DOCKETED	
Docket Number:	19-IEPR-07
Project Title:	Electricity Sector
TN #:	230529
Document Title:	Transcript for the September 24, 2019, IEPR Workshop RE Near-Zero Carbon Electricity
Description:	N/A
Filer:	Stephanie Bailey
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	11/7/2019 1:58:18 PM
Docketed Date:	11/7/2019

CALIFORNIA ENERGY COMMISSION

COMMISSIONER WORKSHOP

In the Matter of:	)	Docket No. 19-IEPR-07
	)	
2019 Integrated Energy Policy Report	)	RE: Near-Zero Carbon Electricity
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CALIFORNIA ENERGY COMMISSION (CEC)

WARREN-ALQUIST STATE ENERGY BUILDING

ART ROSENFELD HEARING ROOM, FIRST FLOOR

1516 NINTH STREET

SACRAMENTO, CALIFORNIA

TUESDAY, SEPTEMBER 24, 2019

10:00 A.M.

Reported by:

Bridgette Rast

APPEARANCES

STATE LEADERSHIP

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Genevieve Shiroma, Commissioner, California Public Utilities

J. Andrew McAllister, Commissioner, California Energy Commission

Patty Monahan, Commissioner, California Energy Commission

Suzanne Casazza, Legal and Policy Advisor, on behalf of Commissioner Randolph

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Maureen Hand, California Air Resources Board

Zachary Subin, E3

Debra Lew, Consultant to Western Interconnection Regional Advisory Body

Melanie Kenderdine (via WebEx), Energy Futures Initiative

Caitlin Murphy, National Renewable Energy Laboratory

AGENDA

P R O C E E D I N G S

10:03 A.M.

SACRMENTO, CALIFORNIA

TUESDAY, SEPTEMBER 24, 2019

VICE CHAIR SCOTT: Good morning everybody and welcome to our IEPR Workshop this morning on the Near-Zero Carbon Electricity. So we're glad to have everyone here, glad to have this conversation.

Let me turn it to Heather. And then we will come and do some opening remarks.

MS. RAITT: Great. Thanks.

Just a few housekeeping items. If we need to evacuate the building, please follow staff out the door to Roosevelt Park, which is diagonal to the building.

And just to let folks know that we are being recorded on WebEx, so there will be -- we'll be posting an audio recording and a written transcript on our website in about a month.

If you would like to make comments at the end of the day, you have -- fill out a blue card and give it to me. Blue cards at the entrance of the hearing room.

And folks on WebEx, if you'd like to make comments at the end of the day, use the raise-your-hand feature on WebEx to let us know that you want to comment. And if you change your mind, you can also use that feature to take your hand down.

The meeting materials, all materials for this meeting, are posted on our website. And the notice gives information about how to submit written comments and those are due on October 8th.

And then finally, I'd just like to thank our speakers for being here, representatives. And just to remind you that when you're speaking, if you could just identify your name each time? It's very helpful for the folks on WebEx to try to follow along with the conversation.

That's it. Thank you.

Commissioner?

VICE CHAIR SCOTT: Okay. Great. Well, good morning. This is Commissioner Scott. And welcome everybody. We're glad to have you here.

So this is a really important workshop, as you all well know. The state is thinking about how we get to 100 percent clean energy. And it seemed that we must have a near-zero carbon electricity workshop as part of the Integrated Energy Policy Report proceeding as part of that. And we fully recognize that many of these goals are 2045, 2050. They're, you know, 20 years from now which is, actually, a very short amount of time, but also quite a ways out.

So we need to kind of balance that and think through a lot of the practical considerations that we all need to be keeping in mind, keeping an eye out for some of the red flags that might come our way, things that we know now that we need to start putting in place, but also kind of think about the types of technologies, the types of distributed resources, the types of analysis and things like that that we will continue to need as we make our way from here in 2019 through 2040, 2045, and 2050 to meet our climate change goals, and also the clean air goals that are tied to that.

So at today's workshop, we will hear some of the key scenarios from some world-renowned folks who have really been spending some time thinking about this. And then we will hear from a set of folks who will talk through some of the practical considerations that policymakers and decisionmakers may want to keep in mind as we make our way toward our near-zero carbon electricity future.

I did want to just clarify that this is, while there's a lot of information that is very similar to what you might here in the SB 100 proceedings, this is not an SB 100 proceeding. That has its whole own set of workshops and proceedings and folks that are going to be gathering together and continuing to work on that. But we would be remiss in putting together an Integrated Energy Policy Report that didn't also touch on this.

So if you are engaged and interested in SB 100 proceedings, please be sure to follow those closely as well.

And I really want to say thank you so much to our friends from the Public Utilities Commission, and also from the ISO, for joining us here today. This is, obviously, a consideration that's important to all of the agencies across the state. Air Resources Board is out a little bit ahead of us and had a very similar workshop just a little bit ago. But our agencies are all working really closely together, really well together to dig into these topics, so thank you for being here.

And let me turn to others on the dais for opening remarks.

Would you step down here?

COMMISSIONER SHIROMA: Okay. Well, good morning everyone. Thank you. Thank you, Commissioner Scott, McAllister, Monahan, and colleagues at the dais. I'm very pleased to be invited to participate, to listen, really, to listen and learn today.

As you know, the CPUC, the California Public Utilities Commission, has an essential role in this effort, not only SB 100, but also in the IEPR insofar as the CPUC directs procurement, adopts rates, implements policy through our investor-owned utilities, and in and around that, look at the impact on low-income communities, disadvantaged communities, as you do, as well, and balancing, always making that assertive process towards lowering our greenhouse gas footprint, utilizing innovative technologies, looking around the corner at what might be there to help in this path forward, and always with a keen eye to affordable rates, safety and what have you.

So I'm looking forward to learning today, to hearing.

And then, having said that, I'm apologizing in advance because at 11:30, I need to peel off to head to the Bay Area for another meeting. But I've already sort of taken a preview glance at the PowerPoints and really appreciate the work and effort that has gone into those. And again, I'm here to learn and listen.

Thank you so much.

COMMISSIONER MCALLISTER: Well, thank you, Commissioner Shiroma, and thank you for being here, and everybody on the dais.

My name is Andrew McAllister, a Commissioner here at the Energy Commission, and second on the IEPR in general, but mostly forecasting. I'm mostly focusing on the forecasting piece of the IEPR.

But, you know, I want to -- don't want to reiterate what Commissioner Scott said but I think, you know, we do have to remember that SB 100 is a standalone thing. And I think it's where a lot of the continuity of the long-term discussion sits. How do we get -- how do we maintain reliability? How do we really sort of, you know, systematically get to our goals over the long term? And this is a little bit more of a snapshot as part of the 2019 IEPR. And completely agree, I mean, we need to have a high-level conversation about this in the IEPR and put that in a chapter on the record so that people can refer to it. But over the long term the heavy lifting happens in the SB 100 proceeding.

I wanted to just highlight, you know, this is a relatively short workshop, the two big inputs we're discussing are the E3 work and the EFI work. And those are, I would say, you know, similar in some ways but kind of the two distinct inputs thus far on decarbonization of the energy system in California. And so it made a lot of sense to sort of put them together and listen and learn what those look like. Obviously, lots of unknowns in both cases. But I think really grateful to have both E3 and the Energy Futures Initiative here. Well, I guess Melanie is remote. But those perspectives on where we might be heading, I think, pathways with a small P, I think, is a really valuable thing to have in front of us and to begin to think about.

And so just thanks everybody for coming. You know, the standard comment periods will apply. And I think it's really helpful to have multiple jurisdictions at the dais. Thanks to the ISO and the CPUC for coming, and the ARB is sort of in absentia. But again, you know, they are the third entity in the SB 100 realm. This conversation is slightly distinct so we have, also, the ISO here with us.

So looking forward to getting the viewpoints from our presenters. And we'll pass it along to Commissioner Monahan.

COMMISSIONER MONAHAN: Well, I got to say, as the Trump administration takes steps to roll back California's authority to set vehicle standards, it is a joy to be on the dais with fellow agencies all working towards a 2045 deep decarbonization goal. It really is wonderful to be here in California making progress on climate and clean energy and showing the rest of the world how it's done.

I think there is -- we are encountering increasing tension between near-zero and zero emission grid and transportation system and we need to navigate those challenges. As Commissioner Shiroma said, we need to make sure that we have safe, reliable, affordable electricity. And we need to make sure that California meets its clean air goals.

So I'm very much looking forward to this conversation. I think we are treading new territory. And every day we're surprised by how prices are dropping on renewables, on batteries, opening the door for greater ambition here in the state of California.

So with that, I'll pass the baton to Mark.

MR. ROTHLEDER: Thank you. And thank you for the opportunity to share this dais with you.

The ISO, we play a supportive role in terms of the carbon goals and the environmental goals. Our primary focus is reliability. And so when it comes to that mix of sustainability, affordability and safety, we're the fourth one, we're reliability. And in that regards, what we'll be focusing on today is watching to see what's happening in terms of the changes on a couple things in terms of operability in the system.

And some of the things that we -- I'd like to break it up into like thirds. The one-third we've kind of gotten through and we did it and we showed how it could be done, but we've got two-thirds to go. And I think those two-thirds are really going to be a challenge on all fronts.

And on the operational front, some of the three challenges that we're focusing in on over the next few years, some of them are more near term than later, but one is: Do we have the right capacity and capability of the system to continue to maintain reliability in all periods, especially as that daily load shape is changing?

The other thing that we were looking at is that with the changing mix, we have increasing need for flexible resources, ramping capability so that we can balance a system in those hours when the supply and the load picture is changing.

And then the third area that I think we need to focus on, and I'm glad to see it in some of the material, is that we also have to keep preparing for those days when you don't have production from those clean resources. How are we going to meet the demand in multiple days? And, certainly, storage will become part of the solution. But do we have the right mix of resources and the right types of storage to do that?

So those are probably the three major challenges that we are most focused on.

I think the other area that we are interested in understanding is that as the other sectors decarbonize, what is the impact as fuel switching occurs and what's the effect on the load on the electricity? It's nice to be in this kind of nice stable pattern where load isn't really increasing, maybe even going down a little bit with energy efficiency. But there's going to be a turn here in the near future and how do we prepare for that turn in the load pattern? So those are the areas that I look forward to understanding.

And, again, thank you for the opportunity to share the dais with you.

MS. CASAZZA: Good morning everyone and thank you for having me today. Thank you to the CEC for organizing today's event. My name is Suzanne Casazza and I'm a Legal and Policy Advisor for CPUC Commissioner Randolph. Commissioner Randolph, unfortunately, could not be here today because she has a conflicting event. But I am representing her and I'm really excited to hear today's discussions and share with her what I learn today.

Commissioner Randolph is the assigned CPUC Commissioner to Integrated Resource Planning, or IRP. And an IRP, the CPUC sets out the optimum portfolio of supply and demand-side resources needed to achieve our state's ambitious greenhouse gas emission reduction targets within the electric sector.

And as part of IRP and our partnership with ARB and the CEC, we are examining what 2045 looks like for the energy sector. And we will be producing some early looks alongside the 2030 portfolios soon, in early October. We will have an IRP workshop on October 8th which will be noticed formally very soon. And I'm just really excited to see today's discussions.

Thank you again for having me and I look forward to it.

VICE CHAIR SCOTT: Great. Great. All right. Thank you everyone for being here on the dais with us.

Let us now turn to our overview of

California’s climate and energy policies and goals.

And so first we’ll hear from Le-Quyen Nguyen, who will talk with us a little bit about SB 100 and what’s going on in that space. And we will also hear from the Air Resources Board about AB 32, SB 32, kind of the overarching climate goals, so we can kind of set the stage for why we’re having this dialogue today.

So go ahead, Le-Quyen. Thank you.

MS. NGUYEN: Thank you, Vice Chair.

So my name is Le-Quyen Nguyen. I am the manager of the Supply Analysis Office in the Energy Assessments Division within the Energy Commission. And so today, I’m going to supply a brief overview of California’s climate energy goals and actions that we’re taking to achieve them.

