conduct 16 feasibility studies into the feasibility of the pipeline, everything from environmental impacts, economic demand reports, all of that, community impacts, and it required extensive stakeholder engagement.

Okay, just this last June, they filed for a cost recovery for Phase 1, as I said, a memorandum account didn't guarantee that, requesting around $24 million. They didn't spend the full $30 million for cost recovery. That proceeding has not even been scoped. I can't really say a whole lot about that. It's literally just at the beginning stages. We have an application, and we've had a few comments and protests come in from parties.

And back in December, they filed an application to start Phase 2 of their study, which is a much kind of larger study. They're requesting around $266 million to move the project from feasibility to more detailed, well-defined design, including the front-end engineering studies. Again, that proceeding has not yet been scoped. We've had initial comments by parties and protests, but nothing has been scoped. So that's the Angeles Link project.

Next slide.

Very quickly, the other big, big thing that's going on is another application for hydrogen blending demonstration pilots. So some years ago, the utilities came with a set of applications. Those were rejected. They were then asked to reapply.

In March last year, the four large gas IOUs, I'm not sure Southwest Gas qualifies as large, it's a large one but not within the state, but SDG&E, SoCalGas, and PG&E filed an amended application requesting around $206 million to conduct five different pilot programs to test hydrogen blends up to 20 percent in our pipeline system. Those pilots are supposed to build on a hydrogen blending impact study and a hydrogen blending compendium report that were prepared for the CPUC by UC Riverside, and they would be used to develop an injection standard.

I say all this -- next slide, please -- and I say all this just as background to how we use the information that might come out of the IEPR right now or the 1075 Report, because as you'll notice, both of these are applications, so there's no rulemaking. We're not initiating these policies. We're receiving requests with fairly large price tags from the utilities for projects. And so, you know, part of my role is to evaluate those.

I have to say that the CPUC has clear and unambiguous authority over hydrogen blending and the natural gas pipeline system. That is without dispute. Its authority to regulate a pure hydrogen pipeline has not been clearly established either by law or regulatory decision, so there is some uncertainty there regarding the Angeles Link project and whether the CPUC would be the regulatory authority over that project. There's none over the blending pilots.

When we evaluate a project and when we approve a project, we are supposed to ensure that any requests for ratepayer funding are just and reasonable; right? And this is where having data -- or rather having reports like the 1075 Report are really helpful. I'm going to have 16 reports from SoCalGas. And it's extremely useful to have, you know, really detailed information and reports that are not coming from an interested party so that, you know, we can evaluate those.

But one of the things that's become really evident in my work is, and I think this is fairly obvious to people who work in hydrogen space, is that we really have to consider the uncertainty surrounding investments. So if we're thinking about, in my case, ratepayers paying for a very large pipeline project, right, you want to think about the uncertainties and the risks.

We all know in hydrogen that there's uncertainty in every sort of step of the value chain, so there's uncertainty around production and whether the costs will come down, as we hope they will, and how quickly they would come down and what will be available. We're being asked to fund this sort of transportation thing. There's uncertainty around storage, certainly, technical uncertainty. We haven't completely -- we have no direct experience of storing outside of salt caverns at this point, storing hydrogen underground. And, of course, there's huge uncertainty around the demand side and around alternative technologies that could be used in use cases and how quickly demand would pick up in any event.

And these uncertainties compound on each other, of course. We all talk about the chicken and egg problem. It's quite real when you're thinking about spending money on something like a pipeline.

So the takeaway, since we're not really the main authors of this report, what I wanted to add to this meeting was to say we need realistic assessments around uncertainty, right? Because sometimes it's easy to write reports that give a roadmap of how we're going to meet state goals. And I understand that and I understand why that's done. But I find myself more and more saying we also need to be realistic and have a realistic assessment put in there of the different fragilities and potential failure points in the development of this hydrogen ecosystem and feed that into a risk analysis.

So, you know, policymakers need to be aware of the financial risks involved when they're committing public resources so that they can prudently balance these against the urgent need for decarbonization. And so, you know, I hope that both of these parts, and I've been in consultation with Jea and her team, really take seriously and don't kind of gloss over those because I think that it's important that they're there for us to make really prudent decisions.

So that's all I wanted to say today and appreciate your time and the chance to speak at this meeting.

MR. SOLANKI: Thank you, Sharsha, for your presentation.

I will now move on to the third topic on the agenda. Can you hear me? The third topic is the hydrogen potential for electric generation and transportation as part of the 2025 IPA. I

will start with a brief overview of our agenda and revisit our 2023 findings and then hand it over to Sammy Sallam, our Low-Carbon Fuels Lead with the Fuels Analysis Branch at the CEC.

Next slide, please. Okay.

And then Sammy Sallam will walk us through the 2025 analysis.

Next slide.

Today's presentation includes a quick recap of the SB 1075, the 2023 analysis, and a look at how we expanded our scope for 2025. Sammy will then discuss the Demand Scenarios, our updated analytical approach, and key takeaways.

Next slide, please.

As Jea mentioned, SB 1075 directs CARB to develop a comprehensive hydrogen plan across all sectors. It also tasks the CEC, in consultation with CARB and the CPUC, to study the potential for green hydrogen growth in both the power and the transportation sectors.

Next slide, please.

There's no real specific policy drivers giving us a structured approach for hydrogen demand. So in 2023, we looked at the bookends for potential to understand higher hydrogen and lower hydrogen generation and what that might entail to achieve those.

