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IEPR COMMISSIONER WORKSHOP ON BUILDING DECARBONIZATION: EMBODIED CARBON AND REFRIGERANTS

REMOTE VIA ZOOM

THURSDAY, AUGUST 26, 2021, 2:00 P.M.

Session 2 of 2 - Refrigerants

Reported by:

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Commissioner Cliff Rechtschaffen, California Public Utilities Commission

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PUBLIC COMMENT

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P R O C E E D I N G S

2:00 P.M

MS. RAITT: Good afternoon and welcome to today's 2021 IEPR Commissioner Workshop on Building Decarbonization: Embodied Carbon and Refrigerants. I'm Heather Raitt, the Program Manager for the Integrated Energy Policy Report or the IEPR for short.

This workshop is being held remotely consistent with Executive Order N-08-21 to continue to help California respond to, recover from, and mitigate the impacts of the COVID-19 pandemic. Public can participate in the workshop consistent with the direction in the Executive Order.

This afternoon is the final session of this workshop, and to follow along with the discussion, the workshop schedule and presentations are available on the Energy Commission's website. Just go to the 2021 IEPR page.

All IEPR workshops are recorded and the recording will be linked to the CEC website shortly following the workshop, and the written transcript will be available in a few weeks. Attendees have the opportunity to participate today by asking questions or upvoting questions submitted by others using the Q&A feature, or making comments during the public comment period at the end of the afternoon, or by submitting written comments, and instructions for doing

so are available on the meeting notice. Written comments are due on September 9th.

With that, I'll turn it over to commissioner Andrew McAllister. Thank you.

COMMISSIONER MCALLISTER: Thank you, Heather. I wanted to just again, start out thanking you and your team for putting together another day of really substantive and thought-provoking panels. This is really great. This morning, we had a substantive and thought-provoking and I think highly relevant panel around embodied carbon in our built environment.

And I think a lot of good things will come from the basis that was built by that conversation this morning and going forward. I think a lot of good work needs to be done with urgency. And again, we have to frame all of what we're doing in the context of accelerating climate change.

So, this afternoon, another facet of that large relatively complex topic; decarbonizing our entire economy and within that the built environment; we are obviously leaning on electric technologies as a key enabler of decarbonization and none more important than heat pumps for space and water heating particularly.

And one, I just thank the Efficiency Division staff for putting together the workshops today and the whole building decarb track of this year's IEPR. Really

fantastic work by Mike Sokol and Christine Collopy leading that division, and Jennifer Nelson her team and the Existing Building shop, our appliances team, our Building Standards Office, just a lot of effort.

And Kristy Chew as well is really cobbling together all of these different topics and making sure that people have the information they need when they need it. So, just thanks to the whole team, it's really a massive team effort. Even though it may look seamless and effortless on the surface, it's really not. We all know what a huge effort it is and how much competence it takes.

So, one aspect of our electrification journey is the fact that we'll have increasing amounts of refrigerants out there in these heat pumps, in these various compressor cycles and refrigeration generally, and then heat pumps.

As many of you know, the commission recently adopted the 2022 update to the Title 24 Part 6, the California Building Energy Efficiency Standards, and those really make a landmark pivot toward heat pump technologies and electrification generally, trying to prepare our building stock for a more electrified future really increasingly, deeply electrified future.

And so, the refrigerant conversation comes to the fore pretty quickly there and both in the Building Standards update, the analysis behind that, and then an

analysis behind our also recently adopted Assembly Bill 3232 assessment. The global warming impact of high global warming potential refrigerants is a big chunk of the problem.

And we actually quantified, I think it's 10 or so gigatons of CO2 equivalent that is in play here across the state in our refrigeration impact. And so, which is I think a quarter or so of the overall … it's about 10 to 15%, I think of the overall, global warming impact of the building sector itself.

If you take into account the electric emissions, the electric generation system emissions, and as well as the onsite emissions of gas combustion. So, I think refrigerants are 12 or so gigatons of that overall, roughly a hundred. So, I think they're going to be increasingly important. Our policy is pushing heat pumps as an enabling technology for de-carbonization.

And so, alongside that, we really need to build the infrastructure to manage the refrigerant challenge. And so, lots of different ways to do that, moving towards low GWP refrigerants, making sure that we capture the refrigerants that are in the system and manage the leakage. And so, we're going to talk about all of these topics today. I'm not the expert here, so I want to make sure we do get to the experts.

But we wanted to put together this panel just to kind of put these themes around refrigerants, kind of in one place and create a foundation for discussion.

Now, the Air Resources Board really has primary jurisdiction here, and I just want to acknowledge that right out of the gate. And there is a statutory framework around this issue and we'll hear about that.

Today, certainly, we'll be hearing from ARB and I just want to in advance of the conversation, thank Aanchal and her colleagues for being with us, really appreciate that. And our job at the Energy Commission is to have kind of a productive sharing of ideas and coming up with strategies potentially, but really just collaborating across the agencies on all these different issues and with the PUC and the Air Resources Board, and any other agency including the Building Standards Commission and others to just get and be on the same page around these issues. So, I think this is a great opportunity to share information and ideas.

With that I'm pleased to be a company on the dais, virtual dais by Commissioner Siva Gunda. And I wanted to pass the microphone to you, Commissioner Gunda in case you want to make some opening comments.

COMMISSIONER GUNDA: Yeah. Thank you, Commissioner McAllister. I think you really captured what

we heard this morning really well, and as I mentioned this morning, I'm in a learning mode today and it's been really helpful to hear the conversation around the embodied carbon.

I think a couple of takeaways that you already mentioned that I think are worth noting for myself; it's just that there's a large range in the embodied carbon in the existing stock of buildings, and that really points to the opportunity of reducing embodied carbon. And also, the importance of ensuring that the existing building stock is really utilized to the maximum, and the incremental cost of decarbonizing the buildings from an embodied perspective is not that much more.

And I think those are points that I would establish this morning. And it’s helpful for me to understand those things. So, looking forward to listening to our colleagues from CARB and the broader conversation this afternoon. And I know Commissioner Rechtschaffen is also on the dais Commissioner McAllister. So, thank you.

COMMISSIONER MCALLISTER: Sorry, there you are, Commissioner Rechtschaffen, and sorry about that. You were on my second page and I didn't see you. Would you like to make any opening comments? Thanks for being with us again.

COMMISSIONER RECHTSCHAFFEN: I just want that cup of coffee that you had at the start of the … that’s the

problem with these virtual meetings. If we were meeting in the Energy Commission auditorium, I know that staff would provide us with pads, pens, briefing documents, and coffee, and now we're left to our own devices.

I'm delighted to be here to join you for the second panel. Of course, the regulation of refrigerants and buildings is something that crosses into our jurisdiction. We'll hear from folks at the PUC as well as the Energy Commission and CARB this afternoon. And I very much look forward to the discussion.

COMMISSIONER MCALLISTER: Okay, thank you, Commissioner. Really appreciate your being with us. So, with that, I don't have any further comments and really looking forward to getting to the substance of the day this afternoon. So, Heather, you want to kick us off with the first panel?

MS. RAITT: Yeah. So, our first panel's on refrigerants, the current status and what's needed. And I'm happy to have Aanchal Kohli here from the Air Resources Board, and she's an Air Resources Engineer where she's currently working on fluorinated gas emission reduction strategies.

And Aanchal has a doctorate in environmental science and engineering, and a master's and bachelor's degrees in mechanical engineering from UCLA. So, go ahead

Aanchal.

MS. KHOLI: Thank you, Heather. Good afternoon, everyone. Like Heather said, I currently work on emission reduction measures for fluorinated gases, particularly hydrofluorocarbons or HFCs as we like to call them at CARB.

I'll start today's discussion with a brief overview of the upcoming AB 32, 2022 Scoping Plan. And then I'll discuss current and proposed HFC measures in place to meet our state's climate goals.

Next slide, please.

AB 32 directs CARB in coordination with other state agencies to develop the AB 32 Scoping Plan. The Scoping Plan is an actionable plan that lays out cost-effective and technologically feasible paths to ensure we made our state's GHG reduction targets.

Each Scoping Plan includes a suite of policies, is economy-wide, and spans many years. The first Scoping Plan was released in 2013 and subsequent updates have been released at least once every five years. The next one is upcoming in 2022. The Scoping Plan is designed to provide GHG and air pollution emission reductions.

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The 2022 Scoping Plan update will require us to redefine our scope of sources and sinks in the framework of carbon neutrality. Simply put, carbon neutrality is

achieved when emission sources equal sinks. Up until now, every Scoping Plan has focused on reducing emissions from sources.

As we shift to the framework of carbon neutrality, we will expand the scope to include additional sources as well as sinks. Sinks include natural and working lands, carbon capture and sequestration, and direct air capture, and permanent storage of CO2 from the atmosphere.

As a scale of the climate crisis becomes clearer, it also becomes clearer that mearly reducing emissions will not be enough, but that we will need to more actively reduce GHGs from the atmosphere.

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We kicked off the 2022 Scoping Plan update with a series of workshops in June. The plan will be considered by the board in late 2022. The 2022 plan differs in content and purpose. The 2030 SB 32 target is in statute and we must reduce GHG emissions by at least 40% from 1990 levels by 2030. So, we will be assessing progress towards the 2030 target.

We recognize that 2030 is a milestone to achieving carbon neutrality by midcentury. We cannot wait until 2031 to start planning for 2045 because the level of transformation needed across economy is unprecedented. And we need to start planning for that now.

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Given that the 2022 scoping plan looks out over 20 years, this Scoping Plan will have the longest planning horizon of any previous version. And we are also evaluating a path to achieve carbon neutrality by 2035 per direction from Governor Newsom. We must consider achieving near term air quality benefits and longer-term greenhouse gas benefits.

As I mentioned, CARB is currently hosting Scoping Plan workshops, and there is a short-lived climate pollutant focused workshop, which will include a discussion on HFCs. That's coming up soon and I'll talk about that later. I'll now switch to HFC emission strategies and sources.

Next slide, please.

Many of you may already know this. I'll just cover it very briefly. What are HFCs? HFCs are synthetic fluorinated compounds most commonly used in refrigeration and air conditioning. They're also used in some other end-uses in small amounts.

HFCs are the fastest growing greenhouse gases worldwide. One of the reasons they are growing so rapidly is because they're replacing ozone-depleting substances, such as hydrofluorocarbons and chlorofluorocarbons that have been phased out per the Global Montreal Protocol.

Although HFCs are not ozone-depleting, they're powerful short-lived climate pollutants with very high global warming potential values. California's legislature recognized the importance of reducing HFC emissions and in 2016, passed SB 1383, which requires CARB to reduce HFC emissions, 40% below 2013 levels by 2030.

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This graph shows HFC emission trends in California from 2005 up to 2040 and the relative contribution of emissions from each main end use. This graph accounts for emissions with existing regulations in place, without which emissions would be even higher.

Refrigeration and air conditioning depicted in pink and dark blue are the two largest sources of HFC emissions. And air conditioning in particular is projected to grow rapidly over the next couple of decades. This is because of the phase out of ozone-depleting substances, as well as an increased demand for cooling.

This data is from CARB's F-gas Emission Inventory. CARB developed the first bottom-up state specific inventory in the world.

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Now, I'll cover existing and proposed regulations to reduce HFC emissions. I'll discuss two of the larger HFC measures in place, the refrigerant management program

and Senate Bill 1013, and then I'll move on to our proposed regulations, which we're in the process of finalizing. And then I'll briefly discuss national as well as international action on HFCs.

Next slide, please.

CARB adopted the Refrigerant Management Program in 2009. One of the largest contributors of HFC emissions as you saw in the graph earlier are stationary refrigeration systems such as those found in supermarkets, cold storage warehouses, and industrial process facilities. The refrigerant management program requires facilities to register and report annual refrigerant usage, conduct leak inspections, and repair refrigerant leaks promptly.

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In 2018, the legislature passed Senate Bill 1013, the California Cooling Act. SB 1013 maintains high GWP prohibitions adopted by the federal government in 2015 and 2016. These were partially vacated at the federal level in 2017, following a legal challenge and California adopted them to prevent a rollback. These rules include high GWP HFC prohibitions for refrigerants used in a wide range of applications.

SB 1013 is an important measure in moving towards the state's SB 1383 target. However, more action is needed.