So California has a long history of strong leadership and ambitious initiatives to fight climate change and promote clean energy. We’ve set goals for reducing greenhouse gas emissions, calling for a reduction to 1990 levels by 2020, 40 percent below 1990 levels by 2030, and 80 percent below 1990 levels by 2050.

One of California's core strategies for reducing greenhouse gas emissions is our Renewables Portfolio Standard which sets targets for the percent of retail sales that must come from renewable energy. The initial target was 20 percent by 2017 but it has increased several times and it is now at 50 percent by 2026 and 60 percent by 2030. In addition, California also has a goal of achieving carbon neutrality by 2045.

So this slide shows California's electricity consumption by sector in 2018. Residential, commercial, industrial, and manufacturing make up the largest percentage of California's electricity consumption. So Maureen from ARB will talk about GHG emissions in her presentation. But I do want to point out that a sector's percentage of electricity consumption does not necessarily correlate to their percentage of California's total GHG emissions.

Energy efficiency is one of the ways that California is reducing the need for new electricity generation. Since 1978, we've set building energy efficiency standards for reducing energy consumption in new and existing buildings.

The standards are updated every three years through a transparent and public process. And the most recent standards, the 2019 standards, take effect January 1st, 2020. And notably, they require solar on new homes.

Also, in 2018, California joined the Net-Zero Carbon Buildings Commitment administered by the World Green Building Council for the Global Climate Action Summit. The Commitment calls on signatories to enact regulations and planning policies to ensure that all new buildings operate at net-zero carbon emissions by 2030 and for all buildings to do so by 2050.

California has also set minimum efficiency levels with energy and water consumption in products such as showerheads, computer monitors, light bulbs and televisions. And over the last 40 years, our cost effective appliance and building energy efficiency standards have saved consumers well over $100 billion -- I was going to say $100 million but it’s $100 billion.

So the chart on this screen shows that combining the efficiency gains and standards and efficiency programs, the cumulative annual efficiency and conservation savings for electricity surpass 70,000 gigawatt hours in 2017.

Other key policy measures that the Energy Commission is responsible for include: AB 758, which directs us to develop a program to increase energy efficiencies in existing buildings; SB 350, which called for us to establish a target that would achieve an accumulative doubling of energy efficiency savings by 2030; AB 802, which requires utilities to provide building-level energy data to owners upon their request; and more recently, AB 3232, which directs the Energy Commission to assess the potential to reduce greenhouse gas emissions from California's commercial and residential buildings by 2030.

So on this slide, I have behind-the-meter solar PV installations in California. So behind-the-meter, or the customer side of solar, plays a role in achieving California's climate energy goals. So on this chart, you'll see the growth of behind-the-meter solar, and you'll see that it's a great ramp up. And if you look at the small blue bar at the top of the 2019, you'll see that we actually reached -- or went over 1 million installed systems earlier this year, so applause for California. Yay.

So -- but this grid can be attributed to solar incentive programs, such as the California Solar Initiative and the new Solar Alliance partnership, as well as other financial mechanisms such as net metering and the Federal Investment Tax Credit.

So as I mentioned earlier, the Renewables Portfolio Standard is a core strategy for reducing greenhouse gas emissions. This chart shows renewable generation procured for California between 1983 and 2018 by resource type. You'll see that renewable energy generation alone hasn't increased substantially over the past ten years. And it's solar generation over the past five years that's increased by nearly 490 percent.

So in 2018, an estimated 34 percent of our electricity demand was met using renewable energy, which was up two years ahead of our 33 percent RPS goal. So again, more applause for us. Yay.

So now I'll talk about what we're doing in the transportation space.

On January 10, 2018, then Governor Brown issued an executive order calling for 5 million zero-emission vehicles by 2030 and the installation of 250,000 electric vehicle chargers and 200 hydrogen refueling stations by 2025.

At the CPUC, they've authorized about $1 billion in IOU transportation electrification infrastructure spending through 2023. This will fund light-duty charge ports at workplaces, apartment buildings, medium- and heavy-duty infrastructure programs, fast charging ports, and also pilot programs designed to address identified barriers to zero-emission vehicles adoption.

They also have an additional $800 million pending their review. And that would go towards additional light-duty charge ports, pilot programs to install light-duty infrastructure at schools, state parks and beaches, and a pilot to install infrastructure at low- and moderate-income residences.

So at the Energy Commission, we have a Clean Transportation Program. And we have annual investments of up to $100 million that promote accelerated development and deployment of advanced transportation and fuel technologies. We've provided nearly $830 million to more than 600 agreements that covered a broad spectrum of alternative fuels and technologies.

Our 2019-2020 Investment Plan Update establishes funding allocations based on identified needs and opportunities. And it does include a near-term focus on zero-emission vehicles and infrastructure.

At the ARB, they have the California Climate Investments Program they administer through their Low Carbon Transportation Program. They have over $2 billion in funds that have been cumulatively allocated to that program. And over 80 percent of the funding has gone to transportation electrification, so battery, electric, fuel cell electric, and plugin hybrid technologies.

In the research space, we have our Electric Program Investment Charge, which is also known as EPIC. So in 2011 the CPUC created the EPIC Program to support investments in clean energy technologies that benefit the electric rate payers of PG&E, SCE and SDG&E. The Energy Commission administers 80 percent of those funds.

And the three investor-owned utilities, together, administer the remaining 20 percent of those funds.

So our funding covers the following three program areas, applied research and development, technology demonstration deployment, and market facilitation.

Applied research and development is for investments in applied science and technology that provide a public benefit but for which there is no current business case for deployment of private capital.

The technology demonstration deployment projects are investments in technology demonstrations at real-world scale and in real-world conditions to showcase emerging innovations and increase technology commercialization.

And then for the Market Facilitation Program, those are investments in market research, regulatory permitting and streamlining, and workforce development activities to address non-price barriers to clean technology options.

The focus areas that we have for our EPIC Program are renewable energy, efficiency, grid-scale storage, resilience and reliability, climate science and adaptation, and innovation. And to date, we've awarded over $760 million for 431 projects.

So I will also mention SB 100 in my presentation. So we're working very closely with our sister agencies on this. SB 100 sets a planning target of 100 percent renewable and zero-carbon electricity resources by 2045. And it also increases the 2030 RPS target from 50 percent to 60 percent. It requires the Energy Commission, the PUC and the ARB to issue a joint report to legislature by January 1st, 2021, and every four years thereafter. And it must include specified information relating to the implementation of that policy. So I will do a quick plug for an upcoming scoping workshop. We have three that will be held this year for that report. The first one will be Monday, September 30th, in Fresno. It's a wonderful drive, if you'd like to leave Sacramento at 5:30 in the morning with us. If not, you can attend via WebEx.

And that was my last slide. Thank you for your time. And if you have any additional questions, you can contact me at le-quyen.nguyen@energy.ca.gov, or you can go to our website for additional information on any of the topics that I briefly touched on in my presentation.

Thank you.

VICE CHAIR SCOTT: Thanks. Do we have any questions from the dais for Le-Quyen on this topic? No? Everyone's good? All right.

Thank you very much, Le-Quyen.

We will now turn it over to -- oh, I don't have my agenda in front of me -- here we go, to Maureen Hand.

Thank you, Maureen, so much for being here.

And she's going to talk about AB 32, SB 32, and how we're -- our scoping plan and how we're going to get there.

Welcome.

MS. HAND: Thank you. Thank you very much. Good morning. Thank you for inviting me to provide an overview of the state's greenhouse gas emission reduction targets.

As you know, the California Air Resources Board is responsible for monitoring and regulating sources of greenhouse gases that cause global warming. So today, I'm going to talk about -- provide an overview of the state's greenhouse gas emission targets. I'll talk about some statewide trends in emissions and economic indicators. I'll describe our portfolio of policies that were identified in the 2017 Scoping Plan that are intended to support achievement of the 2030 greenhouse gas emission investment target, and then some thoughts related to continuing progress beyond 2030.

So this slide shows the impact of the key statutes and executive orders that guide the state's climate targets. In 2006, AB 32 set our initial 2020 target to return to 1990 emission levels. Then SB 32 called for a 40 percent reduction in statewide greenhouse gas emissions below 1990 levels by 2030. CARB's 2017 Scoping Plan lays out a cost-effective and achievable path to achieve for this target. The 2030 target is on the path to achieving the executive order goal of reducing greenhouse gas emissions 80 percent below 1990 levels by 2050.

Both last year's executive order calling for carbon neutrality by 2045 and the climate science presented in the IPCC Special Report on

1.5 Degrees Celsius requires us to find ways to reduce greenhouse gas emissions from fossil fuels, and they emphasize our need to focus on sequestration opportunities. Carbon neutrality will require reduction in greenhouse gas emissions, as well as increases in carbon sinks.

This chart shows trend in California GDP, population, and greenhouse gas emissions from 2000 to 2017 in terms of percent change since 2000.

So at the top in light blue in the Xs, you see the GDP. And we see strong economic growth interrupted by the recession around 2009.

In the dark blue diamonds, we see that California's population, and therefore its demand for services and goods, continues to grow steadily each year.

Now despite this growth in GDP and population, the statewide greenhouse gas emissions, in the blue triangles, have been declining since 2009.

And we also show greenhouse gas emissions per capita in the green squares and greenhouse gas emissions per GDP in the yellow circles, and you see that those are also declining at a steeper rate.

So California's suite of greenhouse gas measures is working. And we are on track to meet our 2020 target. These emission trends must continue and accelerate to ensure our future goals are also met.

California uses a portfolio approach to address climate change, as identified in the 2017 Scoping Plan. This suite of policies includes energy efficiency, renewable energy, renewable fuels, zero- or near-zero emission vehicles, cleaner freight options, an economy-wide cap and trade program, and protection of our natural and working lands. Money from the cap and trade program is reinvested in communities to reduce emissions and improve air quality. And finally, we also have programs to address super pollutants, such as fugitive methane from dairies and landfills and refrigerant gases.

So this policy portfolio includes incentives, prescriptive regulations, and carbon pricing. A combination that the IPCC has identified as necessary for rapid, cost-effective economic transitions that are needed to slow global warming.

The transportation sector represents the largest sector contribution to the state's annual greenhouse gas emissions. When combined with the industrial sector greenhouse gas emissions associated with refining fuels, the transportation sector accounts for nearly half of the state's annual GHG emissions. While overall state greenhouse gas emissions have been declining, emissions from the transportation sources have been increasing since 2013, although last year's increase of one percent is the lowest over this period.

California's leadership in emissions' regulations has created a hotbed of investment in vehicle technologies and fuels. And we are seeing signs that these investments are transforming our vehicle fleet. Nearly half of the zero-emission vehicles sold in the United States were sold in California. And in 2017, conventional internal combustion engine vehicles fueled by gasoline and diesel accounted for less than 90 percent of all on-road vehicles registered that year.

In 2017, diesel sold in California was 18 percent biomass-based, and that's a substantial increase from, essentially, zero a decade ago.

California has also received a flood of investments in clean fuels and transportation. In 2017, clean transportation was the largest segment of clean technology venture capital investment and California received 75 percent of the total investment in the United States.

The California Climate Investments is a statewide initiative that puts billions of cap and trade dollars to work reducing greenhouse gas emissions, strengthening the economy, and improving public health and the environment, particularly in disadvantaged and low-income communities and low-income households.

These funds are generally directed toward reducing demand for fossil energy and they work in tandem with supply-focused policies. For example, the Low Carbon Fuel Standard increases the supply of clean fuels. The climate investments help deploy vehicles that use these clean fuels.

The low carbon transportation portion of the climate investments accelerates our transition to low carbon transit, freight and passenger transportation modes. And the incentives are targeted across the vehicle fleet, including light-duty, medium-duty, and heavy-duty vehicles.