In 2023, we framed power generation using two bookends. We chose the CARB's 2022 Scoping Plan and modified it to assume full replacement of natural gas generation with hydrogen, about 1.8 million tons a year. At the lower bookend, we analyzed the results of the CEC-funded UC Irvine study that treated hydrogen like a long-duration energy storage technology, i.e., hydrogen would be used to replace half of the new long-duration energy storage and half the grid power from geothermal resources, as forecast by CPUC's 2018 Resolve Resources Planning Model.

For transportation, we built on the 2022 Scoping Plan to come up with the IEPR truck choice model, adjusting hydrogen prices and fuel cell vehicle costs for the upper bookend. For the lower bookend, the CEC staff used the AATE 3, Additional Achievable Energy Efficiency 3, and those numbers are 971,000 metric tons a year, and the upper end was 300,000 metric tons.

So in 2023, we focused on the PEM electrolysis, that's proton exchange membrane.

Now, let's switch our mind to 2025. For 2025, we used the same framework for power generation we used in 2023, but we changed up the transportation as follows. For transportation in 2025, the upper bookend uses CEC's SB 100 hydrogen high-use scenario, consistent with CARB's estimate of 1.4 million tons a year. The lower bookend uses SB 100 Policy Scenario at 810,000 tons a year. For 2025, we expanded that scope to evaluate additional production technologies.

Next slide, please.

I will run through this quickly.

In 2023, the high-bookend scenarios, particularly from CARB's Scoping Plan, reflect significantly greater hydrogen demand compared to more modest estimates from the UCI study. These comparisons here highlight the scale of infrastructure needed and the importance of diversifying hydrogen production technologies as explored in 2025.

For electric generation, in 2023, we saw capital costs ranging from $16 billion to $3 billion in the low case. For renewable energy generation, it ranged from 36 gigawatts in the high to 6 gigawatts in the low. And the land use ranged from 250,000 acres in the high case to 47,000 acres in the low case. For transportation, we saw costs ranging from $8 billion in the high case to $3 billion in the low case. Renewable energy generation capacity ranged from 18 gigawatts to 6 gigawatts in the low case, and land use ranged from 130,000 acres to 40,000 in the low case.

These scenarios highlight the scale of electrolyzers deployment, renewable build-out, and land requirement for solar generation. They also underscore why we broadened our analysis in 2025 to account for a more diverse set of production options.

Next slide, please.

So in 2025, we expanded our analysis to include nine hydrogen production pathways. We used both the PEM and the alkaline technology, streamlining reformation with and without carbon capture, using both fossil and renewable natural gas. For biomass gasification, we used crop residue, forest residue, and urban waste. For pyrolysis, we considered both natural gas and renewable natural gas.

So what's new this year is a more holistic assessment. We explored how hydrogen production interacts with grid operations on an hourly basis, incorporating production, storage, and balancing dynamics.

Next slide, please.

Sammy will now walk us through the 2025 analysis.

MR. SALLAM: Thank you, Max.

Good afternoon. I'm Sammy Sallem. I've been with the CEC a little over two months at the Energy Assessment Division, and I look forward to covering with you the 2025 analysis for hydrogen potential.

This is a summary of high and low cases of hydrogen demand used for the 2025 IEPR for both the electrical and the transportation sector. Now, Max has already covered this in detail. I note that for the power sector high case, the demand was based on the plan level of fossil gas replaced with hydrogen, which is about 1.6 million tons of hydrogen per year in 2045. In the low bookend, as you can see there, the hydrogen would be used to replace much of new, long-duration energy storage and much of the grid power from geothermal resources, which involves a total of 350,000 tons of hydrogen per year.

In reference to the transportation sector, I will let my colleague, Quentin Gee, talk about this in more detail shortly after this presentation.

Next slide, please.

For the 2025 analysis, more pathways were included to meet hydrogen demand, starting with Demand Scenarios. Then we asked the question, basically, what are the various inputs to use to generate clean hydrogen?

So we looked at renewable energy and biogenic resources as inputs. We then examined various methods to produce hydrogen, and that includes electrolysis, steam methane reforming of natural gas and carbon capture, steam reforming of renewable natural gas, gasification of biomass, and pyrolysis for both natural gas and renewable natural gas. Then we evaluated hydrogen storage, which includes aboveground and underground or subsurface reservoirs, if you will, also delivery methods such as pipelines and by trucks. Now, the final step on the right-hand side there is the hydrogen conversion to the electric grid for end use.

Next slide, please. Next slide, please. I'm sorry, that's correct. That's correct. If you go back one slide? My mistake. Thank you.

So this is a simplified diagram of the IVCA. Basically, we start with hourly electricity from the SB 100 electricity generation profiles for both the power plants and long-duration energy storage. Then evaluate the balance of hydrogen production demand and storage needed in order to meet those demand profiles.

Note that much of the discussion in previous studies revolved around production and demand. However, we must now start thinking about the middle, which is the storage and delivery.

Finally, we need to quantify the amount of inputs to production processes, process from different technologies, that includes electrolysis and thermochemical processes, and quantify cost and equipment needed to produce and store hydrogen. We've also considered input resources requirements such as renewable power, biomass volumes, amounts of water needed, and land requirements, which can be extensive.

Next slide, please.

This is a more deft illustration summarizing the different variables and model parameters in the integrated value chain analysis, which includes variations in hydrogen demand, amount of storage available, and amount of hydrogen that needs to be produced from the four technologies and applicable resources shown on the right-hand side there.

So the key question to answer, basically, here is how much clean hydrogen production, delivery, and storage capacity is needed, what is needed, basically, to meet that demand for each end-use scenario?