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Moving on to our proposed HFC measures; in December of 2020, the CARB Board adopted HFC measures affecting stationary refrigeration and air conditioning, which if you remember from the graph earlier were two largest sources.

I'll start with stationary refrigeration. Starting January 1st, 2022, all new facilities with refrigeration systems containing more than 50 pounds of refrigerant will be required to use refrigerants with a GWP less than 150. This includes the same facilities regulated under the Refrigerant Management Program. Supermarkets, cold storage warehouses, and industrial process facilities.

Additionally, CARB is also placing company-wide emission reduction targets for existing supermarkets, which are responsible for the majority of emissions from the refrigeration sector.

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Next, I'll discuss the new rules for stationary air conditioning equipment. This is the first time AC equipment is being regulated in the nation. CARB placed a 750 GWP limit on all new air conditioners and space conditioning heat pumps; residential as well as non-residential. Many alternative refrigerants used in air conditioning under the 750 GWP limit require a change in

the building codes.

Because of the expected date for building code updates, AC equipment have staggered effective dates ranging from 2023 to 2026. Smaller ACs have a 2023 date, while larger systems have a 2025 or 2026 effective date.

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As part of the proposed regulation, CARB introduced a new program; the Refrigerant Recovery, Reclaim and Reuse, or R4 program. AC manufacturers will be required to use at least 10% recycled refrigerant between 2023 to 2025 or 2026, depending on equipment type.

Recycled refrigerant can be used in new equipment or in servicing existing equipment. This will promote refrigerant recovery at the end of life, which is the largest source of emissions for AC equipment and will enable a more resource-efficient circular economy.

The proposed regulations are the first of their kind in the nation.

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Moving to national and international action. At the end of 2020, the U.S. Congress enacted the American Innovation and Manufacturing Act of 2020. The AIM Act directs EPA to address HFCs by providing new authorities in three main areas: to phase out production and consumption of HFCs, refrigerant management of existing systems, and

facilitating a transition to next generation technologies.

Globally, the Kigali Amendment to the Montreal Protocol, which has been in effect since 2019 is a global HFC phase down that has been ratified by over 100 countries. While the US has not yet ratified the agreement, the phase down and the AIM Act will accomplish the Kigali agreements phase down goals. And HFC phase down was identified in CARB's short-lived climate pollutant plan as one of the strategies necessary to meet the state's SB 1383 goals.

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Next, I'm going to briefly discuss HFC emissions from building decarbonization. This is a plot from the recent report by Energy and Environmental Economics that was prepared for CARB, depicting several scenarios to achieve carbon neutrality by 2045.

In the scenarios depicted, high GWP gases are projected to be among the largest remaining sources of greenhouse gases as indicated by the dark green blocks. Thus, reducing HFCs is critical not just for meeting our 2030 mandate, but also for meeting the state's carbon neutrality goal.

Additionally, like Commissioner McAllister mentioned, HFCs are further expected to increase as refrigerant containing heat pumps are widely adopted. This

topic will be explored as part of the short-lived climate pollutant focus Scoping Plan Workshop on September 8.

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Lastly, I will discuss CARB's existing incentive program and the need for coordination on future incentives.

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Senate Bill 1013 established the first incentive program dedicated to increasing the adoption of low GWP refrigerant technologies. We received $1 million in 2019 and launched an incentive program shortly after.

The bill also directed other state agencies; CPUC, CEC, as well as the Community Department of Services and Development to consider low GWP refrigerants in existing programs. Going forward, there's a need for coordination on HFCs for building decarbonization efforts to ensure that we adopt low GWP heat pump technologies as much as possible.

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In conclusion, to meet our specific mandate, additional action is needed, especially actions to meet our 2030 target as well as action to meet our state's long-term climate goals. We will be discussing some of these next steps as part of our upcoming Scoping Plan workshop on September 8th, for which I included a registration link.

Thank you very much.

MS. RAITT: Thank you so much, Aanchal.

So, our next presenter is Nicholas Janusch, and he's at the Energy Commission, and he's works in the Energy Assessments Division, and he is one of the primary authors of the AB 3232 California Building Decarbonization Assessment Report. So, go ahead Nick.

MR. JANUSCH: Thank you. Good afternoon. Thank you, Heather, for the introduction.

Today, I will present some results from the AB 3232 California Building Decarbonization Assessment. And why focusing on refrigerant leakage matters both for achieving the state's 2030 emission goals and long-term emission goals beyond 2030.

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This report was developed as a result of Assembly Member Friedman's authored Assembly Bill 3232 in 2018. The primary directive of AB 3232 is for the Energy Commission to assess the potential to reduce greenhouse gas emissions from residential and commercial building stock by at least 40% below 1990 levels by 2030.

Other considerations in the assessment include the cost per metric ton of decarbonization strategies, the cost effectiveness of space and water heating decarbonization, challenges associated with the decarbonization and low-income multi-family and high-rise buildings, load

management strategies, and impacts to ratepayers, construction costs, and grid reliability.

The Energy Commission formally adopted the final report a few weeks ago at the August 11th business meeting. I will give a quick summary of the results, but the focus of my talk is on the impacts of refrigerant emissions.

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As for the quick summary, staff first developed two greenhouse gas baselines needed to account for a reduction relative to 1990 levels. Both baselines include emission sources from onsite fuel combustion, refrigerant leakage, and behind the meter gas leaks, and any electric generation emissions from the incremental loads from building electrification.

The key difference between the two baselines is whether to include 1990 electric generation emissions attributed to buildings or to focus strictly on onsite emissions. So, after establishing the two GHG baselines, staff identified seven key strategies to decarbonize buildings.

These strategies include building electrification, electricity generation decarbonization, energy efficiency, refrigerant conversion and leakage reduction, distributed energy resources, decarbonizing the gas system, and demand flexibility.

Staff also identified variables, which impact the success of these strategies ranging from cost to equipment availability to workforce preparedness, to building conditions, and more. Using these strategies, staff then assessed several GHG reduction scenarios.

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I'll now summarize some of the results of our assessment of the different analyzed scenarios. A major takeaway message from the assessment is that even although some decarbonization strategies may be more cost-effective, to go the distance to reach the state's emission goals require technological transformation through build electrification, particularly through existing buildings.

This figure summarizes the potential reduction of GHG emissions in 2030 for each of the nine analyzed building decarbonization scenarios, relative to both the direct and system-wide 40% reduction emission targets.

All these impacts in 2030 are relative to our business-as-usual case that is based on the 2019 IEPR California Energy demand forecast, which already embeds many of these decarbonation strategies.

Starting on the left, we see incremental gas energy efficiency from four different illustrations scenarios in green, and renewable gas scenario, incremental electric energy efficiency, incremental rooftop PV, and

accelerated renewable electric resources. The four green building electrification scenarios vary by the rate of electrification penetration in new and existing buildings by 2030.

The efficient aggressive electrification scenario is a modification of the aggressive electrification scenario where staff handpicked the most efficient electric appliance to be installed. So, for example, for water heating, instead of any electric water heater replacing a natural gas water heater, the scenario assumes an efficient heat pump water heater is installed.

Also, in this figure, we see two horizontal lines representing the two 40% GHG reduction targets. The red line represents a system-wide emissions baseline target, which includes electricity generation system emissions in the 1990 base year.

This means if you're measuring a 40 percent greenhouse gas reduction relative to the system-wide baseline, then a successful scenario in 2030 must avoid 5.5 million metric tons of carbon dioxide equivalent.

The other horizontal line is the more aggressive dash black line above, which represents the direct emissions baseline target. It is not based on including electricity generation system emissions in 1990. A successful scenario for this direct emissions baseline

target would need to reduce emissions in 2030 by 22.1 million metric tons of carbon dioxide equivalent.

We present both of these baselines since the legislation does not recommend one and suggest that the two approaches are valid. So, both have merits and reporting both provide different perspectives.

A takeaway from this figure is that the electrification scenario and renewable gas scenario reached a system-wide baseline target, but none of the scenarios reached the direct emissions baseline target. However, there's more emission reduction potential for all these scenarios from refrigerant mitigation efforts from SB 1383.

Next slide, please.

As the 2016 Senate Bill 1383 established economy-wide goals for 2030 for short-lived climate pollutants such as methane, hydrofluorocarbons, and black carbon. These HFC emissions have significantly high global warming potential relative to carbon dioxide.

To examine the effects of SB 1383 meeting its 2030 goal of 40% reduction from 2016 levels by 2030, staff approximated the impacts of this outcome solely for residential and commercial buildings. Staff did this by using data provided by CARB staff and approximated an extreme all or nothing case, a with and without SB 1383 HFC goals being met.

This approximation adds about 7.5 million metric tons of carbon dioxide equivalent of reduction in 2030. So, how does this look in our figure?

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The impacts are shown by the diagonal pattern regions on the top of each decarbonization scenarios bar. Again, the diagonal pattern boxes represent an all or nothing case in 2030 for reducing hydrofluorocarbons, HFC emissions from refrigeration and air conditioning in the building sector.

In actuality, with the state's current effort, the amount of HFC of emission reduction is likely somewhere in between these two extreme cases. As such, there are two important takeaways I want you to walk away with from this figure.

The mitigation of HFC refrigerant leakage is absolutely essential and instrumental for the state to achieve its 2030 decarbonization goals for buildings. And when assessing GHG reductions relative to the black dash direct emissions baseline target line, only the two aggressive electrification scenarios with assistance from HFC reduction achieve this 40% GHG reduction target.

More discussions of the costs and cost-effectiveness are contained in the final report. But please note that the net cost of these two aggressive

illustration scenarios are roughly $40 billion, which translates to roughly $140 per metric ton for emissions reduction.

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But that figure and takeaway only shows a snapshot of emissions happening in 2030 and not the long-term consequences. Moreover, CARB staff commented that the HFC reductions called out in SB 1383 in 2016 did not address the increased usage from moving to new electric heat pumps.

As a recap, there are two sources of refrigerant leakage; annual leakage, and end of life leakage, where most of the leakage happens with end-of-life venting. For the assessment, staff estimated that for all our electrification scenarios, the incremental increase of HFC leakage in 2030 was less than half a million metric ton of carbon dioxide level.

But since the newly installed heat pump equipment is assumed to have an average useful life of 15 years, the impacts from any end-of-life leakage occurs outside the study's time horizon, and thus is not quantified in 2030. As such, when considering the long-term consequences of HFC emissions beyond 2030, it is likely quite significant.

According to the E3 study developed for the Air Resources Board in October, 2020, the emissions from these high GWP and non-combustion sources dominate in 2045 and

are significant even in their zero-carbon strategy scenario.

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So, to summarize, the AB 3232 Building Decarbonization Assessment showed that the mitigating HFC refrigerant leakage is critical and essential in achieving the state's 2030 building decarbonization goals. The assessment did not focus on what occurs beyond 2030, particularly end of life venting of newly installed heat pump technologies, and that the long-term consequences beyond 2030 from not addressing HFC refrigerant leakage is likely significant.

As such, the CEC will track CARB's actions on refrigerant emissions when modeling building electrification.

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Thank you. And that concludes my presentation.

MS. RAITT: Thank you, Nicholas.

So, our next speaker is Christy Torok. Christy is a Senior Regulatory Analyst at the California Public Utilities Commission. She joined the CPUC and the Energy Efficiency branch in 2016 and has been part of the emerging trends section ever since. She works on statewide program administration, market transformation, normalized meter energy consumption, and refrigerants.

Go ahead, Christy.

MS. TOROK: Thank you, welcome. I'm here to talk about some developments at the CPUC and policies related to refrigerants.

Next slide, please.

So, my presentation today begins with the basics, which my co-presenters have covered. So, some of it will be repetitive, but and then I'll touch on SB 1013, and then move to really the meat of why I'm here, which is to share out the nuts and bolts of the CPUC policy and some of the key decisions that have been adopted recently.

And then talk about the implications in the near term on our energy efficiency portfolio, distributed energy resources in general, and then some upcoming changes that are pretty exciting as we move towards new metrics for our accomplishments and our goals under the energy efficiency portfolio.

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So, just ABCs of refrigerants here. Of course, refrigerants are in many common appliances, including heat pumps, which are front and center in our building decarbonization efforts. And they're also in refrigeration equipment and air conditioning equipment.

And as an example, one commonly used refrigerant, 410-A, has more than 2000 times the global warming

potential of carbon dioxide, and bottom line is that the refrigerant-related emissions from heat pumps would be a good portion of a building's lifecycle, an all-electric building's lifecycle emissions.