To date, the climate investments have appropriated nearly $12 billion into individual projects. And these projects support emission reduction efforts across the economic sectors, including investments to improve forest health and resilience, incentives to replace farm equipment with a cleaner model, and building affordable housing near transits. Now more than 60 percent of the investments are benefitting disadvantaged and low-income communities.

Our thinking about how to approach the climate challenge is evolving. The concept of carbon neutrality is gaining importance. The concept is that to address climate change the carbon dioxide and other greenhouse gas emissions generated by sources, such as vehicles, power plants and industrial sources, must be less than or equal to the amount of carbon dioxide that is stored, both in natural sinks and such as forests and biomechanical sequestration.

The magnitude of climate change impact will depend on when carbon neutrality is reached.

In general, limiting warming to just 1.5 degrees Celsius reduces climate-related risks and increases flexibility and mitigation and adaptation options. The IPCC Special Report released in late 2018 finds that to limit global temp to 1.5 degrees Celsius, we need to both reduce greenhouse gas emissions and remove carbon from the atmosphere. We need to reach carbon -- global carbon neutrality by midcentury.

The report also indicates that on a global scale some regions may remain net emitters while other regions may be better suited to be sinks.

In California, we have an executive order that calls for carbon neutrality by 2045, consistent with the IPCC Report. This executive order introduces the concept of balancing carbon emissions and carbon sequestration within the state.

The framing of near-zero emissions is not sufficient to meet the challenge laid out in the IPCC Special Report. We need our greenhouse gas emissions flux to be at zero or net negative, where we remove more carbon than we emit. The science is clear on where we need to be and getting there will require contributions from all economic sectors.

The path to carbon neutrality requires action on both sources and sinks. Today, we track statewide greenhouse gas emissions from transportation, electricity, residential, commercial, industrial, agricultural, and waste management sectors, including high global-warming-potential gases.

And we also track emissions and sequestration in our natural and working lands. Currently, these lands are a source of greenhouse gas emissions, releasing more carbon than they are sequestering. Some emissions from this sector are part of the natural cycle and are necessary for healthy systems, including emissions from periodic fires. Today, California emits more -- emits greenhouse gases from fossil energy and industrial sectors, as well as from our natural and working lands.

To achieve carbon neutrality by midcentury we must minimize emissions from our fossil energy and industrial sources to at least 80 percent below 1990 levels to achieve our 2050 goal and transition our natural and working land from a source to a sink such that we achieve net-negative greenhouse gas emissions.

As we start to consider the concept of carbon neutrality our starting point is CARB's existing accounting framework which includes all major greenhouse gases, major greenhouse gas emissions, and not just carbon dioxide.

CARB's 2017 Scoping Plan established a strategy to achieve the state's greenhouse gas emission targets. The programs implemented to date put us on track towards the 2030 target. But we must diligently monitor and adjust Scoping Plan measures to ensure we achieve the 2030 target and plan for continuing greenhouse gas emissions beyond 2030 -- or emission reductions beyond 2030.

In 2019, CARB staff is initiating dialogue and gathering information to assess potential actions identified in the scoping plan, as well as additional opportunities to help achieve carbon neutrality. We're holding a series of workshops to provide a forum to explore several topics. We have explored the role of the industrial sector. We've explored scenarios for deep decarbonization, and the social cost of carbon, and affordability.

In addition, we continue to work with other agencies, academic and international partners. Each of these bring expertise and authority and a diverse set of experiences that serve as assets as we advance the topic of carbon neutrality.

Scoping Plan updates are scheduled every five years. And we anticipate the next update will be completed in 2022. Efforts directed towards the Scoping Plan update will begin mid-2021 and they'll be informed by several interagency projects that will conclude before the Scoping Plan update beings.

California's Energy Demand Forecasts are updated annually through the IEPR process. The purpose of our meeting today, the CEC, CARB and PUC kicked off the process early in September, as was mentioned earlier, to develop a report to the legislature about the impact of achieving zero-carbon electricity. And I'll just mention again, as Le-Quyen did, that the first scoping meeting for that is next Monday on September 30th.

Later today, CalEPA is seeking input on the scope of two studies. One of the studies will focus on vehicle emissions. The other study will focus on fossil fuel demand and supply. And these studies are done in the context of achieving carbon neutrality by 2045.

The concepts that result from this body of work, as well as our carbon neutrality workshop series, will be assembled into a technically-feasible, cost-effective pathway to carbon neutrality in the next Scoping Plan update.

So here's a link to the existing 2017 Scoping Plan. And we encourage you to follow the carbon neutrality workshop series. You can find materials for these workshops at this link, as well.

And again, thank you for inviting me, and I'm looking forward to learning from the panelists today.

VICE CHAIR SCOTT: Great. Thank you so much for being here.

Let me see if we have any questions for the Air Resources Board on the Scoping Plan or the carbon neutrality workshops?

Yes. Please, go ahead.

COMMISSIONER MONAHAN: So thank you.

That was really helpful. Great presentation.

I'm curious about the situation with wildfires because the emissions are so -- I'm looking at an estimate that CARB staff made this year, that 45 million metric tons of carbon were released last year alone.

Is CARB thinking about -- more about entering the mitigation world on wildfires, or what's your role, besides the emission monitoring? And if you can't answer it, that's okay. I know it's a big question.

MS. HAND: I'm afraid I shouldn't, really.

COMMISSIONER MONAHAN: It's just that it is such a big amount of emissions, it's daunting for the state, as we are making so much progress on reducing emissions through all the great work of CARB, we still face this challenge with wildfires. Actually, the emissions are greater than the emission reductions, I think, we got last year. So they are a major issue for us to wrestle with that as a state, I think, as we all know.

MS. HAND: Right. It's certainly a very important topic. And there a number of agencies that are working together to try to develop a plan and figure out how to address that.

COMMISSIONER SHIROMA: Commissioner, so certainly the CPUC has a major role in this arena insofar as requiring wildfire mitigation plans from the investor-owned utilities which they -- which were adopted back in May and the implementation has been underway, and also included the public safety power shutoffs, which are in the news, in particular here in Northern California which PG&E having invoked that protocol because of humidity, high winds, and the circumstances that could be ripe for a wildfire.

So these are all mitigation efforts that have been put in place. And there is a cost that comes along with that, of course, but towards preventing wildfires for all the reasons outlined, the horrific impacts, loss of property and life, and the tremendous release of greenhouse gas emissions that arise from wildfires.

COMMISSIONER MCALLISTER: I guess I'm wanting to know a little bit more about the agricultural sinks and just wondering. Well, I saw a presentation the other day from a company that's based in the Midwest that seems to have pretty good success increasing the organic content of soils and doing so in a way that's accountable and measurable and basically costing them, they say, about roughly the clearing price of the cap and trade, and so I thought that was pretty spectacular. I'm going to hook them up with ARB.

MS. HAND: Oh. Thank you.

COMMISSIONER MCALLISTER: But I'm kind of wondering how much sort of meat there is on the bones in the Scoping Plan discussion right now? Because it looks like, as we move towards identifying promising sinks, that's a conversation that really has to be successful in order for us to reach our goal.

MS. HAND: Right. Thank you for mentioning that. And certainly, I think, folks will be interested in that.

You know, again, we're in the phase, before we get started with the next Scoping Plan, of trying to gather information, hold workshops and understand what many of these opportunities are. So we're paying attention to a number of these proceedings.

I think also in the climate investments there are some projects working with some of the other agencies in the state and, through the natural and working lands organizations, exploring those kinds of opportunities as well.

COMMISSIONER MCALLISTER: Great. Thank you.

MS. HAND: Any other questions?

VICE CHAIR SCOTT: Okay. Thank you so very much. We appreciate you being here.

We're going to take just like two minutes to shift over to our next panel so they have a minute to come on up to the table here. So we will -- that will be planning for deep decarbonization, moderated by Siva Gunda. Zach Subin from E3 will join us. Melanie Kinderdine is on the phone. She's be joining about 11 o'clock. Debbie Lew, who is a consultant to the Western Interconnection Regional Advisory Body. And Caitlin Murphy from our National Renewable Energy Lab. So let's give them just a moment here to get to the table.

While they're doing that, I'll mention, if you are here in the audience and you'd like to make a public comment, we have those blue cards.

They're out on the table in front. Please fill one of those out, get them to our IEPR team, and they'll bring them up here to me. That's how we know that you'd like to make a comment at the end of our workshop.

And I also want to welcome Ken Rider, who is the Advisor to Chair Hochschild, to the dais.

Thanks for joining us.

All right. Let's give folks just a second to get settled in, and then we will -- yeah. So just give us about 60 seconds, and then we'll jump into this panel.

(Pause)

MR. GUNDA: Thank you. Good morning, Commissioners and representatives from CAISO.

Thank you so much to the speakers for being here today to help me kind of go through this panel on planning for deep decarbonization.

So I'm Siva Gunda. I'm the Deputy Director for the Energy Assessments Division of the Energy Commission. And I will kind of help moderate this panel.

So the format would be for each of the panelists to go through their presentations and some prepared remarks. And as the presentations go, from the dais, if you have any questions, clarifying questions, please feel to ask them. I have some prepared questions towards the end, just general questions for all the panelists, as well as specific questions that may come up as we go.

So with that, I will introduce each panelist before they speak. So some of these bios are much longer than mine, so I'm going to take my time going through this.

So the first presenter will be Dr. Zachary Subin from E3. So Dr. Zachary Subin studies the economic feasibility options for climate mitigation and policy implications of large-scale change in the energy system. He's skilled at building computational models and communicating technical information to diverse audiences. Zach is currently using E3's pathway model to analyze deep decarbonization trajectories for California.

Zach joined E3 in 2016 with over eight years of previous experience in climate change science and policy. Zach previously worked at LVNL and Princeton University where he collaborated with world-class scientists to improve global climate models and a panel of expertise in modeling and impacts of climate change and land ecosystem.

Zach, it's yours.

MR. SUBIN: All right. So I'm going to talk us through, primarily, our work for the CEC that we published in 2018 and, in that terms, some other recent studies with the focus on the role of electricity in decarbonizing the entire energy system.

So first, kind of the big-picture view of economy-wide decarbonization in pathways.

So our 2018 study examined ten different scenarios to reach, at that point, the, you know, kind of policy frontier of 80 percent emission reductions by 2050. And that passes through the intermediate goal of a 40 percent emission reduction below 1990 levels by 2030. And you can see, we analyzed three different categories of scenarios.

So the reference scenario was sort of a business as usual pre-2016 policy. And then we have an SB 350 scenario which is sort of explicit known policy commitments. And then that's contrasted with the mitigation scenarios in yellow which show much deeper emission reductions. And of the ten scenarios that we evaluated, the high electrification scenario was found to be relatively low cost and low risk.

So we've identified four pillars of decarbonizing the energy system. There's a slightly different version of the pillars than you might have seen but focusing on the energy system as a whole. So the left two pillars have to do with energy demand. Energy efficiency and conservation in the broadest sense includes things like light bulbs, all the way to building apartment buildings near transit. Electrification, you know, the big ones there are heat pumps in buildings and zero-emission vehicles. And then on the energy supply side, we have low carbon electricity and then other low carbon substitute liquid and gaseous fuels, which could be biofuels, or they could be derived from electricity to make hydrogen or synthetic hydrocarbons.

So one of the big features of the 2018 study is that we excluded purpose-grown crops and forests, which we determined to be an environmental and technologically risky strategy.

And because we did that, that kind of leads to more heavy reliance on renewables and electrification to make up the difference as compared with some of the previous studies, you know, five or ten years ago, reading the deep decarbonization literature.

We still do use California's population weighted share of residue biomass. And that allows us to minimize the use of more expensive substitute fuels, like the electrolytic fuels.

The high electrification of vehicles and buildings leads the way for even more challenging sectors. So you can see that buildings and light-duty vehicles are the largest sources of emissions in 2015. However, in the high electrification scenario by 2050, we've eliminated nearly all of the emissions from those sectors. And that leaves room for some remaining emissions in more challenging sectors, like industry, both combustion and non-combustion, off-road transportation, and then non-combustion emissions from waste and agriculture.