So the upper-left graph shows an example of hydrogen demand to produce electricity in a gas-fired plant over the course of a year. This is similar to transportation, but transportation demand varies much less on a day-to-day basis. So in summary, the model solves the mass balance of the system by exploring the space of different combinations of production and storage capacity.

The analysis showed here that the large seasonal variations in hydrogen use driven by electricity production needs will require strategic hydrogen storage facilities that are large and centralized. The diagram shows an underground storage there in the middle of your screen, a facility or a reservoir, if you will. However, we did evaluate tank storage above ground as well. Hydrogen volumes, storage costs, and safety issues can be critical factors in choosing the appropriate storage method.

Next slide, please.

This slide shows the comparison of three portfolios of hydrogen production pathways for this analysis. It can be seen from the table there on your right that four main hydrogen technology pathways have been defined, electrolysis, reforming, and gasification, and finally pyrolysis. Each of these requires energy and material feedstocks to convert to hydrogen.

So for the electrolysis-heavy portfolio, electrolysis makes up the large majority of this mix at over two-thirds of the production capacity. Natural gas pathways are de-emphasized. And biomass resources are used at one-third of their statewide potential.

For the next one over, which is the biogenic portfolio case, biogenic feedstocks are deployed at 100 percent of their estimated statewide potential. Pathways involving natural gas develop moderately, but not to the level of what we call balanced, in this case balanced portfolio. Electrolysis assumes the rest of the hydrogen supply, which still makes it the largest source in comparison to the other technologies.

Now moving over to the balanced portfolio case, it's based on premise, on the premise, basically, that all major pathways, fuels, and feedstock will contribute to the hydrogen production profile.

The use of natural gas to produce hydrogen grows steadily for two reasons. One, the lack of temporal variability in the amount of hydrogen that can be produced is found to be important, and two, it assumes that the carbon intensity of the supply chain will be well managed, including upstream natural gas release, carbon capture for SMRs, and significant use of natural gas pyrolysis.

Biomass resource usage is 50 percent of its full potential, and virtually all of the available RNG is used for hydrogen production. Electrolysis makes up the remaining production and becomes the, basically, the largest source of hydrogen among the four pathways.

Next slide, please.

So this slide shows the production capacity requirements to produce clean hydrogen for the combined high electric and transportation bookends. There are four -- three different pathways, basically, that you see there on the slide, portfolios and technologies. The graph on the left represents hydrogen production capacity required for the full storage case. Now if you look at the right graph, that represents the hydrogen capacity required if there was no storage. The y-axis scale is in millions of tons of hydrogen per year.

So the key takeaway here is that with demand profiles as seasonably variable as future gas-fired power plants not having storage, that will lead to a requirement to massively overbuild production plants, hereby almost a factor of 4.5.

Next slide, please.

So this slide illustrates the electrical energy supply required by feedstock and portfolio, for this case of combined high bookends. Both graphs are in gigawatts hours per year. The graph on the left is the electric energy requirements to produce hydrogen by electrolysis, and the one on the right is the electrical energy requirements to produce hydrogen for the production pathways that use RNG, biomass, and fossil gas feedstocks. Of the other production modes, fossil gas, SMR, uses the most electricity just because of the use of carbon capture.

So a key takeaway from this slide is we expected electrolyzers would use the most electricity, but please keep in mind that significant renewable energy would also be required to generate the electricity.

Next slide, please.

The graph shows the water requirements to produce hydrogen for the three different portfolios and from the four different technologies. If there's a key takeaway here, it would be basically, you know, again, as expected, the electrolyzers would have high water volume requirements compared to the other production modes. Note that the fossil gas, SMR, also requires significant amount of water. The main reason is that fossil gas reforming with carbon capture storage uses large amounts of water, primarily carbon capture cooling water, but also in the steam reforming process.

Next slide, please.

So these graphs illustrate the feedstock requirements to produce hydrogen from biomass in tons per year on the left and also from gas, mainly RNG and fossil gas, and that's the one shown on the right-hand side, and that's measured in million BTUs per year. Biogenic feedstock availability may be a limiting factor, so we must have processes to efficiently collect, stockpile, and process them to meet the demand of hydrogen production. RNG is also produced in a very distributed manner, so we assume that the plants that process it into hydrogen are fairly small, something in the order of 15 tons of hydrogen per day.

So the key takeaway from this is the biogenic profile -- portfolio, rather, maxes out the estimated biomass and RNG, yet there's still a good amount of fossil gas use. This is because the overall demand is very high, and so fossil fuel in this case is needed to fill out the supply. So in other words, if electrolysis alone were used to fill the gap, it would compromise -- comprise, actually, 66 percent of supply. So this is quite substantial.

Next slide, please.

So the two tables on the right-hand side demonstrate the CapEx in order to meet hydrogen production capacity requirements for 2045 for full storage, which is shown in the upper table, versus no storage, shown in the lower table, and that is for the nine different pathways and four feedstock types, mainly water, RNG, biomass, and fossil gas. Note that these CapEx figures do not include transportation or storage costs.

So the key takeaway from this is the cost differential between storage and no storage is quite significant, more than 300 percent or so. Therefore, similar to production capacity, the associated CapEx significantly increases as storage is reduced. In the best case, CapEx is estimated at $45 billion to $65 billion, and it is the lowest for the biogenic portfolio. So if it is possible to build larger plants for biomass and RNG, the CapEx figures would actually be better because of the economy of scale.

Next slide, please.

Similarly, the number of production plants would also increase in the no storage case by almost a factor of four, or actually four plus, 4.3, 4.4, shown in the lower table in the slides there, in the slide, compared to the case where storage is considered. In other words, the CapEx is much lower when you have full storage.