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A few more just basics that hopefully are useful to someone here; refrigerants only contribute to global warming when they leak. And this is most likely to occur at the end of life particularly in the residential sector on removal of old equipment and installation of new … not terribly uncommon for there to be illegal venting.

But refrigerants also have some small amount of leakage that occurs during their lifetime and during their use.

There are new low global warming refrigerants that are much less destructive to the environment and are becoming increasingly available in the US. So, for example, in contrast, R-410A which has 2000 the global warming potential of carbon dioxide, R-441A has only five times. Engineers in the audience, I have no idea if those two are interchangeable or not.

But yeah, as Aanchal shared out, CARB is working on methods to reduce refrigerant leakage and policies to promote and celebrate these low global warming potential refrigerants.

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I want to highlight that in Senate Bill 1013, passed in 2018, that legislation directed the Public Utilities Commission to consider developing strategies for low GWP refrigerants in the equipment and project measures that it sponsors through the energy efficiency portfolio.

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So, really the tenants or the goals of our refrigerant policy at the CPUC, is we understand and believe that tracking and managing refrigerant leakage is really key to achieving our building decarbonization and greenhouse gas reduction goals. We believe that an accurate assessment of costs and benefits of all distributed energy resources should account for the greenhouse gas impacts associated with these refrigerants.

We want our policy to evolve with practices as leakage rates may change over time., and contexts may change due to policies rolling out from the Air Resources Board and the California Energy Commission.

And so, ultimately, refrigerant-related avoided costs are integral to our cost-effectiveness assessments for all of our building decarbonization and energy efficiency programs.

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Now, I'm going to move on to the nuts and bolts of

what exactly did we do, what do we adopt.

Next slide.

So, in 2020, so every two years, we do what we refer to as a major update to our Avoided Cost Calculator, which is used by all of the distributed energy resources, kind of to assess what using this energy efficiency measure or other demand response intervention, what costs did we avoid?

And so, in 2020, they had a major update and, in that update, they included a new type of avoided cost, which is something that hasn't happened for a long time. And it doesn't happen often. And this new type was related to emissions from both methane and refrigerants.

And so, to support this, they wanted to adopt this new type of avoided cost and to implement that, built the Refrigerant Avoided Cost Calculator. This is a spreadsheet-based tool. It's available on CPUC website, or you might have to go to E3 right now because I don't think our website's not like at 100% yet.

A spreadsheet-based tool that you enter in the type of equipment, the amount of refrigerant, the type of refrigerants, maybe something about the building type and equipment type -- and then it will provide back in net present value in dollars, the damage to the environment that is related to that over the lifetime of that equipment

that you represented in the input.

So, this calculator is a standalone calculator. The methane side of things is also integrated into our avoided cost, but that is done under like a larger umbrella of things. The refrigerant avoided costs are done in a separate calculator.

And then for energy efficiency, we have now expanded our cost effectiveness tool to take outputs from the Refrigerant Avoided Cost Calculator and can be entered into that cost-effectiveness tool.

Next slide, please.

So, also recently, there was a decision in the energy efficiency proceeding D.21-05-031, which is the energy efficiency reform decision. And in that decision, which brings a lot of very major and important changes. So, I encourage everyone to go and look at it if you haven't yet.

But also, in that decision, we direct the program administrators to begin using this refrigerant avoided cost calculator tool in their portfolio forecasts and filings for energy efficiency. We also directed them to submit new and updated work papers for low GWP refrigerant equipment beginning in program year 2022.

And so that does mean that our fuel substitution workpapers…so, those that calculate the savings and the

cost effectiveness of removing a gas water heater say, a piece of gas equipment and replacing it with piece for electric equipment, which applies to a lot of heat pump water heaters.

We also asked them to consider and incorporate strategies to support low GWP refrigerants in their upcoming business plan filings. And those are coming February of 2022. Sorry about that. These are like long-term strategic documents that guide the year-to-year portfolio. So, it's a long-term planning document.

The one that will be filed next and the sort of first one of its kind, out of the reform decision and it will cover 2024 to 2031. And they're going to update that every four years. So, even though it's an eight-year planning document, it will be updated every four years.

And we also just generally encourage program administrators to seek out all of the cost-effective opportunities to incorporate low GWP measures in their portfolios. So, right now, the program administrators are focused on the process of updating their deemed measures to incorporate the avoided costs related to refrigerants.

Next slide, please.

So, some of the things that we haven't done that we are looking to do or will be done over the horizon is to address ways to integrate into our programs' goals,

credits, requirements around responsible disposal of used refrigerant, refrigerant recycling, and reducing existing equipment refrigerant leakage.

So, we'll be looking to have more in-depth, get more focused discussion and input from stakeholders on those topics moving forward.

Also, our Codes and Standard Building Code Advocacy teams are starting to scope, work along with the Energy Commission for the upcoming 2025 code cycle. And I believe that that they're considering ways to address refrigerants. So, we might see some exciting stuff on the horizon there.

Next slide.

So, what to expect around the energy efficiency portfolio in the near term, and then over a little bit longer timeline.

Next slide.

So, now, that we've adopted this Refrigerant Avoided Cost Calculator, what does that do? Well, right now, because it contributes to our calculation of the avoided costs, which are essentially the benefits of measures, it will affect the cost-effectiveness assessments of projects and measures that contain refrigerants. And there will be greater cost-effectiveness for projects and measures that use low GWP refrigerant.

Where a high GWP refrigerant might be standard and you replace it with a lower GWP refrigerant version of the equipment, then that would be incorporated in your total resource cost ratio, or your cost-effectiveness calculation. So, we expect that that will encourage more use of low GWP refrigerants in the portfolio, but there's more, and I think what is even more exciting.

Next slide, please.

So, also in that EE reform decision, we adopted a new metric for setting goals for the program administrators and for the program administrators to submit claims against those goals. So, in the past, we've used KWh, kW in therms to set goals. And then we had cost effectiveness separately, and those were two separate requirements.

But going forward, we'll have Total System Benefit, which reflects all of the operating costs of the grid and associated with a given piece of equipment. There was a whole separate presentation … I'm stumbling a little bit because it's a little bit complicated. I hope some of you were able to see, I think on Tuesday, Jessica Allison did a whole presentation on Total System Benefit. And I have her information up in case anyone has specific questions on that.

Next slide, please.

So, here's a better, more specific definition.

So, Total System Benefit represents the avoided cost of all the operations, management, and maintenance of the energy grid. And this will include the avoided cost of emissions from refrigerants.

And what that means is that our EE portfolio administrators will get equal credit for creating avoided cost, whether that be through efficiency or through reduction in greenhouse gas emissions from using low GWP refrigerants.

So, it's a very powerful evolution. And we want to work really closely with CARB and the Energy Commission to make sure that as we move into this new paradigm, that we're working together and making sense about how all of these will work together.

So, those are the challenges, but this is I think a big deal and really positive overall.

Next slide.

Oh, I'm done. Okay, thank you.

COMMISSIONER MCALLISTER: Thank all of you, so much really appreciate the really context and all the good work; Aanchal, Nick, and Christina. I really appreciate that.

I don't have any specific questions, but I just want to say how optimistic I am about making coordinated progress on this issue.

And they're sort of speaking slightly different languages, but across all three agencies, we've really heard that we are looking at the refrigerant issue through similar lenses in a way that's internally consistent.

So, I think that's important to keep in mind going ahead and just keep the cross-agency collaboration going. And finally, I just wanted to call out Christina, you mentioned the CASE effort, the Codes and Standards Enhancement teams that are funded with ratepayer money through the large investor owned utilities and work collaboratively with the Energy Commission.

And I just want to call that out as a really great example of coordination for the benefit of our climate enterprise. In that case, the building sector and the code development. And the same applies for the Appliance Efficiency Standards as well.

I just want to call out … really make a note of thanks to the Commission, to the PUC and just point that out as a really great foundational coordinated effort that helps us reach our state policy goals. So, thanks for that.

Maybe that's more to Commissioner Rechtschaffen directly. So, thanks for supporting the CASE work. I don't know if my colleagues have any questions, Commissioner Gunda, Commissioner Rechtschaffen?

COMMISSIONER RECHTSCHAFFEN: Christina did talk about this. I don't know if you are familiar with how we're dealing with incentives under SB 1477, and in our heat pump water heater proposals under SGIP to provide higher incentives for equipment that has low global warming potential. Have you filed that, Christina?

MS. TOROK: I haven't. This is the first I've heard of it, but it will make sense for any cost effectiveness calculations that those programs should be reflected. They all have to use this new Avoided Cost Calculator for refrigerants. So, that will help substantiate those additional incentives. Sounds like a really good idea.

COMMISSIONER RECHTSCHAFFEN: So, I don't know the exact details, some of which we've just proposed. Like we have a proposal for a $45 million program for heat pump water heaters in our SGIP program. And we have a ruling out for comment, we're working through public comments.

But in that program in particular and just generally, we're thinking we have in mind that the strong conclusions that Nicholas talked about in the AB 3232 report, that refrigerants are a source of high global warming pollutants in the building sector.

And we want to encourage the manufacturer and adoption of appliances with the lowest GWP. So, that's a

policy direction we have very much in mind and we're going to be implementing over time.

In addition to the excellent work that Christina talked about; about how approaching energy efficiency programs, the Total System Benefit changes the whole calculation about fuel substitution and allows much more shifting to electric appliances, because we are now measuring not just therms reduced, as she said, but GHG benefits and system benefits, including avoided refrigerant emissions.

So, that that's very, very important work. I think it fits nicely in with more direct regulation from the CEC.

COMMISSIONER MCALLISTER: Thank you for that, Commissioner. And we have been, the compliment to the TECH program, the BUILD program that the Energy Commission is just getting close to rolling out -- we've also had a similar conversation.

And in the program environment, I think we have a really great opportunity to kind of keep just ahead of the marketplace and put those incentives in place, making sure that there is supply chain for the products that do have the low GWP refrigerants so that it doesn't impose too much of a burden and it doesn't slow things down, but that it does push the marketplace in that direction pretty clearly.

So, I think this is an area where collaboration across our kind of complementary programs is imperative and very helpful. So, thanks for that.

There is a question in the chat, the Q&A here from Robert Glass. And I'll just take advantage for this panel. So, this would be for Christina, I think; does the RACC, the Refrigerator Avoided Cost Calculator take into account that most equipment will use a lower refrigerant charge than current higher GWP refrigerants? This should have a lower impact accordingly.

MS. TOROK: I believe that the calculator will take … you enter in the charge and the type of refrigerant and the amounts and the equipment. So, if you have a lower charge requirement, as long as you are reflecting that in the inputs.

We are looking to make refinements to that calculator that we rolled out. It was first rolled out in 2020 and this next major update to the Avoided Cost Calculator in 2022, we're working within the commission to try to scope in some updates to that. So, we appreciate stakeholder participation in that, the scoping is going on right now.

COMMISSIONER MCALLISTER: Thanks a lot. I have a question for Aanchal. Well, it could be for anyone, but perhaps Aanchal with the technical expertise really that

you have.

Could you give us just sort of a general idea of the evolution towards the sort of mid-level, hundreds GWP and maybe the flammability question in there, because that seems to be one thing at the federal level that's holding things back because these partially flammable refrigerants that seem to have more use in Europe and other places, but sort of have a stumbling block here in the US.

MS. KHOLI: Yes, I'd be happy to provide some input on that. So, I guess you're right. There's a lot of lower GWP refrigerants that will be considered for refrigeration and air conditioning are classified as A2L refrigerants or mildly flammable refrigerants, and they have taken off internationally. They're common in Europe, in Asia, in Australia.

One of the reasons that they've been slower to be adopted here is because the types of systems that we have in the US are a little bit different. So, when you look at countries like Asia or Japan, the air conditioning systems, for example, tend to be a lot smaller. They tend to use mini-splits, window ACs, portable ACs, a lot more. Whereas, the US, you have large central systems.

So, just by the nature, the architecture of the types of systems, we just use a lot more refrigerant charge. So, that's one of the impediments to that.

And the other impediment has been … and I think one of the speakers later in the second panel will also talk about this. It's just the US is a little bit slower to the way that risk is viewed in this country is a little bit different from other countries. And generally, there's been more resistance to adopting flammable refrigerants because of the way that risk is perceived.