So if we look at that on a timeline perspective, you can see that there's really a rapid acceleration of action that we need to meet the 80 by '50 target. So I've highlighted on all of the measures the ones relating to electrification and you can see that, you know, our emissions are now just coming to the 1990 levels. And so as we exceed historical progress in emissions reductions, the last two in this scenario reach something like 50 percent of more of sales of light-duty vehicles and building appliances to be electric by 2030 and reaching 100 percent of sales by about 2035 to 2040. So as I mentioned, that's a, you know, significantly, you know, faster rate of progress than historical.

And it's important to emphasize that that's to reach the 80 by '50 scenario. And carbon neutrality in 2045 would require either accelerating those measures further or identifying additional measures.

So now I want to pivot to the role of electricity in that timeline in achieving all those emission reductions.

So we isolated the emission reductions from electricity in 2050 in the high electrification scenario. And you can -- you start on the left with the blue bar being the SB

350 scenario, which is approximately kind of extrapolating current known policy commitments. And then further emission reductions in electricity are actually smaller than the additional emission reductions we expect to get from electrification. So electricity is doing even more work by decarbonizing other sectors than further electricity decarbonization with the existing loads. That's associated with a rapid growth in electric loads and generation post-2030. So through 2030, efficiency and electrification roughly balance. And then post-2030, we see large growth, especially in transportation, which is the largest source of electrification loads.

And the existing strategies that we're using to decarbonize electricity of wind and solar, flexible loads, and starting to see more batteries, these provide low-cost GHG reduction, and that's why we rely heavily on them in these scenarios. But simply scaling up these strategies don't get us all the way to zero emissions in electricity. And you can see this marginal abatement curve in electricity we put together in 2018. The sort of sweet spot in the high electrification scenario was reaching about 95 percent decarbonized electricity. And, you know, as wind and -- or as solar and batteries continue to get cheaper, that line will get pushed to the right a little bit, you know, as we've seen in the last year or two. But without a new firm zero-carbon resource, we don't expect, you know, to be able to get all the way to zero.

So in conclusion, efficiency and electrification are identified as low-cost and low-risk pillars of energy decarbonization. They can be done with existing technology in buildings and vehicles and at, you know, a very high level of efficiency. And the limited sustainable biofuels that have should be targeted towards high-value uses that are difficult to electrify or otherwise substitute, supplemented by electric fuel -- electrolytic fuels and CCS, so we're talking off-road transportation, industry heating and, potentially, backup electricity generation.

Electricity serves as the lynchpin for decarbonizing the rest of the energy system. And we can get to 90 to 95 percent, maybe even a little bit higher, decarbonized electricity by scaling up current approaches but we need an additional option if we were to get to 100 percent decarbonized electricity generation. That could be one of any number of options, including using biomethane or hydrogen in gas turbines, it could be nuclear CCS, or it could be advanced long-duration, you know, multi-day storage. And until that option becomes available it's critical to maintain sufficient from capacity which likely means, you know, keeping much of the existing gas generation fleet around in California.

Because electrification is consumer facing, in summary, California, really, in order to make sure we get that electrification, has to prioritize affordable and reliable electricity.

Thanks.

VICE CHAIR SCOTT: Thanks. Let me see if we have some -- any clarifying questions or questions for Zach from the dais?

And, actually, I have one back on slide 11 for you where you mentioned that until the additional options are available, we need to maintain the sufficient firm capacity. Can you unpack that just a little bit more for us?

MR. SUBIN: Sure. So that's, yeah,

that's the subject of ongoing work. E3 has published a number of studies on that, you know, including a study on kind of long term, you know, resource adequacy in California earlier this year, and is now working with the CPUC to look at this question in the context of their IRP. And, you know, really it has to do with these sort of occasional multi-day events where you have low levels of wind and solar.

And you may, you know, even if you have some, you know, eight-hour storage, you don't have enough energy to keep charging the storage to get you through that event, so you need some sort of additional energy supply that you can call on, and right now that looks like gas turbines. You know, it wouldn't necessarily have to be natural gas, but some sort of chemical that, you know, that has those properties, or you can imagine other technologies that would fill that role.

COMMISSIONER MCALLISTER: So right at the end you mentioned sufficient affordable electricity. What about a sufficient affordable electrification? You know, I mean, that's a big investment. And where it's relatively easy in our new buildings, but our existing buildings are -- you know, I think we all accept that's a challenge, right, to get into those buildings. And not just electrification, per se, but flexible, you know, demand.

And so I guess what are your thoughts about how that fits in, how critical that piece is, you know, sort of, you know, maybe prioritize, you know? How much policy effort should go into that versus the supply as you've described it?

MR. SUBIN: Um-hmm. Yeah. A couple points.

First, I would say that, you know, it should really be thought of as a transition. So there are capital costs associated with the transition. But once you electrify, that affords you lower fuel costs than we would expect with substitute liquid and gaseous fuels used over the long term in buildings.

We do think that we need to retrofit a lot of the existing buildings to meet the 2050 targets. And there could be different ways of approaching that. Some of our other work this year showed that if you electrify space heaters in existing buildings that have air conditioning, that there's little or no incremental costs associated with that relative to buying an air conditioner plus a gas furnace.

But, yeah, I think there's a lot of attention that's going to be -- you know, the policy is going to need to bring to bear to that question.

MR. ROTHLEDER: Kind of related to the earlier question, and that is if -- I guess kind of the expectation is that the gas resources are kind of a bridge type of fuel resource. But you're kind of painting the picture that even out to 2050, you're -- it may be necessary and it may be economic to maintain the gas fleet to maintain reliability and affordability.

So I guess it may, I guess, highlight additionally what those gas resources will be using as fuel at that point in 2050, and then what is their capacity factors? Is it a different kind of set of circumstances than what we see today, especially in light of those increasing loads that will start out in about 2030?

MR. SUBIN: Yeah. We do see, you know, a

really different story in, you know, the gas infrastructure and the distribution system and, you know, serving buildings versus the transmission system that's serving electricity in industry. So we do see the potential need for, you know, the large pipes to stay around.

In our scenarios we see that the gas turbines would stay around with a pretty low capacity factor, you know, in the single digits. So, you know, that still could be viable. You know, if there's some sort of, you know, capacity payments to them, it still could save a lot of money compared to other options.

VICE CHAIR SCOTT: I have -- okay. I have another question for you as well.

So on the reliability component, if everything is electrified, as you have rightly noted, that is going to be a huge component of it, in addition to the affordability. Do you have a sense of what types of things we need to be looking at or thinking about to ensure that reliability is built in as we're going that direction? That might be a little bit outside of your study. If it is, that's okay.

MR. SUBIN: Yeah. Do you have a more,

kind of a more specific --

VICE CHAIR SCOTT: Well, you know, I'm just wondering for -- and I'm not really a reliability coordinator. Maybe this is a better question for Debbie or Caitlin. But I know that there's a lot of things that go into -- and maybe -- or maybe for ISO -- into reliability in ensuring everything's balanced and power is where it needs to be when it needs to be there, and all of those things. And I just wonder, as we shift over, are the considerations that we're using today, as we shift to having more things electrified, are the considerations that we use today adequate enough to kind of cover having more and more and more things become electrified? I'm not sure if I'm articulating that very well but --

MR. ROTHLEDER: No. I think you are. And if I could just try to highlight that those new loads, to the extent they become resources or opportunities for helping balance the system, I think that's how you help navigate it.

And I think that's kind of the question is are those new loads and how do you maintain reliability, that balance, in light of the new capabilities of the resources and demands that will exist at that point?

MR. SUBIN: Yeah. And I'll just kind of say, there's different conceptions of reliability, perhaps, on the bulk system scale and the distribution scale. So, you know, certainly we're seeking, you know, this week, you know, continued focus on the local scale. You know, and pathway is -- we're kind of looking at the bulk system scale. So, you know, you have enough storage in these scenarios to provide your kind of hourly balancing. And then, you know, we assume you have enough, you know, firm capacity you can call upon for your longer-term energy needs.

COMMISSIONER MONAHAN: Zach, as you note, your analysis didn't assume any new zero-carbon resources. Have you started to explore, I'm particularly interested in hydrogen and fuel cells? And there is some new analysis that indicates it's possible in the next 10 to 20 years, fuel cells will become economically viable, and so will hydrogen and using our excess renewables to generate hydrogen as theoretical value.

Have you -- has E3 started to do any analysis around that?

MR. SUBIN: We're starting to. You know, we've started to look at that in some other jurisdictions. And, you know, really, if you're using, you know, biomethane or hydrogen in CTs (phonetic) to serve as that reliability resource, the scenario really doesn't look that different than if you're using natural gas. It's really a small amount of energy that's, you know, very high value in certain hours.

And, yeah, I had another point, but I'll come back to that if I remember.

COMMISSIONER MONAHAN: Well, and I guess similarly, I know you've done some analysis around V2G. That could be another zero-carbon resource that is available.

MR. SUBIN: Yes, although I'm not sure if -- you know, I think we're starting to look into that. I'm not sure if you'd want to rely on that for one of the multi-day energy insufficiency events.

The other thing I'll mention about hydrogen is, you know, if you're really talking about using this resource, you know, one week a year, one week every few years, it may make sense to have a cheap capacity resource, like a combustion turbine, rather than a fuel cell which is much higher efficiency but much higher capital cost.

VICE CHAIR SCOTT: Okay. I know we are working to get our next speaker onto the WebEx.

Oh, please, go ahead, Ken.

MR. RIDER: Oh.

VICE CHAIR SCOTT: And then we might, after that, we might just jump so that we can kind of keep on time, but please go ahead.

MR. RIDER: Yes. So just to qualify what I heard you say about the economics of keeping around gas pipes and gas turbines, is that relative to the, you know, the 80 percent target? Because, obviously, you know, SB 45 -- or SB 100 is putting new limitations on what we have access to; right? So if you have 20 percent capacity to use carbon emissions, it's different if you now suddenly have to sequester or do something more if you do burn that gas.

So is that answer qualified around the kind of zero-carbon world or is more just the, I guess, SB 32 kind of constraint answer?

MR. SUBIN: I mean, I would say it's not going to change that much in the zero-carbon world because you're talking about, really, the last few percent of generation, you know, that you would have to either offset or use as zero-carbon fuel. And you know, we don't really see, you know, if you just use, you know, solar and battery, it's pretty outrageously expensive because of the, you know, very large amount of overbuild that you'd have to incorporate so that it doesn't seem like that's going to be more cost effective. But maybe, you know, some other option, you know, some sort of advanced type of battery, you know, could play that role.

VICE CHAIR SCOTT: So with your indulgence, we'll go just a little bit out of order, and we will hear, Debbie, if you're ready to go next, we'll hear from you next? And then when you're done presenting, hopefully we'll have Melanie on the line and go back to scenarios.

MR. GUNDA: Yeah. Ma'am, before Debbie jumps in, I'll just take the opportunity to introduce Debbie.

So the way we tried to structure this panel was for Zach and Melanie to provide some scenarios on how to get to the zero -- net near-zero carbon electricity pathways, and for Debbie and Caitlin to kind of talk about, a little bit, on the solutions' side and the impacts and what to think about in that situation.

So with that, before Debbie starts, Debbie is an independent consultant working on utility integration of wind, solar and distributed energy resources. She has 28 years of experience in renewable energy and recently left GE Energy Consulting to focus on challenges and solutions to 100 percent clean energy.

Prior to GE, she spent 16 years at the National Renewable Energy Laboratory, during which time she was sent to the Hawaii Electric Company to work on wind and solar integration. She's the immediate past Chair of IEEE PEs Wind and Solar Power Coordinating Committee, and a member of SCC 21 which oversees the IEEE 1547 standard. She has a BS in Electrical Engineering and Physics from MIT and a PhD from Stanford in Applied Physics.

With that, Debbie, it's yours.

MS. LEW: Thanks so much, Siva. And thank you very much for inviting me to be here.