Because there are no commercial hydrogen storage facilities, in reference to California at least, that use depleted oil and gas reservoirs, we did not estimate the geological storage CapEx cost. The cost of tank storage is in the order of $1,200 per kilogram of hydrogen. We are planning to gather estimates from different studies for geological storage. We have some sources on that already, but we have not processed them currently at this point.

So the key takeaway here is that because a good portion of the plants that are not fossil, SMR plus carbon capture, are small, about in the order, say, of 15 tons per day, then the total number of production plants would be large, around 400 or so, even with full storage.

Next slide, please.

So what are the key takeaways?

In the electric generation case, if hydrogen is heavily used to replace existing gas-fired generation, there will be large variations in seasonal demand for hydrogen. For the transportation sector, end uses do not really fluctuate that much in demand, but seasonal variations do occur.

For the seasonal changes, rather, in hydrogen use, driven by electricity production, needs will require strategic hydrogen storage facilities. And these are large and centralized, like, for example, geological or subsurface reservoirs, but the alternative is scaling up the hydrogen production capacity in order to meet the demand in just-in-time approach. However, we need to keep in mind that the extra hydrogen production capacity would likely be underutilized for significant portions of the year.

On-site hydrogen production is limited to applications where demand is low, and just to give you for scale in terms of renewable energy and area needed, seven acres of solar PV yields only about 140 kilograms of hydrogen per day, so that's not a lot, basically. So biogenic feedstock may be limited in terms of availability, and there must be processes to efficiently collect, stockpile, and process different feedstocks to meet the hydrogen demand.

Fossil gas reforming with CCS can use significantly more water than electrolysis, since the process requires large volumes, rather, for cooling and for steam.

Finally, hydrogen delivery can be met with trucks to a certain extent for end uses of five tons or less per day, but pipelines would be needed to meet that extensive hydrogen demand.

Thank you. And now I would like to turn it over to my colleague, Quentin Gee, who will be talking about hydrogen in the transportation sector.

MR. SOLANKI: Thank you, Sammy. I appreciate your presentation.

The fourth speaker on the panel is Quentin Gee, a Branch Manager for the Advanced Electrification Analysis at the EAD within the CEC, who will discuss hydrogen Demand Scenarios.

Quentin, are you online?

MR. GEE: Great. Thank you, Max.

Hi, everybody. Good afternoon, Commissioners. My name is Quentin Gee. Like Max said, I'm the manager of Advanced Electrification Analysis in the Energy Assessments Division. We work on advanced electrification technologies, but also transportation broadly, all of transportation, and we also do Demand Scenarios for broader analysis of economy-wide decarbonization, again, with a focus on demand.

So let's move on to the next slide.

So no need to get bewildered by this. This is just kind of there for people in case there's reference. These are posted online. There are a lot of acronyms and initialisms that are in the presentation. As I speak them out for folks in the room here, of course, I will do what I can to try to speak them out rather than go acronymical [sic] or whatever on it, but then for the folks online, you can download the slides here and refer to this if you get a little confused.

Next slide.

Okay, so hydrogen demand for transportation in SB 1075. So Sammy just discussed the sort of supply side and production side of hydrogen to meet the demand, but folks might have some additional questions about the demand itself and where is it coming from.

And when it came to the transportation component on this, we looked at sort of the CEC's Demand Scenarios Project. So as mentioned in the bill, SB 1075 requires us to model potential growth for hydrogen in the transportation sector, and the power sector as well, but for transportation Demand Scenarios, when we came to this this time around in 2023, we kind of developed a one-off scenario to sort of augment the traditional Integrated Energy Policy Report forecast, but for Senate Bill 100, because we had already done this work before, we thought that this would be a logical choice for us to go forward with.

We decided to give it two sensitivities here. The first one is the standard Demand Scenarios Policy Scenario, which is used in SB 1, Senate Bill 100, and then also we had another bill, excuse me, another scenario, Policy Scenario with a high hydrogen use or hydrogen augmentation.

So one thing again to just kind of clarify here, we're talking primarily just about the demand part of Senate Bill 100 reporting. The Senate Bill 100 Report does evaluate hydrogen supply and the electric system needs associated with that production. We did work on that as well. But when it came to this Senate Bill 1075 work that we're talking about today, we are just focused only on the demand component here.

Next slide.

Okay, so let me talk a little bit about the Demand Scenarios Project framework for transportation. So we normally have an -- the Integrated Energy Policy Report has an energy demand forecast, and what the IEPR -- or the IEPR, what we call the IEPR. The IEPR does capture a lot of existing policies. It doesn't always capture every single policy, but they're mostly captured there. The Demand Scenarios kind of takes that as a starting point and then sort of extends out the forecast out to 2050, but also takes a look at near-term policies that have been adopted or are expected to be adopted in the near term.

And then, also, we take a look at goals with clear technological pathways informed by market analysis. We take a look at technology readiness levels, deployment, other sorts of things like that, looking at actually some of the stuff that's out there in the market that's, we saw discussed earlier today.

But combining all of these, we were able to develop a series of different Demand Scenarios, and the ones we're talking about Policy Scenario, and then Policy

Scenario with high hydrogen use.

Next slide.

Okay, so here's the breakdown of how we did the Transportation Scenario. So a lot of this starts with the 2023 Integrated Energy Policy Report for Senate Bill 100, as the Demand Scenarios were developed last year.

