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REEF Presents: Designing for Decarbonization Webinar - Transcript

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Aleisha Khan: So I want to welcome everyone to Reef's third quarter webinar uh designing for decarbonization. And to start us off I want to point out that the task of transitioning away from hydrofluorocarbons HFC's requires a lot of groups to work together um from policy makers to building owner operators manufacturers the service industry many others. So, it's really important that we understand the challenges and opportunities faced by all of those groups. And so, for today, we're going to focus in on those faced by architects and engineers in buildings around system design. And I can guarantee you that no matter how you are coming to this topic, whether it's from climate and super pollutants or HFC policy or building design, you will definitely learn something from our very experienced uh panelists.

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Aleisha Khan: Next slide, please. So, I'm happy to kick us off today. Um, my name is Alicia Khan. I'm Reef's new executive director. And just a minute about us. Um, Reef is a nonprofit collaborative organization. We work with a full spectrum of advocates and policy makers and industry in this space. And our mission is to inspire action by aggregating and amplifying the buyer's voice for solutions. So recognizing the need for by the end user for the enduser representation. and we're dedicated to finding solutions to eliminate the climate impact of refrigerants and specifically the impact related to HVAC equipment where we can find um HFC's that can have 2,000 to 4,000 times the global warming impact of carbon dioxide. So to be clear, we're focused on um reducing a key super pollutant at a time when greater access to cooling is a necessary response to extreme heat and when expanding the installation of heat pumps is a critical part of electrification. So our strategy is to work alongside electrification efforts and decarbonization goals with a focus on accelerating the adoption of both life cycle refrigerant management practices and also advancing technology solutions toward those that have zero climate and environmental impact.

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Aleisha Khan: So this is our agenda for the hour and before we get into the panel I'll make some brief comments on the regulatory environment that architects and engineers are working within to put us all on the same page. Next slide please. Um and uh for those of you um new to the uh sorry the Google Meet platform you will find um the little uh buttons in the bottom uh right hand corner of your screen. um can be used to ask questions and we um hope that you submit questions during the course of the webinar. Um if you have a question in mind for a particular speaker, please go ahead and indicate that or if it's just a general response that you're looking for, this will help us be more efficient with our time at the end of the webinar for Q&A. And also just to point out that everyone is muted and we will are recording this and we'll be posting this to the reef website um after the after the webinar. So let's do some quick table setting here um on the refrigerants landscape.

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Aleisha Khan: Basically the point here is that refrigerants are everywhere. They're in everything. They're all around us and they are also the fastest growing greenhouse gas globally. Next slide, please. So reducing the impact of refrigerants is really a global challenge. And to understand the scale of what we're talking about here on the left, um we can see a look at how refrigerant use is projected to accelerate in air conditioning due to a rapid increase in cooling demand. And then on the right, the very extremely necessary deployment of heat pumps as we electrify our heating and cooling systems to get us off of fossil fuels. But as we support these critical efforts, we really need to do no harm. And that means reducing the global warming potential or GWP of the refrigerant gases that are used in this equipment and which is going to sit there for the next 20 plus years. Next slide. So why is this a problem when you know refrigerants are contained within a system? Um it's a problem because leaks happen and um that's how they contribute to global warming.

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Aleisha Khan: They leak or they're released and this is a significant problem and building operators know this because they pay to recharge their HVAC systems over the course of the lifetime of their lifetime. Um, but adopting life cycle refrigerant management practices or LRM can really address these problems. And with good LRM practices along with effective investment in near zero GWP refrigerant solutions and other sustainable design options, we can get to a place where we're significantly reducing risks and cost for building owners. Next slide. So um I want to take a second here and um talk about the support for refrigerant um transition um in terms of policy. So we have global and national frameworks and other efforts in place to um support the phase down of super polluting HFC's. Um, internationally, if you could go back just thanks. Internationally, um, nearly 200 countries have committed to an 80 to 85% phaseown of HFC production and consumption, um, by signing onto the Kaggali amendment to the Montreal Protocol. And the US enabling legislation is in the American Innovation and Manufacturing or AIM Act.

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Aleisha Khan: This was signed into law in 2020 by President Trump and it gives EPA the authority to phase down the use of CF of HFC's and shift the market toward lower GWP alternatives. And I'll go into this um just a little bit further on the next slide. But before that, um I want to point out if you could go back just one Thanks. Um, I just want to point out also that there are numerous domestic regulations and codes and safety standards that support this. And a few of those, um, are the Clean Air Act, section 608, and that prohibits the knowing release of refrigerant during maintenance, service, repair or disposal of air conditioning and refrigeration equipment. So, this is about known leaks and intentional venting um, making that illegal. Um, this has been around a long time as it relates to older ozone uh depleting types of refrigerant that are no longer being manufactured. Another one is EPA SNAP which stands for significant new alternatives policy and that lays out which refrigerants can be substituted for the types that are outlawed under the Montreal protocol.