I’m very honored to be able to talk with you. And I’d also like to thank WIRA for supporting my presence here today.

So I’m going to talk here today about reliability and maintaining reliability in a low carbon grid. So I’m going to be talking about a lot of the stuff that Mark Rothleder -- what keeps Mark up at night.

I break reliability into different timeframes. And so what’s shown here is sort of from the very short seconds timeframe out to the long-term years’ timeframe. And in the very short seconds timeframe the things that we worry about here are very high penetration levels of invertor based resources because PV, batteries, fuel cells, these are all invertor-based resources, and they all act differently on the grid than conventional synchronous machines do. And so that has its own challenges and opportunities.

In the medium term, I guess you can’t really see this, it doesn’t matter, we’re concerned with the whole system balancing issues, the diurnal mismatch of supply and demand, curtailment, things like that.

And in the long term, resource adequacy and the seasonal mismatch of the supply and demand, and those periods, those multiple-day periods, that have already been mentioned of low wind, solar, hydro, and the need to still try to meet our loss of load expectation metrics is the big challenge.

And I think most people in the industry would agree that 100 percent clean energy is possible with today's technology and what we know today but it might be every expensive.

So the question is: Can we do this smarter and cheaper and in the next 25 years?

Now I'm not going to talk so much about the system balancing medium-term piece because I think we have a handle on what to do there. Even though it is challenging, we know solutions; California is undertaking those actions.

The system stability piece, I'd like to talk about because I feel like we do not understand these questions very well. And the resource adequacy piece, I'd like to discuss because these are big challenges, as was just discussed, in terms of finding commercial cost effective solutions.

So resource adequacy. We all know electrification is essential but we need control, or price signals, or you can make your problem much worse. You saw how much electric growth is going to be growing. I know when we got our electric vehicle, our electricity usage doubled. We need to have some really good signals or controller you can have issues with in terms of trying to balance the system.

Optimizing and coupling across energy sectors is going to be a big challenge for all of us. You know, just think about the difficulties we have in integrating across the gas and electric sector. And then think about expanding it to the transportation and heating and other sectors.

Obviously, we need to control both sides of the supply and demand balance. So we're used to, today, thinking of demand as something fixed. And we control a bunch of generators to meet that. We're going to need to control both sides of that balance in the future. And then the seasonal mismatch and the multiple days in a row that can crop up, there's certainly potential solutions, as was just discussed with biogas, with hydrogen. And there are ways that could possibly address these solutions and we need to, again, make them cost effective.

So I'd like to talk about what I think -- these are some of my out-of-the-box musings on a potential future.

So, you know, obviously, these are really difficult problems. I think it requires some really out-of-the-box thinking to try to address that.

To me, the big lever, the big low-hanging fruit, is controllable or price-sensitive demand. And I think we're going to need to start moving towards dispatching demand.

So we all know prices are a really powerful signal; right? If you wanted a four-hour battery, maybe you should think about time-of-use rates. If you wanted more peakers, maybe you should think about coincident peak demand charges. We can do a lot with pricing, but prices alone are not enough information; right?

So right now, California is doing time-of-use rates for all customers and that's awesome. And people are thinking about moving to day-ahead pricing, and then maybe even getting more load exposed to real-time prices. But as you think through that, you know, you have a whole lot of load chasing real-time prices, you could actually make some of your balancing problems worse. The prices alone are not enough information. You need to know quantity as well.

Even chasing time-of-use rates might cause large step changes in terms of when those peak times start and when they stop. So dispatch and the extent to which we can dispatch demand can help smooth that.

And I'd like to suggest, the way that the industry has moved from the idea of must take wind and PV, you know, whenever wind and PV shows up we just take it, to dispatching wind and PV, we may want to think about dispatching more of our demand instead of demand today, which is really must give. You know, whatever shows up is whatever we serve.

And along those lines, I'd like to bring up the whole metric that we use. So our loss of load expectation on the bulk power reliability system today is one day in ten years. And is that -- is that needed? And I think these are some provocative questions but I think it's worth thinking about these things as we move to these challenging futures.

You know, the distribution system is responsible for much more of our outages than the bulk power system. So could we do with less loss of load expectation on the bulk power system?

And then is it necessary for all customers? Maybe some of us would be willing to pay less to have a two-day-in-ten-year loss in load expectation service, just like we have fast and slow internet today.

And then today, when we do our planning, we treat demand response as a generator. And in the future, we're going to have all these electrified loads, as Zach was mentioning, that are controllable. So what if we start thinking about that kind of demand response, not as a generator anymore but more as demand that's price elastic? And so the question during the peak periods or the risky periods becomes how much do I want to pay for some number of megawatt hours during this particular time? This could potentially eliminate a lot of the issues around demand response, like what's your baseline and is the demand response there when I need it, and things like that?

I would, you know, extend this to think about a future where maybe at your system peak your generation is fixed. You've only got so much wind, so much solar, so much hydro, and however you positioned your storage at that time. And so what determines demand that gets served is how much folks are willing to pay at that moment in time. And if you have a significant amount of price-elastic demand, and we will have more and more price-elastic demand as we electrify more and more of these sectors because transportation, heating, they sort of have inherent flexibility in them, if we do this, the loss of load expectation concept sort of starts to go away, and maybe it doesn't really hold anymore. So these are just some thoughts.

I think I'm running out of time. I was going to talk about some lessons learned worldwide. But, basically, there's a lot of really cool best practices out there that people are doing. People can read this at their leisure.

I next want to talk really quickly about system stability. This was the other piece of the challenge that I think we don't have answers to.

So this is not a smart invertor issue, not a Rule 21 issue at all. The issue here is that, you know, basically, all the invertors that you know about on the grid today are grid-following invertors. They require system strength to operate stably. So what they do is they read the system voltage and frequency and they spit out current that matches that.

So you can think about, you know, if all the electricity in the Western Interconnection came from invertors it wouldn't work with these invertors because there's no voltage reference signal for them to read. But it turns out you start running into problems where before you get to 100 percent. And this is why Ireland caps their invertors on their system, the penetration level, it's a different metric but they cap it at 65 percent.

And this -- you can run into problems before you get into -- you can run into problems when you have high invertor penetration just in a pocket of your system. And this graphic is showing ERCOT, a wind plant, going unstable because of this type of issue.

And I'll even add that when you have even moderate annual average penetration levels of invertors on your system, that can translate to very high instantaneous penetration levels.

So, you know, stability, when we talk about system stability, there's a bunch of different facets to it. I'm not talking about frequency here because I don't think we're going to have frequency issues in WECC for -- I mean, that will take a while before we have frequency issues in such a big interconnection.

But these small signal stability issues and these transient stability issues, these are more localized. And these are things that we don't understand very well.

So what options can help? What are people doing around the world to try and deal with this?

So in South Australia what they're doing is they're just running some out-of-merit thermal synchronous generators as reliability must-run to maintain grid strength. Obviously, that's not economic for, you know, trying to decarbonize.

Fine turning controller settings is something that, you know, all of the invertor manufacturers are improving their invertors. When there are difficult situations, people go out and they try to fine tune settings to make them work. Also building more transmission infrastructure can help alleviate these kinds of problems.

Now these three things, they don't get you to 100 percent and they don't get you to really high levels of invertors but they can help you along the way.

So the two competing philosophies right now as to what's going to help us with really high levels of invertor-based resources are the synchronous condenser option, maybe we can synchronous condenser our way of this. That's a machine that provides that grid strength, the synchronous machine, but it doesn't provide power and it doesn't burn fossil fuel.

Or there's a technology that is out there called grid forming invertor technologies. And the research community is studying now sort of what different types of technologies there are. You know, we need to determine how this is going to interact with the grid, how we would interoperate them, what kind of performance we would want with them. We would then need to commercialize this technology.

I will also add that these things all interact, as I mentioned before. And this little graphic on the right is from Texas. So Texas, they put in -- ERCOT put in two synchronous condensers in the Panhandle to try and alleviate this problem. It could lead to some other problems, as shown here. So there's a lot of interactions that have to be considered and studies in this.

And with that, I'll end my remarks. Thanks.

VICE CHAIR SCOTT: Thank you so much, Debbie, for being here. You always provide such excellent food for thought and really complex topics, but in a clear and understandable way. So I'm delighted to have you as part of the dialogue.

I think what I've heard is let's finish the press and then we'll jump in with a whole bunch of questions. And there's a list of questions up here for you.

But let's shift to Melanie, who I believe is on the phone now.

MS. KENDERDINE: Hi.

VICE CHAIR SCOTT: So I'll let --

MS. KENDERDINE: I am on the phone.

COMMISSIONER SCOTT: Welcome. We're so glad to have you. Let me let Siva introduce you and then, we will do your slides for you from here.

MR. GUNDA: Thanks, Melanie, for joining the call. So, Melanie Kenderdine is a principal of Energy Futures Initiative, EFI, and a nonresident Senior Fellow at the Atlantic Council. She is also currently a visiting Fellow at the Energy Policy Institute at the University of Chicago.

Ms. Kenderdine served at the Department of Energy from May 2013 to January 2017 as the Energy Counselor to the Secretary concurrently as the Director of DOE's Office of Energy Policy and Systems Analysis. She was responsible for the analysis and policy development in DOE's annual review of Renewable Fuel Standard Program requirements, energy innovation and climate change. She produced two installments of the quadrennial energy review and helped conceive of and develop the energy security principles adopted by G-7 leaders in 2014.

As energy counsel to the Secretary, Kenderdine provided key strategic advice on a range of issues, including mission innovation, a 22-country plus EU initiative that supports transmission of clean energy RD&D, North American grid integration and security, and modernization of the strategic petroleum reserve.

Prior to her service at DOE, Kenderdine helped to establish the MIT Energy Initiative and served as its Executive Director for six years. Kenderdine also started the C3E Symposium series, a joint MIT/DOE program to support the careers of women in clean energy with cash prizes. She still serves as DOE C3 ambassador.

Before joining MIT Energy Institute, Kenderdine served as the Vice President of Washington Operations for Gas Technology Institute from 2001 to 2007.

From 1993 to 2001, Kenderdine was a political appointee in President Bill Clinton's administration, where she served in several key posts at DOE, including Senior Policy Advisor to the Secretary Director of the Office of Policy and Deputy Assistant Secretary for Congressional and Intergovernmental Affairs.

I hope I did that right. So, thank you.

MS. KENDERDINE: You did. You did good, although I need to edit my bio.

So, anyway, thank you. So, should I begin?

MR. GUNDA: Yeah, please go ahead.

MS. KENDERDINE: Okay, I'm sorry. And my apologies, we are at a UN Climate Week in New York City and it is absolutely crazy here.

And so, we did a study of deep decarbonization in the State of California. It was -- if you go to slide two, it's called Optionality, Flexibility and Innovation, Pathways for Deep Decarbonization.

If you go to slide two, okay. And we are, EFI is a not-for-profit corporation. We pride ourselves on, as we did at MIT, quite frankly, you give us -- we get funded to do analyses and projects, but nobody tells us what to say or do. And we pride ourselves on our independence and objectivity. And that's on the slide two.

And you can see we did have an advisory group for this study. And you can see the list of names there. We did focus on people in California as much as we could. And so, that's just kind of the set up for this.

We did roll the study out, if you go to slide three, and here people are going to find out how I animate slides. Our study approach was to look at 2030 and 2050 targets. We selected a 2016 baseline. California uses a 1990 baseline. But let me give you an example. When we go through this, I'll give you an example of why that was bothersome to us, just because so much has changed in the technology space since 1990.

So, we used a 2016 baseline. And if you hit the cursor, you see industry coming up there. And the gray is actual emissions in 2016. One thing else -- one other thing I'd say about 1990 versus 2016, total emissions are almost exactly the same. Within the sectors, the emissions are different. Okay, so, that's why we were comfortable on total emissions. The sectoral emissions are very different.

There you see industry, okay, and you've got a 40-percent reduction from 2016. That's the blue bar. And you've got an 80-percent reduction is the green bar.