What we did for the -- so focusing on the sort of the Policy Scenario column, for light duty vehicles and transportation, we use the Advanced Clean Cars II regulation as modeled in the 2023 IEPR. We extended that out to 2050. There's a standard framework that we use for incorporating Advanced Clean Cars II, known as AATE, but we needn't get into that, but it's a standard framework that folks can look at in the IEPR forecast process.

In aviation, we took a look at a scenario where we evaluated zero-emission fuel substitution of jet fuel for in-state aviation starting in 2030, so nothing up until 2030. Right in 2030, we begin to a sort of a linear diffusion of fuel substitution of hydrogen and electricity, but the focus here being on hydrogen, 10 percent hydrogen by 2045 for in-state flights. And then the IEPR also focuses on out-of-state aviation as well. And we did five percent for out-of-state aviation under the assumption that traditionally hydrogen, at least as we were thinking it through in this case, would be for fuel cells. And so there would be a limited amount that a limited distance that you'd be able to get with hydrogen fuel cell powered aircraft.

The in-use locomotive regulations, sort of looking at freight rail and passenger rail, we did zero-emission fuel substitution starting in 2027 and had a diffusion sort of to 2020 -- to 100 percent by 2050. This is part of CARB's in-use locomotive regulation that had been adopted around that time.

We, for freight trucks, we used the Advanced Clean Fleets rule that had been adopted at that time, and also the anticipated at that time, zero-emission truck measure. I don't think it was formally named to this by the California Air Resources Board, but there was discussion of what they were saying, kind of like a zero-emission truck measure to try to get the rest of the trucks that weren't fully covered under the Advanced Clean Fleets regulation. Folks may be familiar with the Advanced Clean Trucks regulation. That is already baked into that as well, but not mentioned here.

For off-road, we had enhanced electrification. We did not have any hydrogen penetration in the off-road transportation component. That is something we might look into in future Demand Scenarios work.

And then finally, ocean-going vessels, or OGVs, we had 5 percent energy demand replaced by hydrogen by 2045.

So that's the Policy Scenario. The Policy Scenario with high hydrogen use, basically we didn't really see a strong case for additional hydrogen demand here in some areas, so for light-duty vehicles, aviation, and in-use locomotive regulation. Light-duty vehicles, we were not really seeing hydrogen fuel as a -- hydrogen-fueled cars as an option that is really set to grow in any significant way. We were not really sure how much further to push in aviation based off of the technology readiness level assessment that we conducted. And then for the in-use locomotive regulation, it was already pretty heavy with hydrogen, so we kept that as in the Policy Scenario.

One of the major areas where we did focus on, though, for additional hydrogen demand was we took that ACF and ZE truck measure, and then we actually did, conducted, a fuel-switching exercise where instead of a lot of battery electric trucks, we had a lot of fuel-cell electric trucks, so -- or battery electric vehicles, we substituted the energy with fuel-cell electric trucks energy.

Off road we kept the same as the Policy Scenario.

And then for ocean-going vessels, we actually were thinking there have been some interesting developments outside of California in the ocean-going vehicle space, and we were thinking maybe it would be worthwhile to pump up the energy a little bit more on that with hydrogen as a potential either direct fuel or a pathway for fuels for ocean-going vehicles, so we had 25 percent linearly adopted by 2045.

Next slide.

Okay, so here are the results. On the left, you can see transportation electricity demand. That's not really the focus here, but you can see that the Policy Scenario compared to the High Hydrogen Use Scenario in different reference years of 2035, 2045 and -- 2040, and 2045, those, you can see electricity goes down a bit because we had some electric trucks pulled out of the population. And then on the right, you can see the transportation hydrogen demand in the Senate Bill 100 Demand Scenarios. You can see that there's quite a bit more hydrogen demand in each of them growing to about a little more than 1400 million kilograms in 2045, or 1.4 billion kilograms in 2045.

Now that's quite a bit of hydrogen for the transportation sector. This aligns fairly well with the California Air Resources Board's Scoping Plan when it comes to transportation. There were other components outside of transportation that we were not able to get alignment with in this Demand Scenario, but since we're talking about transportation, I would say overall this is a pretty close alignment with what we’ve seen from CARB in terms of the millions of kilograms demanded.

There are some sensitivities around, you may have seen the earlier carb presentation, they were talking about exajoules, lots of different energy units, but the conversion, depending on how you do it, we think is closely aligned in the assumptions that you bring to the table with the conversion approach there.

Next slide.

Okay, so hydrogen results and recommendations. So as we saw, hydrogen demand increases by about 72 percent more than the hydrogen demand, primarily from freight trucks, as we saw a little bit from those ocean-going vessels. And the low Policy Scenario, this had some additional expected policies and a little bit more hydrogen than we would typically expect from the standard IEPR approach, but still a good amount of hydrogen demanded in that scenario as well.

Next slide.

Okay, so integrating this into SB 1075, basically we took the annual hydrogen demand derived from here. SB 1075 also analyzes and evaluates the daily hydrogen demand aligned with the battery electric vehicle electricity demand for freight trucks in the Demand Scenarios Project.

So one of the things that we were working on when trying to evaluate it, it wasn't just the annual hydrogen demand, but the sort of the way in which electricity and electrolyzer sizes, as we saw with Sammy's presentation and some of the other folks before, how do you size those and get them done in the right way so that you can meet the daily demand?

So what we did is we said, okay, well, we have freight trucks with sort of the seasonal variation; right? A little bit less driving, I think in the winter, a little bit more driving in the fall. So what we did is we kind of were able to do that seasonal variation thinking, okay, well, hydrogen in the freight sector would look a lot like battery electric trucks in the freight sector as well. So that does play into some of the daily demand and the evaluation that you can see with the supply numbers that Sammy presented.