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Aleisha Khan: And we also have ashray um best practice installation guidance and this is referred to by architects and engineers and utilities. It's referred to in building codes and product certification standards and is very useful for code authorities, insurance companies and equipment manufacturers. Next slide. So just a little bit more about the AIM act and how it works. Um, under the AAC, there are three legs of the stool, if you will, that are all really critical to work together to support a clear phase down of the production and consumption of HFC's by 85% in the US over the next 15 years. So, the first part really addresses supply. So, supply of high GWP refrigerants, it's aimed at chemical companies. Um in 2024 we saw a significant reduction in high GWP refrigerant um production. By limiting new supply we are going to really you know see an increase in demand for alternatives and reclaimed refrigerants. And the next big step down is 30% in 2029 and then there's one in 2034 and again in 2036. The second part is aimed at technology transition for new equipment.

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Aleisha Khan: Um this requires the use of low lower GWP refrigerants um that have different safety classifications in this equipment. And then third, we have um a focus on refrigerant management for existing equipment. So starting in 2029, it rolls out some requirements around leak detection and recordkeeping reporting and use of reclaim refrigerant. Um, I'll say if you want a deeper dive into this, Reef has a um webinar on its site that I would recommend. It's on the California State Bill 1206 and Richie Car from NRDC does a really fantastic job going into the policy um in more detail and walks through it. So, you can take a look at that. But ultimately um for today all three of these regulatory um or all of these regulatory pressures that I mentioned here and then on the previous slide are all reshaping the refrigerant market. And it's really important for us to be aware of what's coming so that um we can plan ahead and especially if you're thinking about building systems that are going to be operating for decades. Next slide.

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Aleisha Khan: So just to wrap up, you know, it it certainly um begs the question that if there's all these benefits to managing refrigerants um in and looking at ultra low GWP refrigerant, so things like um lowering your compliance risk, um helping control costs, improving your operational performance, um looking at you know GHG assets um refrigerants are uh becoming uh more uh visible um when you're when companies are looking at their assets for that and then also meeting corporate goals around climate. Why why isn't everyone doing this and why are we talking about this still? Well, it's complicated. Um it takes different groups really working together and understanding their roles and the challenges and opportunities um whether it's owners or engineers or service providers, policy makers or industry. And so that's why we're doing uh webinars like this so we can really dig in. And um I'm excited to introduce our panel who will show you that we can do complicated things. Um and let me just get to my um my cheat sheet here. There we go. Um so I'm going to turn it over in just a minute to St. Sandborn.

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Aleisha Khan: He's the vice president and director of climate impact at the Smith Group and um one of one of my wonderful um board members at Reef. Um impact is a national uh transdisciplinary team focused on performance analytics, sustainability, climate resilience planning and decarbonization at the Smith Group. Um among a dizzying list of accomplishments and activities including work on ashray committees and supporting cities with electrification, St. serves on the San Francisco mayor's decarbonization task force for new construction and he um is joining us from the Bay Area in California. Uh second we will have Ramy Musa who's a managing principal at Point Energy Innovations. Uh Rammy is an overachiever. I found him on a 2025 40 under 40 list and he's been involved in some really exciting projects including leading the rapid decarbonization of the American Institute of Architects headquarters renovation in Washington DC where I am located and new construction of the decarbonized operation of an international tech company and their 220,000 square foot office headquarters in Alama California. and he will also be joining us from San Francisco.

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Aleisha Khan: And last but not least, we have Jamie Bacus, who's associate principal in building performance at Emmy Engineers. Uh Jamie is also an overachiever and has done it all from sustainability consulting to energy modeling to policy work at state and federal levels.

Stet Sanborn: Perfect.
Aleisha Khan: Uh Jamie is past chair of the lead energy and atmosphere or EA technical advisory group and he was named lead fellow by the USGBC which is the highest level of achievement for professionals in the green building industry and he'll be joining us from Denver. So stat I am very happy to turn the mic over to you for the rest of the the webinar.
Stet Sanborn: Wonderful. Thank you. And um I do want to just encourage folks as we go through because um I know Jamie and Ramy quite well and we are energetic festive folks. Um and I would encourage you to throw your questions into the Q&A. U so just a reminder, it's in the little dots in the lower right hand corner of your screen. Uh throw your questions in there.