So, an industry total, if you -- it's 50/50 here. Those are the emission reductions you need from industry.

If you click again, those are your residential buildings and your commercial buildings. So, you need 31.4 million metric tons reduction from buildings in total. We did divide it between residential and commercial.

The transportation, you need 135 million metric tons between now and 2050. Electricity, you need almost 55 metric tons, agriculture at 27. And nonindustrial high GWP, which we ended up not looking at, high industrial, nonindustrial high GWP wasn't even a category in 1990. That's why I said, okay, so that's why we elected to go with 2016.

And, but here, if you click, to meet the 80-percent target, you need 243 million metric tons of reductions. 71 percent of your total emissions in 2016 are needed from the most difficult to decarbonize sectors. And I'll say a little bit about that in a minute.

Okay, click to the next slide. These are

-- this is not a policy study. We did not make recommendations. We assumed California's policies. While we were in the middle of this study, SB 100 passed, so that's 60 percent renewables. If you click 60 percent renewables for electricity by 2030, click to SB 100 -- or, SB 32, sorry, 40 percent below 1990 levels. These are the policies that guided us. The Executive Order: economy-wide emissions reductions 80 percent by 2050.

If you click again, SB 100, a hundred percent zero carbon electricity.

Okay, click again. We looked at SB 1275, one million zero-emission vehicles by 2023 and 5 million zero -- click again, 5 million ZEVs by 2030.

Okay, so those were the policies that guided our analysis. And what we asked, based on a 2016 baseline of emissions by sector: Can California meet these goals? And what technologies does California need to meet these goals?

Okay, so, click to the next slide, please. These are sectoral emissions in California, in 2016. Industry is 23 percent.

Transportation is 39 percent. That is unusual. The rest of the country, transportation is about 28 percent of the emissions. Where California is better is in electricity was at 16 percent of the emissions.

I have now gone ahead of myself. Hold on one second, let me get back to that. Buildings is 9 percent of the emissions in California. And agriculture is 8 percent of emissions in California.

What you see and what we found in California is that some analyses that we saw embedded electricity into buildings. Okay, but we have separated them out based on California numbers. And this is how the emissions break out by sector.

So, these were our targets. Can you meet these sectoral targets? And we did an analysis that assumed a proportionate reduction in emissions. Okay, if you've got to meet an overall target, okay, net zero or 80 percent emissions reductions by 2050, we allocated those emissions reductions to each sector based on the percentage that they contributed in terms of emissions.

So, click to the next slide. Okay, and this is what -- the heading on this is wrong. This is -- the heading should be -- this is Greenhouse Gas Emissions Reductions Potential. And it's in million metric tons CO2 equivalent. And we looked at these by sector. Did, basically, mini models for each of these based on a range of factors. Cost, penetration, et cetera, et cetera, and turnover of stock, all of those things, and looked at these by sector.

So, each of the bars that you're seeing here are technologies and what we think that you could achieve in emissions reductions with those technologies by 2030.

Okay, is that -- is everyone -- is that understood?

COMMISSIONER MCALLISTER: Yes.

MS. KENDERDINE: Okay, so what I'm going to show you here, okay, so in electricity, click through to the next one. Okay, electricity by far the biggest reductions by 2030 was from natural gas combined cycle with carbon capture and sequestration. So, you get 17.7 million metric tons if you capture the carbon from NGCC plants. And about 50 percent of your in-state power generation in California is natural gas.

Renewables, with up to 10 hours' storage is 8 million metric tons. So, it's less than half. And I don't know what 10 hours' storage is, quite frankly. I'll say a little bit more about that in a minute.

The -- you go click the next to transportation. And this is by far, and I think it's very relevant to what's going on in California right now, and the Trump Administration all wanting to take away California's authorities to set mileage standards.

What we saw in our analysis, by far the biggest emissions reductions you get by 2030 would be from efficiency, CAP A standards. And that's the biggest of any technologies and at 22 million metric tons. We have electrification of vehicles in here and that is 9.1 million metric tons. So, it's not insignificant, but it's not nearly the largest.

Your Low-Carbon Fuel Standard is important for reducing emissions from light-duty vehicles there.

If you click again, you go over to

industry. Again, in industry by far the most significant potential reductions by 2030 are from carbon capture and sequestration from industry. I'll say a little bit more about that. But industry is, generally speaking, the most difficult to decarbonize, probably next to agriculture, which doesn't typically get looked at in an energy analysis, but we did look at agriculture.

If you click again, okay, you go over to buildings. Energy efficiency gets you the most reductions in emissions from buildings. Combined heat and power, I would assume that's going to be largely for commercial buildings, combined heat and power. Electrification gets you a little less than half of what efficiency gets you. That's not to say that electrification is not important and I know that there are policies moving in that direction, but electrification in a 2030 time frame doesn't get you nearly as much as just flat out efficiency does.

If you click again, okay, and we are at -- this is agriculture. And the only significant emissions reductions that you can get in agriculture is using -- is capturing biogas from dairy, and landfills, et cetera, et cetera, and using that to make either renewable gas or other fuels, and from biogas. And so, that's the only significant technology that we could find in the agricultural sector by 2030.

So, I have this one in twice, okay, for some reason. So, let's skip through that. Just if I didn't make the point enough, okay. Skip through that slide.

Okay, and are we now on the slide that says "Sectoral Greenhouse Gas Emissions Reductions"? Are we there?

COMMISSIONER SCOTT: Yes.

MS. KENDERDINE: Hello? Yeah, yeah, okay.

COMMISSIONER MCALLISTER: Yeah, we are.

MS. KENDERDINE: Okay. So, if --

COMMISSIONER MCALLISTER: Hang on, Melanie.

MS. KENDERDINE: Yeah.

COMMISSIONER MCALLISTER: And maybe just speed it up a little bit, we've got one more speaker and some questions, and stuff.

MS. KENDERDINE: All right, okay.

COMMISSIONER MCALLISTER: So, we'll have

questions for you as well.

MS. KENDERDINE: Okay. So, let's go through this transportation, again 39 percent. The top two pathways get you 40 to 44 percent of the target. This does not assume growth to 2030, okay. So, it's just to give you an idea.

Industry, the top two pathways get you half of the way there. Electricity, the top two pathways get you to 100 percent of the target. That is -- remember, that's gas with CCUS. Buildings: The top two pathways almost 93 percent of the way there, almost 100 percent. Agricultural: The top two pathways get you 35 percent.

So, okay, I'm going to skip through. I think that, yeah, let's go to -- skip through the next slide. Okay, and go to the slide called "Challenges with Integrating Intermittent Renewables." Okay, are you all there, yet?

COMMISSIONER SCOTT: Yes.

MS. KENDERDINE: Okay, so just click on it, okay. And I believe what you should be seeing coming up are numbers. What this slide is, these are data. It's not modeling, it's nothing like that. These are data from every day in 2017, wind and solar generation. Wind is blue, solar is orange or red. And the numbers that you saw coming up are the numbers of days in 2017 where there was little to no wind generation in the State of California.

So, if you click now, that's 90 days with no wind, one-quarter of the year. And the circles that are coming up, you have 10, 11, 12, 5, 6, 7 days in a row with now wind. So, if you just keep -- and I've just circled them. So, that's one thing you have in California that's problematic from a storage perspective.

If you go to the next slide. Seasonal variation in solar and wind in California. Okay, and if you click on the meter, click once, metered solar generation in California was 1.5 terawatt hours in January and 3.2 in June. You have the same pattern. The delta there is 1.7 terawatt hours, if you click.

Click over to wind. You have the same pattern in wind, .6 terawatt hours in January, 2 terawatt hours in June. Click again. That delta's 1.4 terawatt hours. The total delta between -- click again -- between winter and summer in wind and solar generation in California is 3.1 terawatt hours. That is huge. For those of you that don't reside in the terawatt hour world, an enormous, enormous difference seasonal.

So, you've got 90 days with no wind. You have 10 days in a row with now wind. And you have the enormous differences. And hydro peaks in the same way, too. I've got a slide here on hydro. Let's skip through that. The next slide, just skip through it. It's just showing you huge differences when there have been droughts in California. And hydro has the same pattern as wind as solar, peaking in the summer and troughing in the winter.

I'm going to skip through all of these. Skip through the industry. This is just showing you industry's difficult and showing you where your sequestration sites are, and where your oil and gas reservoirs are, your saline formations in California, so that it is possible to sequester that carbon if you capture it from industrial sites.

So, quick through, again. There is a tax credit for capturing and sequestering carbon, and for dedicated geologic storage. It's up to $50 a ton of C02. And if you click through again, I've just got the numbers there. The expanded 45Q tax credit. The first of a kind cost. Click through again. Over on the left, fertilizer, biomass, ethanol, natural gas processing are all substantially lower costs to capture from your industrial sector. You're the number one manufacturing state in the country, the first of a kind costs are far less than the tax credit you get for 45Q. That is the point that that is making there.

So, let's click through biogas. You've got good biogas sources and that's the only way you can capture
-- that's the only pathway we see for agriculture.

And I'm going to say one other thing and we can skip the rest of the slides. It is that on the 90 days with no wind, et cetera, et cetera, the 7 days in a row with no wind, California, it's generally speaking, your lithium ion batteries are four hours of storage. We do not see by -- certainly, by 2030, major changes in the duration of storage for wind and solar. And so, it's four hours of storage and you're going 10 days in a row with no wind. And so, that's highly problematic.

Ultimately, we think -- not ultimately, we do think you need fuel to run your system. Right now that fuel is natural gas. To run your system reliably with a lot of wind and solar on the system. Right now that fuel is natural gas. We think at some point in the future that could be hydrogen, produced with wind and solar, but that's a long way off and you can't use all of the current infrastructure for that hydrogen, or much of the current infrastructure.

So, I'm going to shut up. I know you all are in a hurry, so --

(Laughter)

COMMISSIONER SCOTT: This is an excellent presentation. Thank you so much for taking the time call in, especially during a busy climate week, I know, in New York.

We will go up to our next presenter and then we'll come up to the dais for questions.

COMMISSIONER MCALLISTER: So, Melanie, if you could hang on the line for a few minutes and, hopefully, stick around for questions. It shouldn't take too long.

COMMISSIONER SCOTT: Yes, please.

MR. GUNDA: Thank you. With that, I would like to introduce Caitlin Murphy. Caitlin Murphy is a Senior Energy Policy Analyst in the Economics and Forecast Groups within the National Renewable Energy Laboratory. Her expertise lies in evaluating how energy policies and technology innovation impact the evolution, operation, and environmental impacts of the U.S. energy system through quantitative analysis methods.

She has a BS in Earth, Atmospheric and Planetary Sciences from MIT and a PhD in Geophysics from Caltech.

With that, it's yours.

MS. MURPHY: Great. Thank you, Siva. And thank you, everyone, for this opportunity to present to you on behalf of the broader Electrification Future Study, or EFS team. This presentation will have a slightly different style than the previous studies because at its core the EFS has not taken a deep decarbonization perspective.

So, what I tried to do in the slides is really highlight for you the modeling tools and the datasets that we have generated as part of this EFS study, which I hope will be helpful for you in your consideration of the IEPR and your broader planning efforts.

So, just as a quick background, the Electrification Future Study, or EFS, is an NREL-led collaboration. It's a multi-year study that was sponsored by the U.S. Department of Energy. And it's being executive with NREL in the lead, but with many external and other National Laboratory research partners.

And, really, what the study is seeking to do is address the high-level questions of how much electrification might we expect in the future and how do we plan for that electrification?

So, to approach those really large research questions, what we've done is broken them down into smaller chunks to look at sort of in series. So, the first two circles here are what the presentation today will focus on. The first one is what electric technologies are available now and how do we think they might advance over time. So, this is both in terms of cost and performance of the key electric technologies. So, electric vehicles we've talked a lot about today. Air source heat pumps is another key technology. So, we really spin a variety of the energy sectors.

The second question here is around energy consumption. How might electrification impact electricity demand and use patterns?