Next slide.

That's it for me in terms of the hydrogen demand. Thank you. I can take any questions from Commissioners or the audience.

MR. SOLANKI: Thank you, Quentin. And thank you for the presenters on this panel, Jea, Sasha, and Quentin, and Sammy.

I will now pass it on to the dais for their remarks and questions.

VICE CHAIR GUNDA: Yeah. Thank you. Just thanks to Jea, Sasha, Sammy, Quentin. Thank you, Max.

Could we start off with the Q&A that came through? I just want to -- you know, I know we're running out of time. We'll stop there.

MS. NAKAGAWA: Yeah. Let's have Amanda come on in. If you want to read through, Amanda, the Q&A from the Zoom, that would be great. Looks like there's a couple for Quentin.

MS. WONG: Hi, everyone. My name is Amanda Wong. I'm an Electric Generation Systems Specialist in the Fuels Analysis Branch, and I will be moderating today's Q&A for this section. So we have a couple of questions in the docket now.

The first question is from David E. This is to Quentin. "Can you please elaborate on the ACC2 framework that is adopted by IEPR? I believe you said AEET."

MR. GEE: Great, great question in need of clarification. Sorry. I didn't talk about it a whole lot in the presentation, but the standard Integrated Energy Policy Report forecast does integrate CARB's Advanced Clean Cars II regulation. It does it in a framework called additional achievable transportation electrification, or AATE. What we do is we take the -- so the forecast results sort of show different -- all vehicles, all light-duty vehicles that are adopted. So we have commercial vehicles, personally-owned vehicles, rental cars, government cars. They all have their kind of pathways of adoption. People like certain body types, so they like, you know, like SUVs, kind of a growing segment. They tend to also like a lot more pickups, even if they're not necessarily using them for traditional purposes.

And so we kind of take all of those preferences and build them into an econometric model and are able to kind of get those as sort of new vehicle purchases. And then they, kind of, they go into the population and then they get older and older and they start to leave the population. So each forecast year is this complicated dynamic of that with a baseline forecast.

From what we do with there with the framework is we adjust the fuel types of the new vehicles that are sold to align with the zero emission vehicle requirements that CARB has established under Advanced Clean Cars II. It's a little bit complicated, but we like the fact that it's able to maintain a lot of this sort of the rigor and kind of consumer preferences of those body types and acceleration and trunk space and all the other variables that we have in the model. It keeps a lot of the preferences there, but is able to switch the fuel types to align with zero emission requirements.

Yeah, and it’s called Additional Achievable Transportation Electrification, AATE. The one scenario that we tend to use is AATE 3. But I can -- feel free to reach out to me. I can email and give you more information in the forecast.

MS. WONG: Thank you for that, Quentin.

We have another question for you from Rod.

“So Quentin, could you speak to the California policy and hydrogen versus SAF, sustainable aviation fuel, locomotives and OGVs versus fuel cells?”

MR. GEE: Yeah, that’s an interesting question. That’s a little bit outside of the way the Demand Scenarios approach work, but we did look at a lot of the technology readiness levels in this area. So hydrogen, so thinking like in aviation versus SAFETY, or sustainable aviation fuel, arguably one might say that hydrogen is a sustainable aviation fuel to the extent that it can be zero carbon. You know, it could arguably be a sustainable aviation fuel. A lot of them, a sustainable aviation fuel is typically regarded as what we call a drop-in fuel. So it’s kind of like more or less chemically almost the exact same thing or very similar to kerosene that’s used in jet engines. So there’s some distinctions there. Hydrogen could theoretically be a pathway there, but oftentimes hydrogen is more often used in the production of like methanol and ammonia.

So in aviation, it could be a little bit tricky. There's a lot of interesting pathways on sustainable aviation fuel. I'm not quite sure about the direct hydrogen connection there, but a lot of interesting work in that space. But we did not include any sustainable aviation fuel demand outside of sort of just assuming hydrogen and electricity, which in theory are, but they're not traditionally thought of as SAF.

And locomotives, so any kind of drop-in fuel, we didn't assume any kind of work like that. Theoretically, a lot of locomotives operate on diesel. They could operate on biologically-sourced diesel, renewable diesel, biodiesel blended, so there are some potentials there. We didn't really look at that potential. We just worked primarily from the Air Resources Board's assumptions on hydrogen being a preferred fuel there. It is zero-emission, so whereas even renewable diesel has a lot of nitrous oxides and other pollutants.

And then ocean-going vessels versus fuel cells, that's a big area that's ripe for discussion when it comes to fuel cells in ocean-going vehicles. It's kind of tricky. There's some projects out there. We've been tracking a few of them that are either in production or will soon or have been recently deployed where they're actually using hydrogen in a fuel cell and, you know, running a big huge ship turbine to propel the ship forward.

You could also use methanol or ammonia, which hydrogen is oftentimes a pathway step in the process development of that. Those can be used in a much more traditional combustion form. One might argue that air quality benefits are not as problematic when you're sort of on the ocean or whatnot. At the ports, you know, that's a different question.

So, yeah, a lot of interesting issues on that front. Happy to discuss more with folks who want to email me and reach out.

VICE CHAIR GUNDA: Amanda, before you jump in --

MS. WONG: Yes.

VICE CHAIR GUNDA: -- Quentin, I think just on the SAF, I think we are looking to work with the CARB, you know, some of the analysis that's being sponsored there to the consultants for the petroleum work. That could also be insightful for us as we move forward.

MR. GEE: Oh, yeah. Yeah, definitely. Yeah.