But things are progressing and we do hope to see the Building Codes being updated relatively soon. I hope that answered your question.

COMMISSIONER MCALLISTER: Yes, it did. Thank you very much. And I have some other questions of a technical nature, but I think we have another panel that will be perfect for asking those questions as well.

I think there's great opportunity to have the lowest GWP refrigerant, which would be CO2. There are systems that use that as a refrigerant. Got one in my own house and the they're still not quite accessible to everyone, but they show a lot of promise. And I think if we can sort of leapfrog to very low GWP refrigerants, then that would help a lot. But thanks so much.

I wanted to ask any other questions from the dais? Commissioner Gunda, any questions? Going once, going twice. Commissioner Rechtschaffen, nothing else?

Okay, great. Alright, well, we're right on time.

So, thank you all for a great set up for our next panel. I really appreciate the engagement participation and really looking forward to collaborating across our agencies going forward. So, thank you very much.

MS. RAITT: Great. Thank you, Commissioner. And again, thank you to Aanchal, and Nicholas, and Christina. So, this is Heather, and now we're going to move on to our next panel. As Commissioner mentioned, is on low global warming potential refrigerant.

And Samuel Cantrell is going to be moderating, and he is a Senior Mechanical Engineer in the Energy Commission's Standards Compliance Office. Sam worked in the Heating Ventilation, Air Conditioning and Refrigeration industry for 20 years prior to joining the CEC.

He's worked on the end user side, designing refrigeration systems for Raley's supermarkets, as well as working for manufacturing companies, consulting firms, and design-build contractors. So, Samuel, go ahead. Thank you.

MR. CANTRELL: Thank you, Heather. I do bring a unique perspective coming from the private sector and spending most of my career there prior to coming to the Energy Commission. And I can tell you that the grocers and people representing the food chain industries are cautiously watching what we're considering in all these

regulatory efforts and trying to weigh the decisions of whether to go with these new generation of low GWP gases which might mean that they are able to keep some of their existing equipment or going to natural.

Which would definitely mean they'd have to replace everything and weighing that very nuanced decision ahead of them and what comes out of the Energy Commission and the Air Resources Board definitely has a huge impact on that.

I think probably they're all worried that they're going to find themselves in the position that Raley's was in … when I got hired there in 2003, they were on the downhill run of changing out all their ODPs. And I think we got to about 92% of our ODP inventory in all of our stores was changed out. And then the bad news came that our precious lily pad that we had jumped to, R404A was the highest GWP gas available. And we were kind of back to square one again.

And so, it's a big decision and it has a huge impact especially for all of those California-based businesses, they're definitely … came with a lot of unprecedented competitive pressures. And they're trying to navigate through these challenging times.

So, have patience with them. They're going to be looking to us for leadership and direction, and we've got a great panel here to give them some great information.

So, our first speaker that I'd like to introduce is Helen Walter-Terrinoni. She's the Vice President of Regulatory Affairs at the AHRI, which represents more than 90% of the US manufacturers of HVAC equipment and water heating equipment.

She's also currently a co-chair of the UN Montreal Protocol Insulating Foams Technical Options Committee, and a member of the Technical and Economic Assessment Panel. She holds a master's degree in chemical engineering with a concentration in environmental engineering from Syracuse University.

She spent seven years in the development of next generation, low global warming potential foam expansion agents and refrigerants, including examining impacts of insulation in energy usage. So, go ahead, Helen.

MS. WALTER-TERRINONI: Thank you very much. And thank you for having me today. So, the introduction for me really should have said I'm a massive refrigerant technical and policy geek. And I'm going to answer some very nerdy questions about refrigerants as well as provide some very down to earth basic solutions.

I'm also going to give you all a to-do list. So, I hope you don't mind that I'm going to do that. You can go to the next slide. Thank you.

So, we heard from Aanchal a little bit about the

background around moving forward from the Montreal Protocol to the American Innovation and Manufacturing Act. I will tell you that there were articles last week in Nature and Science talking about the monumental success of the Montreal Protocol as a climate agreement.

And I will tell you that one of the reasons that it has been so successful is there is significant stakeholder input and significant stakeholder support.

You can go to the next slide. Thank you.

So, you may know that the phase down of supply and production of HFCs is required under the American Innovation and Manufacturing Act of 2020, and also the Kigali Amendment to the Montreal Protocol. So, you can see the graduated steps down in supply as you go through the next 15 years down to 85% reduction in 2036.

You can go to the next slide. Thank you.

So, the HFC phase down is designed to create this imbalance. So, this economic imbalance between supply and demand. Of course, with reduced supply economics, there's scarcity and increased prices.

And you can go to the next slide.

So, I'm going to tell you a little bit about a chaotic transition and the lessons learned in Europe.

Next slide. Thank you.

So, the Montreal Protocol step down I just showed

you is depicted here in the orange line to the right. Europe went faster than that, very, very fast. And in fact, in 2018 they dropped the available supply of refrigerant by 37 point a half percent. So, the supply reductions outpace demand reductions.

The next slide shows that what happens when that goes on. So, the prices ratcheted up according to the Cooling Post (this is their information) by a thousand percent in that timeframe. There is also a lack of available supply and people didn't really know what to do. So, it was very, very chaotic.

And then next slide.

We decided that we'd like to not have that happen in the United States, and we'd like to proceed with a very orderly transition. So, the next slide talks about how we plan to do that.

So, there are options, of course, doing nothing is not one of them. The next slide kind of shows some of the things that we're working on. So, in order to balance that 40% reduction that we anticipate happening in 2024, with the steps down under the AIM Act, we actually have petitioned the EPA to set GWP limits in certain years.

We're trying to increase the use of reclaimed refrigerant, reduce charge sizes, retrofit equipment to lower GWP alternatives, reduce leaks, and retailers are

working to implement new architectures, so different types of equipment.

So, we're trying to balance supply and demand, and we're encouraging everybody in the supply chain to be very, very proactive because everybody impacts each other in this reduction of supply.

Next slide.

So, these demand reductions are coordinated with the supply reductions. So, in California, the California Air Resources Board, CARB, does have some of these refrigerant bans that the EPA also has tried to implement, and also global warming potential limits. And we've actually petitioned the EPA to limit the GWP, the Global Warming Potential to 750 for refrigerants, in 2025 for air conditioning. The second set of CARB HFC regulations also have this type of regulatory structure.

So, the next slide talks about better refrigerant management. And this is the goal of increasing recovery and recycle of reclaimed refrigerants. So, this is where I have a little bit of a to-do list for California.

So, one of the things that is kind of a quick action, quick hit item that California could move forward with, is they could contemplate requiring that only recovered and reclaimed refrigerants be used in public buildings.

So, in state-owned and operated buildings, use recovered refrigerant. So, this kinda depicts the refrigerant lifecycle. It kinda shows how refrigerant is produced and packaged and shipped, and then used, and then recovered, and then it goes back and it's cleaned up, and then it goes back around again. That's how it should work.

There are a lot of competing needs though, and a lot of challenges to this system. Some of the other things that I would suggest that California contemplate are starting an awareness campaign to educate responsible stakeholders on the need for better refrigerant management as a legal requirement.

In addition to that, I would suggest to you that this natural phase down of refrigerant, this supply reduction over time is going to help to drive some necessary economic recognitions to encourage the use of reclaimed refrigerant.

So, the price is going to go up for the new refrigerants. And so, people will be encouraged to use the reclaimed refrigerants. However, recovery economics could use some support. So, just so you're aware, contractors and technicians are challenged from time perspective to move very quickly through a job.

And through some additional training, perhaps they can find a way in their busy workday to choose to address

this environmental issue by … if we set up some things around shipping back to the wholesaler and doing some things around the reverse supply chain.

There are also some challenges around availability of cylinders for that reverse supply chain. So, these are some very important things that are going to need to be worked through, and really nobody in the world has the perfect answer for this.

I know Washington State is looking at this, and I do hope that California's going to come back and have another fresh look at this next year as well.

The next slide will move away from recovered and reclaimed refrigerants to talk about leak management.

You may not know this, but according to the United Nations Environment Program fact sheets, about 52% of the global warming potential is used to charge leaking equipment. So, this is a significant issue here in the United States and of course, around the world.

I'm going to give you some good news about leaking equipment here, as we go on through our discussion.

You can go to the next slide.

So, I'm going to talk about the different architectures. This is some different types of equipment that you might see in a grocery store, and the next slide shows how those might transition to alternatives that are

lower in global warming potential.

You can see here some very large charge sizes, a thousand pounds in some instances. And the next slide shows that some of those types of systems might no longer be in use in the future. So, when Building Codes are updated to allow for the low global warming potential refrigerants to be used, some of these types of systems may go away and folks may look at tighter, smaller systems that are going to leak less inherently.

So, I think that that's some of the good news that we'll continue to talk about. The next slide kind of shows the to-do list for EPA under the American Innovation and Manufacturing Act.

So, they've got to complete a supply side allocation rule that's going to drive up prices and drive down available supply by October 1st of this year.

On the demand side, we have coordinated filing of petitions with a number of other stakeholders. There's about a dozen petitions in the EPA's desk right now for them to work through to implement these demand-side sector transitions.

They need to respond to the first batch that we submitted with NRDC and others by early October of this year and indicate whether or not they will move forward with them. The next thing on their to-do list, we expect

them to start next year. They've had a lot of work to do around the AIM Act so far around refrigerant management program.

So, and again, they encourage very strong stakeholder input, which means they have very strong stakeholder support.

The next slide.

Now, I'm going to talk a little bit about the question that we heard earlier from Commissioner McAllister. What is the holdup already with these low global warming potential refrigerants?

You can go to the next slide.

It's the Building Codes.

Next slide.

So, with lower GWP comes flammability. Although there are some non-flammable refrigerants, like carbon dioxide, they're not suitable for every possible use. And so, unfortunately, and so some of these alternatives are lower flammability, so this pink depicts lower flammability while the red depicts higher flammability.

So, you can see on the left-hand side of this graph are the lowest GWP alternatives, but you can see that most of them are in the red and pink area.

The next slide.

So, what are we doing about this among the supply

chain? We started up the Safe Refrigerant Transition Task Force to examine all aspects of the supply chain to ensure a safe transition to low GWP refrigerants.

So, everything from the way that it's stored and handled in the plant site to the way that it's installed in equipment and maintained, to the way that it's recovered at the end of life, we are working through all of that and trying to move that forward as quickly as possible, to make sure that all stakeholders are aware of the best before. So, we've got these webinar series, and we're certainly trying to work with everyone.

You can go to the next slide. Thank you.

So, we've also done more than $7 million in refrigerant research for these low GWP refrigerants, especially focusing on the lower flammability A2L refrigerants or higher flammability A3 refrigerants. We've found that the A2L refrigerants are actually very difficult to ignite. They have a slow flame speed and a low heat of combustion.

You go to the next slide. Thank you.

So, you can see here that the heat of combustion is very low and also, the burning velocity is very low. And you can see a comparison here to hairspray and propane on the upper right side of the slide.

The next slide.

So, what the research has shown is that a refrigerant release, a very significant refrigerant release plus a competent ignition source would lead to an ignition. If you would eliminate one or both of those, you will prevent ignition. And those safety standards have been developed to prevent the combination.

You can go to the next slide.

So, the standards work together around the design of the equipment and the installation, and all of that is kind of wrapped up and goes into the Building Codes. The next slide kind of shows a little bit more about the Building Codes.

So, on the left-hand side of this slide, you see information about the safety standards that are required to be adopted into the Building Codes. And you see the ICC and IAPMO. Those are the National Building Codes along with NFPA, and those have to be adopted into the Building Codes over there way on the right at the state and local level.

The next slide shows where we are in California. So, this is the problem. So, we've been through this cycle before and failed to have the safety standards adopted into the Uniform Mechanical Code, which is mandated by statute to be used in California.

The International Mechanical Code, there is a pass

in the technical committee where that has moved forward successfully and that then needs to be … but the UMC must be adopted in California. The state Fire Marshal can propose a building code change but they're waiting to see what happens at the UMC.

You can see that the deadline for CARB and also potentially at the EPA is January 1st, 2025. The industry generally needs at least six years to transition but has said that they can accomplish this goal with at least two years, between the time that the Building Codes are complete and the implementation of the deadline for the transition for refrigerants.