These are the two that I'll be focusing on today, but I just wanted to note that we did just recently complete the first phase of analysis for the following three research questions, which are really around how the grid might transform in response to those electrification changes? What the role of demand side flexibility might be in sort of being the translation between this demand side evolution and also the power sector response to it?

And, finally, what are the broader impacts of electrification around system costs, potential benefits, and also impacts in terms of emissions and other environmental impacts?

So, those three, the first phase of analysis for those three questions, we are in the process of publishing now.

Okay, just to start with a couple of definitions of the scope of our study. First, we're defining electrification as the shift from any nonelectric source of energy to electricity as the point of final consumption. So, this is just one of the pillars, for example, that was presented earlier about deep decarbonization pathways. It's only one piece of the puzzle here.

And I just wanted to point out that the reason you might see some quantitative results that aren't getting you to your goal is that this is really only one of the pieces.

The second sort of scope definition here is that we are looking at the entire contiguous U.S. energy system, so the results that are presented here will be national average values, but the analysis was performed with high spatial resolution. So, all of the underlying datasets, all of the modeling looked at California as its own entity. And even sometimes, within California, we have higher resolution. So, the results here may not be indicative of what you would expect in California, but they show kind of the various datasets that we've compiled as a result of this analysis.

In terms of sectoral coverage, we looked at the transportation, industrial, residential and commercial sectors, which accounted for about 74 percent of primary energy consumption in 2015. So, that entire box on the right-hand side there is that 74 percent of energy consumption. Everything below the solid black line is already supplied by electricity as its energy source. So, those are the parts that have already been electrified through sort of natural processes.

And the parts above it is what we're looking at. Where is the potential in that space? Clearly in buildings, which are the two right columns, they're already well on their way to being fully electrified. Again, at a national scale here.

And transportation, on the far left, represents the largest source of potential since very little of its energy is currently supplied by electricity.

Finally, our analysis went out through 2050, but we did model all of the years going out to that end date of our model.

So, I just wanted to highlight, there's just one slide here on sort of the main detail dataset that came out of the first two research questions that we explored as part of the EFS.

Here, I just wanted to highlight the results from the transportation sector and the insights that we gained from our modeling of that sector. A lot of this is similar to what's already been presented by the other panelists, so I won't spend too much time on this slide. But just wanted to note sort of the level of detail that we do have available in our datasets.

So, the three columns here represent three different scenarios for electrification. The far left one is reference. That would be sort of a business as usual trajectory.

Medium electrification is where we explored the impacts of electrification within the sectors that the lower perceived barriers to this fuel-switching component into electricity.

And then, finally, in the high electrification scenario, on the far right, that's where we looked at more transformational electrification. So, breaking down some of those existing barriers that we talked about through some of the questions after the first presentation.

So, the different rows in this chart are showing different segments of the transportation sector. And, really, these demonstrate the insights that are listed on the left side of the slide.

So, the warm shades represent where your electric technologies are taking over the sales share and, ultimately, the stock of your transportation fleet. The top two rows are the light-duty fleet. And we see a lot of potential, even under medium electrification, for battery electric vehicles and plug-in hybrid electric vehicles, in particular.

Under more aggressive electrification scenarios, we see that the vast majority of the light-duty fleet transitions over to being sourced by electricity by 2050, in particular.

We see more challenges in the medium- and heavy-duty vehicle fleets, but not ones that are necessarily insurmountable. But just sort of raises questions of where does electrification really make the most sense in these medium- and heavy-duty service demands, and where might you be looking for other emissions reductions pathways.

So, what we found is that particularly for short haul applications there's a lot of potential for electrification.

MR. RIDER: The Y-axis here, it's stock? It's number of vehicles? Is that what the Y-axis is?

MS. MURPHY: This one is -- this is sales, I believe.

MR. RIDER: Sales.

MS. MURPHY: Yeah, but we have a similar chart for stock, also.

Finally, the bottom row here is transit buses and that's where we're seeing a lot of potential under both medium- and heavy- electrification, something that you're all very familiar with, already.

And just the final bullet point here is to note that this is a sample of the datasets that are available for transportation electrification. But we did look at buildings in industry, and one of the key technologies we saw on the building side, in particular, are the heat pump technologies, which I know you're already moving forward with.

So, in terms of what this means from a grid planning perspective, the first metric that we look at is annual electricity demand. So, on the left-hand side of the chart are historical electricity consumption rates. And to the right of the solid black line is our modeled future electricity rates under the three scenarios that I just mentioned before.

So, that emerging blue wedge is coming from -- and sorry for the printouts, you won't be able to see that. But on the screen, the emerging blue wedge is the transportation, annual demand growth that's coming from electrifying both light-duty, medium- and heavy-duty fleets, as well as transit buses. You'll see that that demand growth really picks up more rapidly after 2030. This is due to both stock turnover times of your vehicle fleets, as well as the cost trajectories that we have, which have those technologies declining in cost over time. And at 2030, is really kind of a tipping point where we see a rapid takeoff of the electric vehicle fleets.

Also embedded in here is a little bit of growth from the other sectors. The reason it's a little bit more mass is because of the high efficiency associated with some of these technologies. So, as they displace maybe either less efficient electric technologies within a building, you're not necessarily going to see annual demand growth coming out of them, you're more going to see a more efficient utilization of that electricity for especially your space heating needs, for example.

In terms of the growth rates that we see in our scenarios, they are roughly consistent with some of the more rapid growth demand periods that we've seen on the U.S. electricity system. Again, taking a national look, this does pale in comparison to the chart I saw in the introduction today, with California's growth in electricity generation, so maybe nothing that concerns you guys.

But on a national scale, a lot of people look at this and get a little nervous about the pace of growth. And, clearly, it is a transition from recent years for a lot of the country.

But annual demand is not the only thing we need to think about. This is a snapshot here, showing the impact of our high electrification scenario on peak demand at a state level. So, if we just focus on the California pie chart here, the size of the circle represents the top one hour of demand across the years.

So, between 2015 to 2050, you do see growth in the size of the bubble, which shows that our peak demand is increasing as the grid is accommodating more electric vehicles and space heating services, for example.

But the shading in the pie chart doesn't really change. So, the shading here is showing the timing of that peak demand which, in both 2015 and 2050 occurs in the summer and the fall months.

In other parts of the country you do see a transition in the season when peaking occurs, which I think is an interesting challenge for those parts of the grid. But in California, we really see it can maybe classified as something of more of the same. So, a lot of peak demand, still, and it's growing over time, but it is occurring in similar regions in sort of a similar pattern over the course of a year.

In terms of the downstream impacts of this electrification, here we show again a national average snapshot of the fuel use reductions across our scenarios at a national level. So, the primary impact that we see, if you go from the reference scenario in that kind of grayish black line to the darker red line, the primary impact is the avoided gasoline consumption. So, this is your electrification of the light-duty vehicle fleet. It is -- it does correspond to about a 74-percent reduction from 2016 levels, which is clearly not getting to that 80-percent, 100-percent level that you're looking for. But again, this is a national level snapshot.

The reductions in diesel are more modest, so this represents the fact that we're not electrifying as much of the service demand in that segment.

And, finally, the reductions in direct natural gas use, so this is only natural gas consumed by the end-use sectors, are again more modest. I do think this is more representative of other parts of the country where there are challenges associated with switching to electric space heating, especially in the very cold climates. But this does also represent the remaining natural gas consumption in the industrial sectors, where we didn't see as much potential for electricity swapping out as your energy supply.

So, just my last slide. I posed a number of the key questions that we identified in our previous study. I know California is already tackling many of these around electric vehicle charging infrastructure. How you -- how the utility interacts with your charging timing and whether there can be coordination there. Also around sort of new building construction and how you focus on electric technologies there.

But a few of the questions, I know we talked earlier about the challenges around retrofits. And there's a lot of questions there about how you do get into those buildings and make sure that it's a cost-effective transition for not only the owner, but the resident, and how you deal with all of those tensions within that segment.

I think another important question comes up in the industrial sector. Does electrification make sense? And if it does, which parts of it do you target for electrification and where might there be another emissions-reduction pathway that would be more cost effective, for example.

So, that's all I have. Thank you very much for your time.

COMMISSIONER SCOTT: Thank you very much. Four very thought-provoking presentations for us. With your indulgence, we're hoping, panelists, you can stay for about 10 more minutes, maybe 15, so we can ask a few questions. We have a whole list of burning questions up here for all of you.

And, Melanie, I know you might have a hard stop at noon. If so, that's okay. But if you can stay just a few more minutes, too, that would be terrific.

I know Commissioner McAllister had a few. Would you like to start?

COMMISSIONER MCALLISTER: Really, just I missed the front end of Debra's presentation, but when I walked in, it was music to my ears. And so, I just wanted to follow up on a couple of things.

So, you mentioned this -- really, the price, you know, sort of price response of demand and demand response. And that is something I absolutely think, I agree with you it's central to what we need to do and, you know, figure out how to mobilize demand, and matched to supply, and really have that sort or orchestra playing in real time.

And yet, you know, we're having a hard time kind of getting demand response to be all it can be. And, you know, and partly that has to do with sort of the fraught nature of rate-making in general, and it just has a lot of issues to get that done in a transparent way.

But those aren't the only issues. I mean, we don't have a whole lot of that technology out there at the end use. It's sort of a chicken and egg problem. And I guess, you know, I was actually just in Washington last week, and giving an award to OhmConnect. You know, the Alliance to Save Energy gave OhmConnect an award on dynamic efficiency, which is a new category, right.

And what OhmConnect does is sort of like backdoor real-time pricing. And so, what we really need to get to is walk to a front door with rates, and then just have that be part of the ether.

I guess I'm wanting your -- I know this is a long preamble, but I'm wanting your thoughts on what that kind of business model looks like?

How are we -- who implements? Who goes to the customer? Who implements in a way that does communicate with the ISO at some scale, where we can actually see demand responding to price, or to some other signal that, you know, mimics price. You know, what does that look like in real life?

And, you know, I want to help people visualize what the future might look like that does this.

MS. LEW: That's a really good question. So, that's a lot of, you know, what we've been trying to do, too, is to think about this and what this, you know, 100-percent future is going to look like, and what you're going to need to make that work, knowing what we know now.

And I think the idea of exposing more loads to more price volatility and more, you know, higher peak, off-peak ratios is a big piece of this. Because if you can't get the prices exposed to the loads, then you're not going to change behavior and incentivize anything because, you know, at the end of the day nobody really wants to -- it's just like the energy efficiency thing. Trying to undertake those kinds of things in your commercial facility, industrial facility, or your home, nobody wants to do that kind of stuff.

So, getting more of being -- taking the challenge of actually getting those prices out to people and to the loads, I think is a big piece of that.

I think another big piece of it is developing more of the sort of plug-and-play infrastructure through codes and standards to try and figure out how to make this easy for aggregators to come in with a -- you know, with their plan for different customer groups.

So, like, you know, the Northwest Utilities have their CTA 245, you know, water heater, or control and communication devices that they want to have standard on all electric water heaters. Something like that idea, you know, that could be plug and play with different kinds of appliances that could be agnostic to different types of communication types, and different control protocols, something that's sort of, you know, future-proofed in that way could be really helpful. Right? And that's a perfect role for policymakers is the codes and standards side of things.

I think, you know, trying to really start, yeah, greasing the skids for what these aggregators are going to have to do. There's some -- you know, there's some good lessons maybe to be learned from places like Germany. They actually do go and dispatch rooftop PV. And distributed wind. And they're able to communicate and control to, you know, different distributed resources. So, I think, you know, trying to take what other folks are doing and building on that, you know, would be a good start.

But definitely, we got to get the prices right. Because nobody's going to care. You know, saving 10 percent of my bill, you know, I don't really care. You've got to save a lot of money to make it worthwhile.