MS. WONG: All right, you have one more right now from William M.

"Can you please elaborate on the ACF framework that is adopted by IEPR and how that will impact hydrogen growth for H2ICE, hydrogen internal combustion engine, and H2ICE vehicle adoption?”

Sorry if I butchered that.

MR. GEE: Yeah, so I think a hydrogen fuel cell electric trucks versus hydrogen internal combustion engine electric -- not electric, internal combustion engine trucks, I don’t think that there’s much of an interest by the state with hydrogen combustion trucks. Theoretically, hydrogen could be combusted. I mean, we talked about hydrogen being combusted for power generation. You could also do that. There are piston driven engines and other. There’s also turbine type engines that can do a lot of work there.

But I don’t think that there’s much of an -- Advanced Clean Trucks -- or excuse me, Advanced Clean Fleets and Advanced Clean Trucks framework both would rule out hydrogen combustion on a truck and in favor of hydrogen fuel cell electric vehicles.

I would note that the Air Resources Board has rescinded its waiver request from the federal EPA for Advanced Clean Fleets. So there’s a little bit of uncertainty about that. But given the 2023 IEPR, we were working under the Advanced Clean Fleets framework.

VICE CHAIR GUNDA: Thank you.

I think we have one question in the room, so let’s just take that question. Yes, please, anywhere.

MR. MCRAE: Thanks. I prepared a question and I also will make a comment. My name is Tim McRae. I'm the Vice President for Public Affairs for the California Hydrogen Business Council.

And just on the H2ICE issue, it is the case that there are H2ICE vehicles elsewhere in the world. There are just not any here, basically for lack of policy drivers in the U.S.

I'd like to thank the Vice Chair and the Commissioner for being through -- going through this for the whole day and for your in-depth dive into the clean firm resources and this forum's focus today, this afternoon, on hydrogen.

My question is for Sasha Cole of the CPUC. Sasha expressed deep skepticism around uncertainties he sees around hydrogen and said the SB 1075 Report would be more credible in his mind compared to reports generated by utilities. My question for Sasha is: What are the uncertainties that he would need for the SB 75 report to address to feel more comfortable with hydrogen in his mind?

MR. COLE: Yeah, hi, thank you. That's a great question. You know, it's funny, I don't have a list in front of me, but when we're looking at it, it's not so much the uncertainties, but it's really the address the ways that the ecosystem could fail to fully develop.

So for instance, I think that there's questions about the underground storage is a big one. I think there's questions around whether the price of hydrogen produced will come down as fast as said and what that will mean on the demand side. And I think that there's uncertainties around, for instance, transportation alternatives and alternative technologies more generally, so if you think about large vehicle electrification versus hydrogen fuel cells.

All of these create these kinds of uncertainties where I could see a scenario, when I'm thinking about it, where people are reluctant to make the large investments in the technologies are going to need in order to drive demand, because there's uncertainties around the other factors. So these are the -- I'm not saying for sure that you know, I know how it -- it's uncertainties. I don't know how this is going to play out. It's a dynamic system and it's really at the beginning of its development.

And so what I really want is just an awareness on the part of policymakers. And so I want the reports to kind of point out. Because my impression when I read these reports often, is that they are roadmaps. And I feel like we make better policy when we're really kind of acutely aware that the projections that we're making may be wrong, and that they may be wrong in ways that compound upon each other.

So, you know, I'm not trying to suggest an alternative analysis where none of this happens. I'm suggesting a kind of more cautious optimism, I suppose. And so, you know, this is the thing, is for the reports to, when these uncertainties exist, to make sure that they don't get buried under a certain kind of rhetoric that's very typical in kind of consulting reports, where you, for instance, have a high, medium and low case, right, and they're often bracketed in ways. And to understand that, you know, right now, we're seeing a lot of projects that are being canceled on the production side, I'm aware of that. I'm not fully immersed in the commercial side of things.

And so, you know, I want to make sure that our analysis picks up and it's not creating illusions. I want to make sure that we're cautiously optimistic, but that we're very clear, and that we're flagging these possibilities where the system won't develop. It's happened before many times. But I don't want to be in a situation where we look back, and we said something is going to happen, and we spend a lot of money, and then, you know, it didn't.

So I just want to kind of flag myself as not doubting the analysis, but wanting to make sure that the analysis is very clear about these things. Did that make sense?

MR. MCRAE: That was helpful. It's always helpful to see more into your thinking when you make these presentations, so that will help us in our advocacy. Thank you.

MS. WONG: Thank you, Sasha.

We have one open question. Oh, no, we have no open questions right now, so I'm going to turn it over to Sandra for public comment. Thank you.

MS. NAKAGAWA: Dais, were there any questions for presenters? No?

All right, we will go over to our Deputy Public Advisor, Ryan Young, who's going to be running our public comment for this afternoon.

MR. YOUNG: Thank you. We'll now take public comment. One person per organization may comment, and comments are limited to three minutes per speaker. We'll start with those in the room who have indicated they would like to comment. I did not receive any blue cards currently, but if there's someone, please approach the podium. Provide your comment. Please state your name for the record.

MR. FREEDMAN: Should I use the microphone or do want me to do the keypad?

(Off mic colloquy.)

COMMISSIONER GALLARDO: Hold on, yeah.

MR. FREEDMAN: Hello?

MS. NAKAGAWA: Yes.

MR. FREEDMAN: Yeah, that works better. Sorry. Good afternoon. My name is Yuri Freedman. I'm with the Southern California Gas Company.