However, you can see that the failure of UMC may create a bottleneck, and there may be a situation where California is the last state in the country that allows the use of low GWP refrigerants because of this bottleneck on the Building Codes So, you can see that this is quite a challenge and this needs to move forward.

You can go to the next slide.

And I know my time's up, so we'll move very quickly. So, what we're asking people to do all through the supply chain is invest in future success now. Use all the tools in the toolkit, use low GWP alternatives and new equipment, change the architectures in stores, consider smaller charge sizes, retrofit existing equipment to lower

GWP alternatives, reduce leaks and use recovered and reclaimed refrigerants.

And I think the next slide might be the last. So, you can contact with me with any of your geeky, nerdy, HFC questions, and I'll be very happy to help you with those. Thank you.

MR. CANTRELL: Thank you, Helen. As a fellow refrigerant geek, I appreciate that. We'll have time for questions at the end, but we're going to move into our next speaker.

Ankur Maheshwari is a senior Project Manager at Rheem Manufacturing Company, and he leads Rheem’s global decarbonization projects. He's responsible for developing and executing global decarbonization strategy for Rheem Air and Water Division, where he is bringing about sustainable and energy efficient projects products globally.

Prior to joining Rheem, Ankur, worked as Business Unit Manager at Vernay Laboratories managing their printer business. Ankur holds a bachelor of engineering degree in the polymer science and technology from University of Mysore in India. A master's in plastics engineering from University of Massachusetts Lowell, and earned an MBA from the University of Georgia. Go ahead, Ankur.

MR. MAHESHWARI: Thank you, Samuel. If you can go to my slides, I think that would be great. If you keep

scrolling down, I think it's after these slides. Keep scrolling down, thank you.

One more. That's perfect.

Thank you very much. Thank you for this opportunity commissioners and thank you to the staff. One more slide, please.

Just a Rheem overview; Rheem was found in nearly a hundred years back in 1925. We're the only manufacturer in the world that produces heating, cooling, water heating, pool heating, and commercial refrigeration product. We're the largest manufacturer of water heating products in North America.

Since there is a lot of refrigeration experts here, I will focus my presentation on water heating especially on heat pump water heater.

Next slide, please.

Rheem and CPUC have a shared vision. We have an aligned goal on energy efficiency. We are working very hard and we have a focused goal on increasing energy efficiency of our products and that's a shared goal that we have.

Emission reduction; we have very strict goals of our own around emission reduction, both internally as well as externally.

Early action; we have dedicated a lot of resources

around actions around efficiency, around waste reduction to be more proactive.

Consumer choice and affordability; that still stays the center piece of our design philosophy. We want to make sure that consumer both in terms of end user, as well as installers stays centered to our design philosophy.

Just talking about refrigerant selection, that's the topic here. Refrigerant selection and the management of refrigerant plays a role in the reduction of emission and decarbonization of the building.

I think the selection is important, but the managing of the refrigerant is just as important. As some of the speakers before me already mentioned that the leakage of refrigerant is mainly at the end of the life, and I'll share more what we have done on heat pump water heater.

So, as long as we have a good management of how we manage the refrigerant after the useful life of the equipment, that plays a huge role.

Gains through energy efficiency, still a key role in sustainable decarbonization of the buildings.

Next slide, please.

These are some of the things that we keep in mind when we select a refrigerant; installation is very important. And Helen went through some of these, so some

of this may seem repetition. Installation is absolutely important. I know Commissioner McAlister talked about CO2 unit.

Some of the challenges with some of the low GWP refrigerant especially around CO2. We start having challenges with system size especially in the market where we're talking about replacement market. It becomes a big factor when you're replacing especially for water heating or a furnace, when you're replacing a gas furnace, which is very limited footprint.

We have to make sure that that footprint is met so that we can replace a more sustainable energy efficiency unit in the same footprint. So, system size is absolutely important.

Installation time is important because installers are very particular and it's very important for the installers to ensure that they provide a good service to the end user, otherwise the total cost to the end user will be quite high, and that will impact the payback calculation for the end user.

Safety requirement, I won't dwell too much into it because Helen already covered a lot of that.

Availability of the key components, that's very important especially when you're designing a system to ensure that when we're selecting a refrigerant, the key

components are available, especially around compressors and other things.

Market application is another key factor. We've started to see different market applications, especially around combination systems where a system provides both space heating as well as water heating, is one of the key systems where refrigerant selection becomes a very important part.

Right now, majority of that market is sold by natural gas and selecting the right refrigerant that can work at a very low temperature and also provide a high outlet temperature is absolutely important. At the same time, we have to make sure that it provides a good payback calculation for the end user.

Overall system efficiency, the building owners are always very interested on the commercial side to understand and ensure that they are reducing the cost as well as the consumers are very interested.

So, overall, just to summarize, refrigerant is one part of overall emission potential for an appliance, but energy efficiency is still need to be considered, especially when it comes to replacement scenario of gas appliance to an electric or heat pump appliance.

Next slide, please.

So, I'll talk a little bit in more specificity

about heat pump water heater. We have our heat pump water heater, 240-volt heat pump water heater in the market. We're very proud of it. We are introducing a plug-in solution that was mainly introduced for the California market. This is a replacement solution.

The picture of the two of them on the right-hand side, those are the plug-in solution. They're 110 volts, and they're designed specifically to replace gas water heater.

Next slide, please.

So, here's some of the analysis that we have done if you replace a gas water heater. One of the things that we wanted to make sure is we're providing enough hot water because at the end of the consumer buy a water heater to get sufficient hot water, and the plumbers want to make sure that they provide and check that box.

So, we designed two systems, two solutions; one, to ensure that it provides the same amount of efficiency at the same time, provides the same amount of hot water. And at the same time, reduces the carbon emissions. So, you can look at it -- the new plug-in heat pump water heater reduces almost 79% of the carbon compared to a gas water heater.

And there is no need to compromise on the comfort. So, we continue to innovate in technology to bring solution

forward to the market as a need arises in different markets.

Next slide, please.

We have around 10 systems in field tests for over a year in California. A few of the pictures, and you can see these are common California installation. The challenge we have in water heating is most of the time the installation, water heater installations are in a small closet either outside your house or under a shed outside your house, or tucked in a garage.

And if you guys have not seen your water heater lately, then just take a look at it. It's probably tucked in somewhere tightly. So, installation is key for us. So, space becomes an absolutely important thing. So, it is very important for us to ensure that we have a drop-in replacement. So, that's one thing that we are able to achieve is have a drop-in replacement for a gas water heater.

So, these are all replacing a gas water heater. We were able to check most of the boxes, all the boxes that the consumer wanted, that we set out to achieve. The biggest one that we wanted to ensure was hot water availability. And we were very happy to get a good rating on that.

Next slide, please.

Rheem's approach; like I said, we're heavily invested in R&D in low GWP refrigerant technology. And we are very aligned with CARB and CPUC's initiative and need. But our design for heat pump water heater is factory sealed. It's a factory sealed refrigeration system for integrated heat pump water heater.

Like you see in the picture, we are getting ready to launch our commercial water heater, which will be a monobloc which is a similar system, which is an integrated sealed system, factory sealed system. The leakage rate on these systems are absolutely low.

So, as long as at the end of the life, we ensure that the end of the life is … the drainage of the refrigerant is done properly. There is very, very little opportunity for refrigerant leakage to happen. We are working on changing over our full stationary AC product line, and same thing on our commercial refrigeration with HTPG.

We have an entire team providing input on policy feasibility and timing, and focused on training leak prevention and responsibility end of life management. This is something that Rheem take very seriously. We constantly train installers not only on product installation and features and benefit that are very important for them, but also on how to ensure the end of the life management is

done properly.

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And that's my time. Thank you very much for the opportunity.

MR. CANTRELL: Thank you, Ankur.

COMMISSIONER MCALLISTER: Sam, can we go with Max now? I know that we sort of skipped over him?

MR. CANTRELL: Sure, absolutely.

COMMISSIONER MCALLISTER: Great. I appreciate that. He was waiting for … thanks a lot. Really appreciate it.

MR. CANTRELL: Yeah, I have the order wrong on my end, so I apologize to Dr. Wei.

Dr. Max Wei way is a research scientist in the Sustainable Energy Systems Group at Lawrence Berkeley National Lab. His expertise is in techno economic analysis of existing and emerging technologies and modeling future energy systems and scenarios.

Currently, Dr. Wei leads two projects based in Central Valley of the state; a project to improve heat resilience and disadvantaged communities called Cal-Thrives, and another to improve climate equity for residents and buildings and transportation. So, Dr. Wei.

MR. WEI: Thank you again for the opportunity to present, and I'd like to thank the commissioners;

Commissioner McAlister, Commissioner Rechtschaffen, and Commissioner Gunda, and also the previous speakers who have really provided excellent introductions.

So, this talk will be a little bit deeper dive on the engineering side on some of the features and costs in terms of the benefits and challenges in the deployment of A3 or flammable refrigerants in residential air conditioning equipment, smaller residential air conditioning equipment. And just showing the team members there below.

Next slide, please.

And again, we're very thankful to the CEC for their support of this work, which is just wrapping up now this month.

Next slide.

So, again, the project motivation has been mentioned, is the direct GHG savings that are available from propane also known as R-290 and referred to as R-290. Most of the refrigerant is vented to the atmosphere, unfortunately greater than 80% at the end of life typically. So, this is why it's important for these smaller AC units, 99.9% savings over R-410A, which is a reference HFC high GWP refrigerant, 99.7% over R-32, which is an alternative lower GWP to R-410A.

And so, just shown in the plot below is R-410A is

a nonflammable Class A1 refrigerant. R-32 can reduce about two thirds of the refrigerant's GWP, but is mildly flammable, Class, A2L. And propane there just would have a whisper of the direct emissions, but is flammable and is a Class A3 refrigerant.

Next slide.

One of the other motivations is in addition to the fact that the state has the goal and target to electrify heating for building decarbonization, refrigerant emissions will probably grow further from climate change-induced hotter weather and increased AC adoption.

So, on the left, it's just showing the shifts in the cooling degree days by climate zone in a BAU scenario from 2015 to 2050. So, you can see the blue shifting upward to the red, and also you can see that essentially to the climate zones are shifting.

So, for example, on the right of the coastal San Diego climate is projected to become more like central Sacramento-like weather in terms of cooling demand. And the Central Valley, Fresno area is projected to shift to be more like a high desert. So, even hotter and more cooling demand.

So, two things going on here; we expect more demand in existing air conditioning, but also more AC adoption in places which don't normally have air

conditioning, such as San Diego and the Bay Area.

Next slide.

And so, this is particularly relevant for this work because we're talking about small air conditioners. And if people feel discomfort or very hot, they're likely to just go out and get a small air conditioner, something like a window AC.

So, the project approach here -- and here, we're jumping into a lot of engineering details, so a little bit different talk.

But our first task is to model window air conditioners and mini-split air conditioners for optimal performance using industry standard tools. We also tested six units of small air conditioners, drop-in testing, that is to say, just replacing the reference R-22 refrigerant with propane refrigerant. We tested two units of window AC, two units of package terminal AC, and two mini-split AC units for energy efficiency and capacity.

And then third, we estimated incremental equipment costs associated with shifting from reference refrigerants 410A and 32 to R-290 propane. Finally, we modeled the lifecycle cost impact in a 30-year net impact analysis, which will save the overall GHG and overall cost impact of our transition to R-290 in these products.

And out of scope was a risk assessment of R-290 in

small ACs. So, there have been other projects which are focused on the risk assessment. And I think these are described a little bit by Helen or one of the previous speakers.

And also, we're not considering small commercial or domestic refrigeration because we're already starting to see units on the marketplace with hydrocarbon and propane refrigerants for those systems, like True is one vendor for that.

So, next slide.

For those who are not so familiar with room air conditioners or smaller air conditioning units, we're considering mini-split ACs, and these are not self-contained units. So, there is an outdoor unit. Typically, the indoor unit is mounted close to the ceiling as shown here. And these are very common in Asia. And the nominal size here is one to two cooling tons.

Packaged terminal ACs or PTACs or Packaged Terminal Heat Pumps are common in motels and hotels. So, you've probably seen them. And they're typically mounted close to the floor. And this is important because if there's any propane, leakage propane will fall -- it's heavier than air, will fall to the ground. And so, there's a greater risk of pooling if there's an ignition source. So, it's less favorable to be mounted lower to the ground.