COMMISSIONER MCALLISTER: Yeah. Well, so, thanks for that. I guess, so, I mean heads up, we do have this load management authority that we're getting serious about beginning to use and that -- using again, after, you know, a couple of decades. So, stay tuned for that. It's going to be really good to have your participation in the prerulemaking and then, eventually, rulemaking.

But we do have some authority in this realm to actually standardize some of this stuff, and in addition to the Building Code. So, there's definitely some exciting pathways, but we have to get it right, and it's a big deal.

And my follow-up question is do you have equity concerns? Maybe you're talking more about, you know, commercial, larger installations. But on the -- I know that one of the issues with ratemaking, particularly in the residential sphere, is exposing people to prices, the response to which they don't have a lot of control.

And so, if you have a disadvantaged community, low-income folks who just don't have a lot of flexibility in their lives, or somebody's home all the time, or whatever, like do you -- is there kind of a conversation going about how we insulate some of the vulnerable populations against being exposed to real-time pricing?

MS. LEW: Right. So, I think it's the same way you do it on the generation side. You know, on the generation side you've got the real-time market, you've got the day-ahead market, and you've got bilateral contracts to hedge against, you know, the volatility in the other markets.

So, if you think about it on the pricing side, we've got time-of-use rates, which sort of hedges against volatility and maybe some day-ahead rate, which hedges against volatility in the real-time rate. And customers can sort of choose, you know, maybe where they want to play, depending on what kind of automation and loads they have. So, there might be ways to think of it in those ways.

I mean, it's true, you're going to run into equity issues and those are challenging.

COMMISSIONER MCALLISTER: Okay. Well, thanks. So, I'm going to pass it along.

MR. ROTHLEDER: Can I -- Melanie, are you still on? Did we lose her?

MS. KENDERDINE: Yes, I am. I'm sorry, I was just taking myself off mute.

MR. ROTHLEDER: Okay. I'll just take a -- or, give you a question real quick. I appreciate your graphs of the production and the multi-day production of the wind. If you were to overlay the diversity and the production capability of the broader set of resources in the west, or offshore wind, do you have a picture that kind of illustrates how that would play out differently as a result of that diversity?

MS. KENDERDINE: Well, let me say a couple things. That I look at -- you import a lot of your electricity, 30 percent, California does. And the imports from the northwest, hydro imports from the northwest are -- I looked at the forecast for hydro. It's expected to decline by 21 percent in the next century.

I also have concerns about other states that are providing electricity to California, that have also implemented their own net zero emissions, you know, et cetera, et cetera. And I think Nevada and New Mexico are in that category.

So, there are external influences about the availability of imported resources into California that I think are problematic, and that the state needs to pay attention to.

The offshore wind capacity factors are much higher than they are for onshore wind. I believe offshore wind capacity factors can be as high as 60 percent, 65, 60 percent. Developing offshore will give California a better wind resource than it currently has. And so, I think that that's important. I know there are issues with the Navy that also has to be floating offshore wind.

And so, that's another thing that's expensive. Floating offshore wind is expensive, but you do get a better capacity factor, yeah.

MR. ROTHLEDER: Okay, thank you. And Debra, just are we being aggressive enough in California, or the industry as a whole in terms of developing or requiring grid forming, or leveraging the inverter-based technologies, or are we going to find ourselves 10, 20 years down the line wishing that we had done something more aggressively, and not having leveraged the opportunities now, or can we wait?

MS. LEW: That's a really good question. I think what folks are doing today is they're putting in synchronous condensers and then solving the problems that come out from that.

I think there is some thought that with grid forming inverters you can do this a lot more cheaply. And, but there's a lot to figure out. We don't even know exactly which type of the different grid forming technologies, you know, makes the most sense. And then, you know, how we would actually make that interoperate with the rest of the system, seamlessly going in and out of following and forming load. There's so much that we need to figure out. So, we really need to get on the ball and start figuring that out now, and then I think, you know, the different OEMs can commercialize the technologies. We can -- you know how long it takes to set up standards in this country. The whole standards-making process of what those performance specs are going to be. I mean, this is something we need to start working on now.

COMMISSIONER MONAHAN: Melanie, this is Patty Monahan from the Energy Commission. I had a question about your 2030 versus 2050 analysis. You highlighted the 2030 analysis really well. And, you know, on the vehicle standard size highlighting that the vehicle greenhouse gas emission standards and fuel economy standards, that's the number one carbon reduction strategy for 2030.

But when you go out to 2050, you'll find that we have to electrify transportation. So, there's a little bit of a tension, I think, between what the short-term versus the long-term pathway looks like.

I'm wondering if you did the analysis through 2050 for the specific pathways and whether you found any other tension points in the electricity industry, buildings, or agricultural sector where the 2030 strategy doesn't align at all with the 2050 strategy?

Melanie, are you still there?

MS. KENDERDINE: I'm sorry, yeah, I had myself on mute. One thing, I heard you, but you couldn't hear me. I have just walked 12 blocks in Manhattan traffic, so I put myself on mute.

The 2050, we don't see the technologies yet, in order to meet the 2050 goals. I think it's highly problematic. And one thing that we did look at and we think that hydrogen, okay, is a usually important focus, and should be a focus of innovation in the 2050 timeframe, and figure out how much of the existing infrastructure can be used in basically a hydrogen future.

You asked about tensions. I don't see the long-term, long-duration battery storage that you all need for the types of sources that you have, and the seasonal variation, et cetera, et cetera.

We think that hydrogen could serve as basically the fuel that you need to run a system. Right now it's gas, you need that fuel. We think hydrogen is the technology and the fuel source. You have to be able to produce that hydrogen with renewable energy as opposed to producing it from natural gas, in order to get the emissions down from sufficient to meet your net zero targets.

And so, not necessarily a tension, but a huge need is to invest in some key technologies. I just don't see the battery technology -- there's been a lot of discussion about that here today, to, of battery storage. And there are other issues that I didn't get to in the slide presentation I had. And, of course, long duration storage is something that we should be looking at.

But we also have some pretty significant concerns about the metals and minerals for wind, solar, and batteries, and whether that will affect the prices in the future.

And as you well know, cobalt is basically coming from one country in the world, that's the Democratic Republic of Congo. And, basically, being mined by five year olds. And that's a huge component right now. We have done a fairly significant down-select in the U.S. to lithium ion batteries. And 22 states manufacture them. And so, looking at some of the metals and minerals for those is another flash point. I think we need to be cognizant of tensions. I'm not sure about tensions.

I actually have a question, but I do have to get off the phone. I actually have a question for, I think it was Deb, and it's bothered me for some time. If California electrifies its vehicles, and it should and it's planning to do it, what does that do to tourism from states that don't have electric vehicles?

I know tourism is a huge part of California's economy. I used to drive there all the time from New Mexico, when I was a kid. And I don't -- do you have to have duplicate systems? What does that mean? This is something that's been bothering me. We didn't look at that. And just wondering what that means.

COMMISSIONER MONAHAN: So, Melanie, I'm going to -- this is Patty Monahan again. I'm just going to respond really quickly. On the EV front, which is that, I mean, a number of western states are working together on this --

MS. KENDERDINE: Right, right.

COMMISSIONER MONAHAN: -- electrification of transportation. I think what we're seeing is a global trend where light-duty vehicles, within the next 5 to 10 years will be cheaper, just the vehicles themselves. So, there's performance enhancements with electric vehicles. So, I'm happy to talk offline with you about why we see electric vehicles in the light-duty vehicle sector at least, as inevitable.

MS. KENDERDINE: Yeah, and I tend to think so, too. I was just curious --

COMMISSIONER MONAHAN: And I think we shouldn't get into this -- and, Melanie, I think we need to -- we only have a few more minutes for questions, so let's not go down this rabbit hole.

MS. KENDERDINE: Yeah.

COMMISSIONER MONAHAN: Happy to talk with you offline.

COMMISSIONER SCOTT: Okay, let me turn to --

MS. KENDERDINE: It's a transition issue, that's why I raised it. A transition question I had. So, thanks. Thanks.

COMMISSIONER SCOTT: Thanks. So, if folks can indulge us for two minutes, Ken has a question, I have a question, and then we promise we'll wrap it up. It's such a fascinating topic. But we did want to take a few extra minutes for questions. So, thanks, everyone, for doing that. Ken, please go ahead.

MR. RIDER: Yeah, I'm going to shorten it into just an observation, rather than anything else, and it's really building on what Commissioner Monahan just said. Which is there are pathways to 2030 that might be the least expensive but, then, incompatible perhaps with the longer-term goal.

And, really, also what's clear, I mean we have all these presentations today with sectors, and like measures between, but they're more interrelated than ever before. And I think we need to be more cautious than to look at it as this measure in that sector, and really start breaking down the walls that used to be transportation sector and all these other things. But they're all coming together and they're all gelling around, you know, renewable, like clean energy and then getting everything to use clean energy, and it's cross-sector.

And I've seen bars that they would switch sizes if you did this thing first versus that. Like, I believe in the E3 report it's like here's how much renewable, just going renewable, and then here's how much electrification. Well, if you do electrification first and then you look at renewables, all of the sudden the bar's changed height, right.

So, we have to be cautious in how we perceive these things and just really think of it as a holistic decarbonization plan and be careful about choosing things that work short term versus long term. And, really, we have to bundle it together in a pathway in order to -- a comprehensive pathway in order to be successful. Which you highlighted that issue for me.

COMMISSIONER SCOTT: I just had, and Melanie, if you're still on the phone, you can go first. And then, if you want to drop off, please do. Thank you for taking some time with us.

It's so great to have Zach, and Melanie, and Debbie and Caitlin here together. So, if there was just one thing that you would highlight or pull forward one key finding, one key strategy that we ought to think about, that you either mentioned or didn't have a mention in, you know, 30 seconds each. If you could please say what that is, that would be really helpful.

Melanie, if you're still there, please start. She may have gone back to climate week.

Okay, Zach, please.

MR. SUBIN: Yeah, actually, picking on some more of what we were just talking about, and I wanted to kind of clarify, in answer to Ken Rider's question, one thing that Europe is starting to look at is transitioning the large transmission scale gas pipes to hydrogen as an option. And, you know, the sort of economics would likely be more favorable than doing that for all of the distribution pipes serving the smaller end uses. So, you know, that -- I don't think there's been a study of that in California, so that could be something to look at.

COMMISSIONER SCOTT: Great, Caitlin.

MS. MURPHY: I did not mention this and it's not even related to my presentation today. But I do think this concept of long duration storage is a really key strategy here. And that could mean, you know, trying to get over the couple of days in a row without wind, but it could mean more the seasonable shift instead.

As we look at higher than 80 percent national scale decarbonization studies for the grid, for example, you do start to run into challenges as you get to those last few percents. And that's something that I think would really help some of the transition. So, starting to think about it now is helpful for being able to implement it when it is needed.

COMMISSIONER SCOTT: Thank you. Debbie.

MS. LEW: I guess my suggestion is that we think carefully to not over-constrain the solution space with too many mandates because there's so much uncertainty as to what technology's going to break through, and become cost effective and, you know, new solutions in the future that I think you want to try and keep your solution set really big. And you want to focus, instead, on greasing the skids, you know, business models for how, you know, demand response will play in the future, or things like that. As opposed to trying to mandate any kind of solutions.

COMMISSIONER SCOTT: Thank you. Well, thank you again to our excellent panelists. We really appreciate you being here, all the wonderful information you've provided.

(Applause)

COMMISSIONER SCOTT: And my understanding is that we don't have any public comments. I don't have any blue cards. Are there any comments on the WebEx?

MS. RAITT: No.

COMMISSIONER SCOTT: No. Do we have any -- would anybody like to make some burning closing remarks? All right. Well, let me turn it to Heather just to let folks know when the comments on this workshop are due. And again, my thanks to everyone who helped put this together and to everyone who participated today.

MS. RAITT: Just a reminder, the comments are due on October 8th. And the information for how to file comments is in the notice. Thank you.

COMMISSIONER SCOTT: With that, we're adjourned. Thank you, everybody.

(Thereupon, the Workshop was adjourned at 2:17 p.m.)

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