We appreciate the Commission's, and personally your Vice Chair, leadership in this important area. Thanks to the hard work of the Commission and your colleagues and other agencies, hydrogen now reached the point of broad consensus among public and private sector stakeholders, such as -- as the list is long, so I'll truncate it, the CEC itself, Air Resources Board, Ports of Los Angeles and Long Beach, Los Angeles Department of Water and Power, as you have heard today, Burbank Water and Power, Prologis, Mainspring, and many others. These stakeholders agree that hydrogen will play a critical role in assuring reliable, resilient, and affordable energy transition for California.

At this point, it is important to develop an integrated planning framework for electronic and molecular components of California's energy system, that is, for its power and gas and other energy sectors. Such planning, including, importantly, connected infrastructure, is necessary to assure the state moves toward its decarbonization goals without compromising energy reliability, resiliency, and affordability. This planning is of particular importance for hydrogen, since a large portion of it will be produced using electricity and used across the broad range of sectors, such as mobility, power generation, and industrial heat.

We look forward to the development of such planning process and our participation in that. Once again, thank you.

MR. YOUNG: Thank you for your comment.

Are there any other comments in the room?

I'll now turn to Zoom. If you are using the online Zoom platform, please use the raise-hand feature as a reminder to let us know you'd like to comment. We'll call on you and open your line.

We have, first, have Noah Lueneburg from LADWP. Noah? Noah, your line is unmuted. Okay, we'll come back to Noah in a moment.

Next, we have David E. Park. David, please unmute your line and provide your comment.

MR. PARK: Hi. David Park with the Hydrogen Fuel Cell Partnership, D-A-V-I-D P-A-R-K.

First of all, thank you so much, Energy Commission, for your historic leadership in this space and for this very important work and the focus today. The speakers were top-notch. We're very interested in following up with them and we want to learn a lot more about their work in this space across the board.

I just wanted to note that we are currently working on a California ZEV strategy, a mobility strategy that includes hydrogen fuel cell electric vehicles and ZEV targets. That's soon to be published. And there is a parallel process that ARB is pursuing in the ZEV space. We would greatly appreciate if the SB 1075 work and the work that CEC is doing to support that could look at our work and see how that aligns with your forecasts and perhaps do some scenario modeling around our mobility strategy forecasts.

Quickly, we are looking at policy alignment across state, federal, and regional, and with a focus on economic sustainability, looking at hydrogen and its many forms of production and cost, and how do we light off the market with low-cost hydrogen to the customer, the consumer fleets, and also retail consumers, much as Linde stated from that TCO perspective.

So thanks very much for your work, and we look forward to our continued dialogue.

MR. YOUNG: Thank you, David.

We're going to try Noah again, Noah Lueneburg. If you'd like to make a public comment, please unmute your line. It looks like Noah is unable to provide his comment this time. And I don't see anyone on the phone. Oh, it looks like Noah unmuted.

Noah, can you hear us?

VICE CHAIR GUNDA: I think we might need to open it up again, yeah.

MR. YOUNG: Noah, can you hear us? If, maybe you can unmute right now?

MR. YOUNG: We'll proceed. We don't have anyone on the phone, and so that concludes public comment.

Back to you, Sandra.

MS. NAKAGAWA: Thank you so much, Ryan.

A reminder to attendees that you can provide written comment to the docket. Written comments are due by 5:00 p.m. on August 19th, and you can find instructions on how to provide those comments in the workshop notice, which is posted on the website for this page.

And we'll go back to the dais for Vice Chair Gunda for any closing remarks.

VICE CHAIR GUNDA: Thank you, Sandra.

I just want to thank all the speakers today. That has been a lot of content. It's good for everybody in attendance to know how hard we work here, you know, put you through a whole day. I thought, you know, the discussions, you know, all the way from the morning in terms of understanding the viability of clean firm resources and the opportunity for them, and the benefits and additional insights that we need to draw, specifically on how best to value them, I think is an important thing for our team to take on.

From Hydrogen, you know, again, Yuri, thank you for being here the whole day. I know it's a long day. I see a number of colleagues here for the whole day. I thought the presentations in terms of Bloomberg, the overall opportunity, but specifically the Hydrogen panel from the industry trying to talk about the opportunity and all the work being done is excellent.

Thanks to the state team, CARB, CEC, the PUC on, you know, just the progress on 1075. And I think, Quentin, there's a number of questions that came through both on the transportation side, but also Max and Sammy, just on a few pathways. I think there was a point, there was a few points made on the viability and opportunity to further dig in. So we'll flag those for internal conversations.

But I just want to say thanks to everybody in attendance and the team for putting this together.

Commissioner Gallardo, anything?

COMMISSIONER GALLARDO: Solely, big gratitude to you, Vice Chair Gunda, for leading this, putting it on, and to the team for all the support, the IEPR Team and EAD Team and everyone else.

I also wanted to commend my fellow, Eddie Chen over here, who’s been here the entire day. He’s the next generation of energy leadership, and he’s filling his brain and heart with all of this information. So Eddie, thank you for being here.

All right, I’ll close with that.

VICE CHAIR GUNDA: Thank you, Commissioner Gallardo.

With that, Sandra, back to you. You can do the honors.

MS. NAKAGAWA: Yeah, we are adjourned. Thank you so much, everyone.

(The workshop adjourned at 4:47 p.m.)

CERTIFICATE OF REPORTER

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 9th day of September, 2025.

ELISE HICKS, IAPRT CERT**2176

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I certify that the foregoing is a correct transcript, to the best of my ability, from the electronic sound recording of the proceedings in the above-entitled matter.

Martha L. Nelson

MARTHA L. NELSON, CERT**367

September 9, 2025