And these are typically less than one ton.

And then commonly seen window ACs mount into your window, typically at the lower part of your window. So, they're a little bit intermediate in the vertical height to the other two types. These are self-contained units, and these are again typically below one ton in capacity.

So, next slide.

So, I'm just going to run through one slide for each of the tasks. So, in terms of the modeling results, we do find that R-290 as it's known is a good refrigerant in terms of thermodynamic properties. The optimally designed window AC, we can achieve a 24% energy efficiency increase over the reference R-32. So, that's the lower right-hand plot.

And the second plot here in the upper right, is with a drop-in, you can see that the blue bar, the cooling capacity is degraded a little bit, but with an optimal design, you can recover most of that cooling capacity and achieve within two and a half percent of the original refrigerant's capacity. And there's some details on the lower left that I won't describe.

But just as a side comment, the reason that we're using R-22, which is freon, which is an older generation refrigerant, is because the R-22 compressor was compatible with R-290, so we have to use that for this drop-in

testing.

Next slide.

We also did something very similar for the mini-split and got very similar results.

So, for the testing results relative to the reference R-22 refrigerant, the optimal R-290 charge yields a small decrease in cooling capacity of about 3 to 6%, but a larger increase in efficiency of around 10%. So, the mini-split example is shown there as a function of the charge on the X axis, we're plotting the capacity and the energy efficiency and the maximal point.

So, the summary of that is the optimal R-290 charge yields a 5% drop in cooling capacity, but an increase, an 8% increase in efficiency. And on the left is just an image of the LBL air conditioning test chamber. And there's also a refrigeration test chamber alongside that at LBL.

So, next slide, please.

So, the next thing we looked at was to try to quantify the incremental equipment cost in shifting from R-410A to R-290 or from R-32 to R-290. So, for a mini-split in a window AC, those incremental costs are pretty small at 2.5 and 7% respectively. And these are accounting for several factors. First of all, is to upgrade the factory, but the production facility costs for safety features.

The compressor change in moving to an R-290, appropriate compressor safety measures and the refrigerant change -- those are shown here on in the bar charts on the right where the net cost impact is a black arrow, and the components, the factory upgrade cost is very small, it turns out. The compressor cost is in orange.

Most of the upgrade cost is related to safety measures, and there's actually a cost savings in shifting to the refrigerant for two reasons. Firstly, because the R-290 quantity is lower than the reference refrigerants and also the cost of R-290 is lower than the reference refrigerants.

And then moving from R-32 to R-290, we're seeing about half of the incremental increase. So instead of 2.5 to 7%, it's on the order of 1.5 and 3%. So, pretty, relatively manageable cost increases in this modeling.

Next slide.

Okay. So, in terms of the lifecycle cost and net impact analysis, again, these slides are showing/have the assumption of equivalent energy efficiency for R-290 relative to the reference refrigerants. And here we're showing the average installed cost increase in blue, and the average lifecycle cost increase in orange as a relative percent.

And you can see that all these are pretty much

below 5% with this one exception. So, if you look by product type, it's saying that with a $26 rebate, you can get an installed equipment cost parity.

So, this is typically on the order of 300 to $400 to install a window AC. So, it's that rebate and you can see that the lifecycle cost increases, which include both the installed cost and the operating cost. Increase is again, nominally but in the single digit below 5% in all cases.

In terms of the cumulative GHG savings, and this is like a technical potential, the savings are 12 million to 38 million in comparing to a baseline refrigerant of R-32 or R-410A. So, it can be relatively significant.

Next slide.

But the key regulatory barrier is the charge limit. So, the current UL charge limit is pretty stringent at 114 grams, about 0.1 kilogram. The prior ruling from the EPA, which were also based on an earlier UL charge limit had set the maximum at one kilogram. So, currently we're very constrained for the amount of R-290, which is permitted in air conditioning.

You can see that the test condition for this report for window AC is shown with the blue star and the gray star is for the PTAC. But the blue star for the window AC is meeting the EPA's 2015 limit. So, that's this

curve here.

And one other note here is that the IEC, the International Electric Technology Commission has already approved higher maximum charge limits than these EPA limits. So, internationally, the maximum is actually above one kilogram with some room and configuration requirements.

So, you can also see that the charge limits from the EPA's 2015 rulemaking increased with capacity and the allowable charge increases with the distance of the height above the floor for the reasons that I mentioned.

So, the ceiling-mounted AC has a highest charge and the PTAC has the lowest because it's closest to the floor.

Next slide.

So, just in conclusion, R-290 has deep reductions in direct GHG emissions. The incremental costs for equipment are in the low to single mid-digit percent increase over R-32 and R-410A. Our equipment modeling shows room for potential energy efficiency improvements over reference refrigerants. And our testing is showing that for window AC, the charge can meet the EPA's 2015 charge limit for small AC of below about one ton.

And the current UL limit is very stringent of 114 grams, but the IAC has moved forward with larger charge limits for R-290. So, again, that goes back to the earlier

question to Aanchal, why we're internationally, they're moving forward with A3.

So, that concludes my talk. Thank you.

MR. CANTRELL: Thank you, Dr. Wei. I know coming from the grocery side, we were anxiously awaiting the day when the charge limits would be raised so we can use them on larger display cases. It shows such promise with its energy efficiency and the cost of the refrigerant being so low. So, it's good information. Thank you very much.

Our next speaker is Alex Hillbrand. He's an engineer that has been working on policies related to HFC refrigerants and energy efficiency for six years at the Natural Resources Defense Council. So, Alex, the floor is yours.

MR. HILLBRAND: Great. Thank you so much, Samuel. And thanks to everybody else who has preceded me today. I have the benefit of going later in the agenda. So, I hope you'll indulge me if I give more color commentary than facts here about my first favorite thing and my new favorite thing. And this is HFC refrigerants and increasingly building decarbonization.

Next slide, please.

So, these are two topics, really key to NRDC's vision. By the way, we're an environmental group for those of you who don't know us; national and a strong presence in

California as well. These are two key focuses for us and we need to make them play ball together. And so, that's part of the fun that we have ahead of us.

So, starting out on HFC's -- this has been mentioned. Aanchal and Helen, both gave you the good news about the AIM Act which is dropping our reliance or our use of HFCs by 85% over 15 years.

So, this is a really fast pace of reductions. When we agreed this agreement in Kigali five years ago, we thought we would be starting in 2019. So, we're a little late to the party, but nonetheless, it's happening starting basically in a few months. At the be beginning of 2022, we're going to see that supply constriction that Helen mentioned.

So, as also as mentioned, we're expecting rather a few upcoming regulations out of EPA, other than this supply reduction. And that pertains to these sector end-use bands as was discussed. And the point that Helen made, and I'm glad she did, is that the purpose of these is to make demand cuts, bring down the eligible uses of HFCs to keep pace with these supply reductions.

Also, if you're ambitious enough, and I think collectively, we have been in our petitions to EPA, you can accelerate the transition away from HFCs this way. And the state of California, by the way, has urged EPA to take some

aggressive steps, essentially nationalizing some of the great regulations we're seeing out of CARB which is extremely helpful.

Another set of regulations, again also, discussed, but I'll hit them quickly; refrigerant management and perhaps some new reuse, recycling, so-called reclaiming regulations. This will go a long way to directly cut down the emissions of HFCs already out in the world by setting leak rate limits, things like that. California is no stranger to this.

The 10% reclaim requirement in the new R4 program update hopefully will become something of a template for the federal government going forward.

Next slide, please.

So, while we're phasing down, we're also phasing up in the world of heat pumps. And so, as others have said, this is an interesting paradigm. And in my view, they're not at all at odds, but we do have to be smart about how we do it. It is indeed likely that refrigerant use is going to rise pretty significantly as we decarbonize the built environment. But it's not all bad news.

We can do it. Part of … I have a couple just small comments here. The one thing folks don't always consider is that most homes in the US, and it's a little different and more varied in California, as Max was getting

at, already have air conditioning.

So, if you're looking at an air conditioning/furnace combination in an average residence somewhere, replacing that system with a heat pump system is not necessarily bringing in all that much additional incremental refrigerant charge.

In fact, if the AC that's there is way too big and you do a better job sizing the heat pump, you might not add any at all. But that's not certain. And we do have to all take some purpose work with our OEMs to make sure that heat pumps are designed to use as little refrigerant as is practical.

A quick look at the market today shows wide variability in the amount of refrigerant charged into a heat pump versus an AC, otherwise the same unit. Sometimes there's only 10% more refrigerant. Sometimes there's more than 50% more refrigerant. So, we have to understand better why that is and avoid it when it's not necessary.

My last point here is just the very basic point that we're going to do this by transitioning to new refrigerants across heat pumps. But I won't get so much into the particular alternatives today.

Next slide, please.

So, I, like Helen, have a few to-dos to run through for everybody so that we can phase down while we

phase up. First pertains to barriers that we're looking at. Second, a financial means of clearing some of those. And finally, just some good feelings to move forward with.

So, next slide please.

So, number one problem for me, and I think for all of us who want to make this transition to lower global warming potential refrigerants, as Helen said, is that the California Building Codes, Mechanical Codes in particular are not on track to be updated as fast as they should be to make this transition, given where everybody else is in industry.

The standards updates that are needed to make these changes have been agreed at the ASHRAE level, the UL level, they've passed the International Code Commission, ICC recently. So, these are very well-baked 15 years in the making types of changes that we need to see adopted in California to allow these so-called A2L refrigerants, which are climate friendlier onto the market.

This is the biggest HFC emitting sector, is this A2L using stationary air conditioning systems and heat pumps as well. So, we really can't move forward until we get this done. And so, it would be really excellent as we're bringing together the refrigerant and the decarbonization stakeholders, to have a broader base of support to ask the leaders in California that need to make

this change, hold them accountable and have them make the changes that are needed to do this safely.

And it certainly can be done. 30% of the country's population is in a state that has allowed these onto the market. Although they're not quite there yet, but the markets are open and that's the point.

Next piece where there's good synergy with these two issue areas is technician training, expansion of workforce, this kind of thing; these new refrigerants, these A2Ls are somewhat flammable, they're also going to be more advanced systems for a number of reasons.

It's important to have … and when we look beyond air conditioning, by the way, and refrigeration, we're talking about CO2 based potentially transcritical systems, more complicated to work on -- we need the workforce that can do it. And so, too with heat pumps, as I think you all know better than I. I've personally had several contractors at my house trying to talk me out of a heat pump which is not the way we're going to do this thing.

So, there is an opportunity to kind of move in this direction and cover a number of bases as we work on this HVACR industry workforce.

Lastly, there may very well be, there certainly are some incremental capital cost upgrades associated with going to climate friendlier refrigerants. So, we have to

do something about that in some cases or deal with it.

But in the case of doing something about it, that takes me to my next slide.

Next slide, please.

So, incentives with regards to HFCs I want to say, first of all, lots of heat pump deployment, market transformation programs. That's all a very great idea. I'm trying to talk at the intersection of issues here. Number one thing to keep in mind is this HFC phase down, this 85% over 15-year decrease, this is really significant and that's federal law.

And so, we do have to be careful to make sure that incentive programs except for where we want them to aren't paying for things that are essentially required by some regulation or other, be it federally or California, of course, has many.

But there are many reasons that some targeted spending does make sense and expanding that spending does make sense. So, talking about these newer technologies, more costly, big emissions reductions potential that aren't mandated yet.

CO2 and supermarkets is a great example and CARB with the (indiscernable) Program has started there, this makes a lot of sense. It particularly makes sense in low-income communities and communities of color. We want to

get these facilities transitioned first, so they're not left behind on account of say the higher cost. And then they're saddled with this aging infrastructure.

Helen talked about the rising prices of HFCs as the phase down gets going. We definitely want to avoid that.

So, another key point which came up a little bit earlier, in our view, heat pump deployment is of the utmost importance in terms of transforming our economy to low carbon.

And HFCs also very important, but we've got this major set of regulations happening to start working on that. We don't think that low GWP refrigerants should be a requirement of heat pump deployment incentives programs by way of eligibility, not eligibility criteria.

That just risks basically excluding heat pumps or risking slowing those programs down at a very important time. The HFC phase down bit will get there. Kickers though, as I believe CPUC has settled on proposing in some cases; extra money for low GWP sounds great.

So, next slide, please.

Yeah. So, last point here and reason I'm very happy to join you; I don't think maybe that all of our decarb and refrigerant stakeholders are getting together quite enough, often enough, that is -- this is going to be

an interesting time for refrigerant using appliances in their markets and all of this.

In my estimation, what AIM Act, the federal phase down says by way of its schedule is that every appliance that uses a refrigerant will need to find a lower GWP alternative. They may not be tomorrow, indeed it probably won't always be tomorrow because the supply phase down will have the effect of sort of getting at the biggest refrigerant users first, which is good.

But eventually, if that day comes that we can have a heat pump water heater in every home in America, that's also a lot of refrigerants. So, while they may not be necessarily transitioning first, we definitely need a plan to get everybody moving on to the next generation.

And so again, just reiterating though that heat pump deployment is of utmost importance.

And with that, I'll take my next and final slide.

So, thanks so much to the Commissioners, all of you, I am happy to discuss all of this with you later.

MR. CANTRELL: Thank you, Alex. I think Helen and Alex both touched on some really great tools to use as a means of reducing carbon footprint. And it's funny how in my experience, a lot of times those efforts have their own built-in financial incentive, if you establish a culture of conserving resources. And I think a great example of that

is something that our next speaker's going to be talking about.

I mentioned in my introduction that we ran into kind of a worst-case scenario at Raley's, where we were transitioning away from ODPs. And we got right in the crosshairs of the high GWP gases. And that's kind of made me keen to natural refrigerants in my career since then.

And I focused a lot of my efforts and research and training in that realm and one of the landmark installations, I think in our country in transcritical CO2 systems, it is actually the baby of Mr. Michael Lau who's our next speaker.

He was born and raised in Modesto, California. His parents started Yosemite Meat Company, and Michael spent much of his childhood learning the ins and outs of the meat industry.

In Cal Poly, he pursued a degree in agribusiness and a minor in meat science. He went on to earn a PhD in agricultural economics from Texas A&M University, and worked as a professor of agribusiness at Sam Houston State University for six years before returning to California.

He holds two wine-related product patents. He consults for marketing and grants in the agricultural field. He's currently a Vice President of Yosemite Foods, a sister company to the original Yosemite Meat Company.

So, Mr. Lau, I'm going to turn it over to you.

MR. LAU: Thank you. Well, thanks for allowing me to speak this afternoon. It was kind of our last-minute thing with Sam there, but happy to share with you guys some thoughts about transcritical CO2 and our experience from it.

I believe I'm the last speaker today, so I'll try to keep it short. And I've given a lot of different presentations being a professor before, and there are no words on my presentation, I think, right? So, if you guys want to slip the slide to the first picture there.

So, there's a picture of our control system. I'm going to give you a brief history. We started looking at expanding and building a new facility here in California, back in 2000 and like 16. And with that, we ended up getting multiple refrigeration bids as we would for any contractor for designing this.

And almost all of them were traditional bids. We got ammonia, we had cascade systems, and we had freon systems. And then lo and behold, we started looking at all this and one of the companies happened where Sam worked at RSI, they proposed a CO2 system for us, a transcritical.

And we're like, "Well, this is interesting. We've never seen this before. It's actually brand new to us." And so, one of our shop managers where he … he's not with

us anymore, but he always said that this is the way we need to go, because if you go any other, you're screwed in the future. You know, with regulations and everything else like that.

So, we started investigating and we did a lot of research into transcritical CO2 systems. And after long deliberations and looking at the cost-benefit of it, where the future's going in refrigeration, what we think, we decided to invest in this as we felt it was I guess not future-proof, but the way of the future.

I'm not sure if we're smart because we are the first to build a facility this big, or if we're dumb for building a facility this big at the beginning. But we took this leap of faith and picked a good contractor on our side to build it.

So, this system powers about 116,000 square feet of refrigerated space in our plant, which consists of medium temperature of 32 to 34 degrees and low temperature of -5 to 0 degrees for freezing. There consists of five different racks. You can probably pick the next picture, show some of the other racks there.

But there's five different racks with 13 compressors sit in this plant. Everything here has been automated for us. We looked at many aspects of this as we didn't know what to deal with. And some people thought we

were crazy and some people were really, really supportive of it because they felt in the industry, this is the way some of the future was going.

So, we looked at it and we decided that this this could work well for us and looked at the capital costs. And historically, that's been the main issue in California -- not just California, actually; in all areas that transcritical systems are costly more than ammonia and they were.

But we actually saw some benefits from it that we thought in that this is a system that operates like many systems like a freon system or each rack has multiple compressors and we could vary the speed with EFDs, and there was availability of CO2 and it's much safer than ammonia is out there.

We would've had over a 10,000-pound charged ammonia, which kicks in a bunch of regulations of OSHA, where the CO2 is relatively limited. And I guess, because it's a little bit newer in types of regulations, we're dealing with the pressures and release for the plant here.

So, we took this faith and we built it. And a couple things that we felt made it worthwhile; one, is that is a low greenhouse gas and the lowest thing that helps us. And that this tells a story for the future, we are an efficient plant or a green plant that helps or cares about

the environment. And two is the cost as we felt the cost differential between ammonia and CO2 was minimal in the operating cost. What was modeled was similar to what we would expect from an ammonia system.

Now, we don't have a direct comparison because we didn't have ammonia at this plant here. So, it was hard to tell. I think we felt that that was one of the biggest challenges back in the day, is that most people can calculate how much it cost to run a system per square foot for ammonia.

But with a transcritical system, it's hard to calculate and model that. And I know it's advanced much since then or not like that. But we looked at it and took that seriously into consideration. The other big thing that we see is that there was some efficiency gained in heating water and taking the gas and preheating water for our process systems and our hot water plant.

You can go to that next slide there.

We actually, being a meat processing plant, we have to have sanitary water throughout the plant and we preheat all the water by taking all the hot gas from the refrigeration system, the transcritical and preheating it now. We've implemented after everything was done all these heat exchangers in here so that we could do this. So, it tries to save us money on that end as well.

So, there's been some challenges. I can't tell you that it's been a hundred percent smooth sailing compared to ammonia systems or cascade systems in general here.

Being a plant of this size where there's five racks and 13 compressors on each one, this is much more, I guess … it's a finicky system. And that's why I think you'll see some of the challenges -- the previous presenter said something pretty interesting about service techs and heat pumps and CO2.

And I think we feel the same way here is that I think one of the limiting factors that you'll see in commercial industrial people adaopting this is that most people are going to quote you an ammonia system because that's their history. That's where they have their technical skill at.

And the technical skill here for service and maintenance of a transcritical CO2 system like this, is challenging. And we've had a couple people --- not people, but companies coming to us to shop around and wanting to say, "Hey, we want to take over your service" and we show them what it is and some are "Okay, we could do that."

But we ask system for their specialty and they couldn't really know how it works quite well enough. They think it's like any other refrigerant system, but it's not.

So, that's where it gets a little, I think, challenging in terms of California and in general, all production people adopting this system.

Operation-wise, it has been operating pretty well since it started up. We've had normal few issues with valves sticking open, losing CO2 gas, and such like that. But we built this system as a redundant system where each rack powers coils in different rooms so that if anything ever goes out, we always have a backup rack running and keeping that cool.

In let's see … February, almost two and a half years has been operation, we've only had one rack go down for a few hours because it lost some oil and the compressors couldn't run because there was no oil in there. But other than that, it has worked pretty well in terms of the system.

Another headache that we've actually seen is that we talked about CO2 being used as a refrigerant, but we have to buy refrigeration grade CO2, which is medical grade basically and pure CO2 like this. And normally, I don't know if it'll be a problem at all, but with COVID and everything last year and CO2 shortages throughout the US, it was really hard at times for us to keep CO2 in stock. We keep around 34 bottles of CO2 on stock to replenish anything.

One surprise is that compared to ammonia system leak -- when you have ammonia leak, there has to be notification of everything here. We've had multiple little leaks of CO2 where it's like a valve or pressure gets too high, the safety valve blows off some CO2, and we've had to replace a little bit more than what we thought there was.

And so, that's caused some issues there. So, overall, I think technology is always advancing and we thought that this transcritical CO2 is the kind of the wave of future possibly in terms of refrigerants for a commercial or processing facility.

There are hiccups. I mean we all know what the regulations will be coming up. I know I saw something come across my desk for a two-minute … no, I got my note; two minutes. I better finish up now -- about Title 24 regulations for it and how they play the play. I'm sure there will be some more OSHA regulations looking at this in a second.

So, it's a pretty interesting system and it's been pretty well so far. So, I'm hoping that any questions you guys might have or anything about adoption and how we kind of went about the process more and how we feel the energy uses is and such like this for the plant. So, thank you.

MR. CANTRELL: Thank you. Thanks so much for sharing your experience with this system. We have a few

minutes for questions to be submitted on the Q&A section. We've got a couple in that we can get routed to people. I think the first one-

MS. RAITT: Samuel, do you want to first check to see if the commissioners have some questions?

MR. CANTRELL: Sure, sure.

COMMISSIONER MCALLISTER: Okay, Sam, thanks a lot. And thanks to all of you, all five of you for really great presentations.

I'm not going to pretend to really be able to formulate an intelligent question here because I think there's a serious amount of knowledge already in the room in sort of helping navigate what is doable in the policy realm and what is state of the art and how we sort of guide that I think will be an ongoing discussion across all the agencies.

Helen, I really appreciate your expertise there and Max and Ankur – Max, thanks for your academic treatment and all the good research you're doing. And Ankur, Rheem is such a leader. Yesterday on the Assembly panel on building decarbonization, we had a colleague of yours from … who was it? It was Josh Greene from A.O. Smith.

And so, we're trying to include across the industry voices in this so that we can really craft good policy and work well across the agencies and with all the

stakeholders.

And then finally, Alex always appreciate NRDC and Michael, that was inspirational, really. Thanks for taking that leap of faith that you described. I see Commissioner Rechtschaffen has his hand up, so go right ahead.

COMMISSIONER RECHTSCHAFFEN: I was very crushed when Alex said that he had two favorite things and the building decarbonization was the second one, and refrigerant policy was the first one. And I do building decarbonization, but not so much refrigerant policy indirectly. I'm trying not to take that personally.

I did have a follow-up question for you. You had mention in your slide, we need to focus on low-income communities and communities of colors first. I just wonder if you could provide elaboration about what kind of policy, tools, ideas you have to implementing that objective.

And by the way, anybody else on the panel should feel free to respond as well.

MR. HILLBRAND: Yeah. Thank you so much for the question and I don't mean to offend with my love for refrigerants here.

Yeah, I'm specifically referring to incentive spending and looking at prioritizing those dollars in the communities that I mentioned, for the reason that as Michael has said, there can be significant incremental

costs to some of these technologies for a while. It's important that that not be a barrier or rather that in different types of communities, that can be dealt with totally differently.

And we don't want that disparity to result in saddling this old infrastructure with folks who are maybe not as well able to afford it. And I think CARB's regulations, which differentiate with smaller grocers for this reason, because they tend to be in communities that may have greater food desert kind of issues related.

I think that makes a lot of sense. SMUD with its low GWP efficiency trial pilot program looked at prioritizing certain communities for that. So, these are the types of things that to me make a lot of sense and that's true as well … yeah, I'll stop there. Thanks.

MS. WALTER-TERRINONI: Maybe I could just add that, that we kind of went through some past history around incentives, and what we found is that point-of-sale incentives are the most effective to drive energy efficiency or any new type of equipment. So, somebody's making a decision right there, then and there, if they get a rebate immediately in hand, then they're more likely to choose the option that you'd like for them to go with.

COMMISSIONER MCALLISTER: Can I ask a quick follow on there if you don't mind, Commissioner? No, go ahead,

Ankur.

MR. WEI: Oh, I was just going to add to Cliff's question that there's also on the demand side for cooling in particular, energy efficiency measures, traditional energy efficiency measures, but also passive measures that there are opportunities at the point of changing your roof or repainting your home, for example, for cooler surfaces, cooler roofs or cooler walls, which really are very minimal, incremental to no incremental cost.

So, just keeping that in mind, not widening the scope too broadly, but just on the demand side to try to reduce those demands and to reduce like the peak demands on the hottest summer days. Those measures can also help. And it also ties to what the benefit overall to the grid can be, to the peak demand and speaks to equity as well in really hot areas.

COMMISSIONER MCALLISTER: Thanks for that. I wanted to piggyback on Commissioner Rechtschaffen's question and maybe this is for Helen but others perhaps; so you mentioned the point of sale. So, that point of sale is often on burnout in particular with water heaters, but when you don't have cooling or how water.

So, in terms of just making that happen on the truck or just right there in a really quick turnaround, quick decision kind of mode -- how large do you see that

problem actually being, and assuming it's significant, what solutions would you recommend there?

MS. WALTER-TERRINONI: We've actually seen incentives that the contractor can provide right on the sites. And I think that's especially important in emergency situations, especially for families and businesses with limited means, that they're able to say here's one choice and here's the other choice, and you get $500 off or back with this other choice.

So, I think that … by the way, your energy bill is going to be lower or whatever it is that that else could be offered there. So, I think we've seen that in the past where contractors have been able to do that and with very good success with energy efficiency, afford more energy efficient equipment.

COMMISSIONER MCALLISTER: So, you don't see a resistance to having multiple equipment like on a truck or in a warehouse nearby for that kind of situation? I mean, it seems like the supply chain would need a little tweaking to sort of ensure that that happens consistently.

MS. WALTER-TERRINONI: I mean, it's only a phone call away. When the phone call is made initially, you kind of have the conversation upfront, yes.

COMMISSIONER MCALLISTER: Yeah, okay.

MR. MAHESHWARI: If I can just add a comment

Commissioner, that seems to be one of the big challenges in emergency scenario, if the supply chain does not have a water heater and somebody wants a water heater replaced.

I think the incentive program has to take that into account, especially in a retail supply chain and the current incentive program may not necessarily be best conducive to a retail environment. So, I strongly recommend that there's some program work that will allow the incentive program to be more favorable or conducive to the retail program.

So, that a big box store, retail stores can floor heat pump water heaters because that's where we see majority of the consumers walking and that's where we see foot traction happening.

MS. WALTER-TERRINONI: And Commissioner, maybe the better answer to your question, a lot of times if somebody comes out to diagnose a problem and then they will make a second trip to bring new equipment. And so, that's kind of where the conversations can take place. So, maybe that’s more helpful to understand how that works.

COMMISSIONER MCALLISTER: That seems like there'll be a difference between an HVAC and a water heater. But yeah, it's really helpful. I think this will be an ongoing conversation. We need to figure out what the incentive environment -- this is certainly relevant for the PUC’s

programs and definitely for existing buildings generally. And we've got to figure out where those pressure points are.

And maybe there's a combination of retail and upstream programs. But we should keep that conversation in mind. So, thanks a lot for that, for those answers.

Commissioner Rechtschaffen, did you have another question at all? Okay.

COMMISSIONER RECHTSCHAFFEN: I don't Commissioner McAllister.

COMMISSIONER MCALLISTER: Great. Thank you very much. And thank you for being here both in the morning and afternoon. That's really tremendous … I appreciate that.

So, we're pretty much right on time. So, Dorothy Murimi from the Public Advisor's Office says we do not have any public comment, but we do have a couple on the Zoom Q&A that we can knock out here. So, Sam, you want to try to moderate those two that we have on the Zoom Q&A.

MR. CANTRELL: I think they're essentially the same question. And I think that they were intended for Helen perhaps. It says: Will the CEC, CPUC, and ARB help with the Building Codes that we can use A2Ls?

And the second question; was there something needed legislatively to unblock the process of getting low GWP refrigerants into the Building Code?

And if I could maybe reword that; is there anything that can be done to help streamline that bottleneck that you described in getting the A2Ls through the UMC approval process where it's stalled out?

MS. WALTER-TERRINONI: I think the first question is probably for the commissioners, and I can take the second question and talk about maybe what's been done in Texas.

So, forward-leaning, climate friendly Texas has actually enacted legislation to require the allowance of any refrigerants that is allowed to be used by EPA can be used in Texas according to, in their Building Code.

So, forward-leaning Texas and Oregon have both enacted legislation to that effect. So, whether or not then it needs to be kind of a mechanism that's used in California, I guess, we'll have to see, but I think we've got some leaders with those climate friendly states.

COMMISSIONER RECHTSCHAFFEN: I don't know if that's going to be a selling point to get it enacted in California or not, Helen.

MS. WALTER-TERRINONI: No, I'm being a little bit concerned … I'm being a little bit sarcastic.

COMMISSIONER RECHTSCHAFFEN: So, I'm teasing but that's very interesting.

MS. WALTER-TERRINONI: It sailed through without

an iota of opposition, and it was bipartisan all the way in both states. But I think the first question is to you all commissioners to see if … I think that that's what he's asking you, is whether or not there'll be some support from you all.

COMMISSIONER MCALLISTER: So, I think that the question – and Commissioner Rechtschaffen, with your deeper experience than I have in state government, maybe you have more insight on this. But I think the three agencies; CEC, PUC, and ARB would certainly be supportive of this, but I think the decisions have to be made elsewhere.

We would line up our relative authorities with whatever pathway needed to take place. But we're not where the bottleneck sits. So, we need to sort of utilize our agency level "soft power" a little bit to move this along, I think, and we should talk about how to do that. And to the extent there are questions that actually need to be answered, or at least to the satisfaction of those decision makers, we need to just encourage that.

COMMISSIONER RECHTSCHAFFEN: I don't have anything to add. I agree with you. That's exactly right.

COMMISSIONER MCALLISTER: Great. Okay. Well, thank you for that endorsement. I appreciate that. That means a lot to me.

So, let's see … I think unless we still have no

public comment, I think we might be able to wrap up at this point. I want to just … yeah, go ahead, Heather.

MS. RAITT: Commissioner, I'm sorry, this is Heather. Yeah, no more public comment on the Zoom, you're right. But yeah, go ahead Dorothy. We do have a hand up for public comment, excuse me.

COMMISSIONER MCALLISTER: Oh, we do, great, okay, yeah.

MS. MURIMI: Thank you, Heather and thank you, Commissioner McAllister. So, I'm just going to give announcements just in case other attendees may not be aware.

So, we are now in public comment session. One person per organization may comment and comments are limited to three minutes per speaker. If you're using Zoom, you can use the raise hand feature. It looks like a high five, and that'll let us know that you would like to make a comment.

We'll call on you and open your line. Make sure your end is unmuted. And then you may begin your comment. So, I'll start with our first commenter.

I see Jennifer Lu from SoCalGas. You may unmute on your end and give your comment. Give that one moment. Jennifer Lu, can we unmute Jennifer Lu? There you go.

MS. LU: Hello? Hello, yes, my name is Jennifer

Lu, and I'm representing SoCalGas. Thank you to commissioners McAllister, Gunda, and Rechtschaffen for putting together today's important workshop.

SoCalGas has conducted two successful research projects through the CEC natural gas research and development program to demonstrate the use of gas heat pumps in commercial and residential settings. One of the demonstrations used an integrated single effect, absorption natural gas heat pump system prototype in two full-service restaurants.

Based on the current distribution of gas water heating product types in California, a 10% market penetration of the integrated gas heat pump system could yield an annual natural gas savings of 13.6 million therms and a reduction of 80,000 metric tons of CO2. This is equivalent to offsetting the electricity usage of more than 13,000 homes for one year.

SoCalGas has implemented its aerial methane mapping program that uses light detection and ranging technology integrated to a helicopter that can identify methane emissions as a plume of gas. This program allows us to proactively detect potential leaks as well as incomplete combustion that could be associated with gas-fired equipment.

These detection technologies allow us to exceed

our compliance obligations and proactively identify leaks on our distribution pipelines, providing opportunities for energy efficiency upgrades by targeting customers with less efficient appliances.

Aerial mapping data helps SoCalGas Advanced Meter Infrastructure Team improve its algorithms to better analyze and distinguish customer usage patterns. For example, through enhanced analysis of customer usage patterns, these programs have helped identify when appliances are unintentionally left on or when hot water leaks occur.

As a result, SoCalGas can proactively contact the customer to prevent high bills and possibly unnoticed high gas consumption, which can enable customers to improve their operations or better maintain their equipment as needed.

LIDAR technologies are not as effective at capturing HFC leaks, so there isn't as much data on the leakage rates of high global warming potential gases associated with electric heat pumps, air conditioners, and refrigerators.

To mitigate climate change impacts and reach decarbonization goals, more research is needed to help detect and manage any potential leaks from electric heat pumps. We look forward to continuing to partner with the

CEC to invest in technologies that will help California achieve clean air and climate goals, thank you.

MS. MURIMI: Thank you, Jennifer. Now, I'm going to give one more opportunity-

COMMISSIONER MCALLISTER: Thank you very much.

MS. MURIMI: Now, I'm going to give more opportunity for folks -- apologies, Commissioner McAllister. I do see Michael Lau in the panelist section has a comment, you may proceed.

MR. LAU: Yeah, it's interesting to hear about the incentives. I just wanted to make a comment about that from the industrial side, is that we look at it from two parts; which is the initial investment and then the payback time from operation.

Now, I'm not sure that any of the policies or regulations deal too much with that there, and that we were lucky in that we do have a food program investment or food investment program grant, and that covers a lot of transcritical CO2 systems.

But in terms of the end user, we're obviously a large end-user, we're obviously a large end-user, and there's nothing really available there that would incentivize us to want to put in the transcritical. But we did have what we thought was the right choice at the time, but I think it would be a lot easier choice if there were

some type of rebate and incentive programs.

Because we see all the other ones for VFD motors, installation pumps, and stuff like that. But there's not much focused on the adoption of low gas, CO2 and stuff into, I guess, in their more industrial spaces, including grocery stores and such like that.

So, I just wanted to put that out there and see … I don't know what the Energy Commission thoughts are and stuff like that, but that's where we are … the cost is much higher for a transcritical system than an ammonia system. And if you want large adoption from a lot of different producers and processors, because there's a lot of processors, producers, cold storage in California because we can't rely to … so, it would be very helpful to have those available out there to companies.

COMMISSIONER MCALLISTER: Thank you for that Mr. Lau. So, I hear from Dorothy that that concludes public comment. Thank you for that.

And apologies for my open mic her where I'm coordinating with my kids. So, I think that that concludes this afternoon's panel. I want to thank you Sam for moderating ably and contributing content to that panel. So, appreciate that.

And all five of our panelists really bang-up job. There's a lot of substance to follow up on and to keep

working together on going forward. So, really happy about this morning's panel on embodied carbon, which is sort of a big, relatively new topic for the energy agencies. And also, refrigerants, which I think has a lot of work already done and underway in the state, but really does, as we've heard need some attention at the sort of policy and rulemaking levels.

So, plenty of items on our to-do list, all good things and really appreciate everyone's input for helping us navigate these waters.

Commissioner Rechtschaffen, did you want to make any closing comments?

COMMISSIONER RECHTSCHAFFEN: No, thank you, Commissioner McAllister. I'm very appreciative of the wealth of information presented this morning and this afternoon, and I'm happy to have participated in the panels. I look forward to continue to collaborate with the Energy Commission, the Air Resources Board and our public and private stakeholders on these critically important issues.

COMMISSIONER MCALLISTER: Thank you very much and well-said. So, here is the information about how to submit comments. They'll be due on September 9th. By September 9th, earlier is better obviously, but that's the docket number.

And if you need help submitting, please get in touch with the Public Advisor's Office, that's Dorothy today, or RoseMary or Noemí, who's the Public Advisor herself here at the Energy Commission.

I think we have another slide about all the workshops that we have coming up. There we go. Thank you, Heather.

So, there are the upcoming workshops in the IEPR, both in the building decarbonization track as well as the rest of the tracks. We have natural gas coming up, renewable natural gas on September 10th, and on October 5th, we have building decarbonization workshops.

And so, encourage everyone to attend those. Really lots of, lots of substance as the urgency to upgrade and attack the problem of our existing buildings in particular really gains traction and gets vision at the highest levels and some backing at the highest levels.

So, I'm optimistic that we'll be able to make some progress and that's the goal to lay the path for that this year in the IEPR.

So, with that, Heather, I think we're done. If you can add anything that I didn't-

MS. RAITT: Yeah, we are done. We had a good day, thank you.

COMMISSIONER MCALLISTER: Okay, great. Okay.

Perfect. Well, thank you, everyone, I really appreciate everyone's participation and attention in a long substantive day. So, take good care. We are adjourned.

(The workshop concluded at 4:32 P.M)

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