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Stet Sanborn: And they could be questions like why is Jamie wearing a beard? Um but who knows like we're ready to take whatever questions you have. Um this is the these are topics that we all three of us are really passionate about. Um so please drop them in. Um and we'll hopefully have a really good conversation. It's a it's a good sized group. So um yeah. So with that I'm going to jump in and talk to it uh talk from a perspective of a design engineer um and an architect uh of like how to uh poke your team uh to reduce your long-term risk. Uh this is really when you're designing projects. Um what are some things you could do today to reduce the future risks that you might have on a project or if you're going through project retrofits. Um and there's kind of a few buckets that I like to focus on. Um one you uh the first one is just right sizing equipment. We have a historical um trend amongst engineers to layer on safety factors and fear and more safety factors and fear uh to the point where our equipment might be twice the size that it actually needs to to deliver the the real load in in buildings.

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Stet Sanborn: And when we were doing combustion based equipment that cost delta wasn't that big. You could do that and it wasn't that scary. Um and there wasn't a huge uh there were some efficiency impacts but it wasn't like this big deal. When we're moving to heat pumps, there's a lot of reasons we don't want to oversize our equipment. Um, and that might be about refrigerant emissions, but it also might be about cost and getting your project to actually happen. Um, so right size equipment, please poke your engineer, ask them, you know, let's talk about how you're approaching the sizing of equipment. Um, we have a focus on trying to just reduce refrigerant uh, runs in buildings, not doing refrigerant as a distribution medium for moving heat across an entire building. There's other ways that we love to do that. Um, and not using refrigerant piping is a key way to reduce that likelihood of risks uh, of leaks. Um, we we love and I'll put a little like if I have an emoji going on the screen.

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Stet Sanborn: Um, monoblock equipment, you know, air to water heat pumps, water to water heat pumps where all the refrigerant is contained within a piece of equipment. Um, it's been factory sealed, factory tested, there aren't any refrigerant fittings. Um, it it just makes us happy. Uh, because again, it's all about reducing that that risk for emissions. um considering smaller equipment distributed instead of large uh central uh refrigerant-based equipment. Um and then one that's often overlooked um is specking inverter-driven heat pumps. Um when we do inverter driven heat pumps where the fan is also controlled with an a drive uh inverter drive um the refrigerant charge tends to be even less in that equipment. Um versus single stage or two-stage heat pumps. Um they don't have to flood the coil with uh wintertime peak load amounts of refrigerant. So they can actually rightsize the refrigerant within the system itself. So inverter driven equipment um has a big impact on the actual charge volume of the system. So if you have to sign off right now and disappear into the world, I would say take this little uh this checklist with you and just apply it on every project.

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Stet Sanborn: Next slide. Um, so I briefly just want to talk about one of the So one of the things is we've historically not heard a lot of conversation about refrigerants, you know, other than, you know, is your total charge volume okay to meet a lead point? And everyone's like, great, we I I did that. I don't really know what they were talking about, but it's it seemed important. And we've focused a ton on operational carbon historically. What's your EUI? You know, what's your carbon footprint of your operation? Are you grid tied? Are you doing PV? Um and it's really been within the last decade um and especially in the last say six years that we've taken a much more holistic view of whole life carbon.

Um and so everything that it took to build your building, operate your building and then end of life uh impacts of your building. Um and I want to talk a little bit about why that context has kind of set up this realization that we really do need to focus on refrigerants.

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Stet Sanborn: Um especially uh because their impact shows up at multiple stages in the life of a building. Next. Um, so if you haven't um been sucked into the world of uh EN15978, uh, this is sort of the whole life carbon um, framework uh, that we've borrowed from Europe um, and built on. Um, but it's really looking at the impacts of all the stuff that goes into a building uh, whether it's the steel for the um, structure or concrete, mechanical equipment, you name it, all the stuff. How did we get those materials? How did they get manufactured, get adjusted, get put into a product? How did they get to our site? How did we use them? Um what was the energy use of our buildings? And again, what happens at the end of life? And we talk about these sort of zones of the whole life carbon as cradle to gate, gate to grave, or cradle to grave. Um and what kind of analysis you're doing um just decides which portion of that lifespan uh you're studying.

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Stet Sanborn: On the next slide, you'll see refrigerants pop up, as I mentioned, in a couple different uh stages of life. Um, we tend to think of the consumption of refrigerants through leakage in the B1 category. Um, so that's part of the use and maintenance of a building, just uh incremental leakage from small leaks or catastrophic leakage. Um, when a when a product actually fails, we think that as a consumptive uh refrigerant leak. Um but then at end of life as we're um taking a building down that reclamation um as uh Alicia mentioned uh not capturing that leakage um or letting it vent out at end of life is a real big concern. Um so we see kind of these big impacts. On the next slide though your selection of refrigerants actually shows up in a lot of places or has an impact on a bunch of ancillary and related uses. Um, so this the refrigerant that you pick actually has a can have a really big impact on your energy use from an efficiency standpoint. Um, or if you're taking um say a a cooling tower and a chiller system and converting that to um an air source heat pump, your refrigerant charge uh may go up, your cooling tower water use may go down.

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Stet Sanborn: So there's relationships between all of these things and that's part of that whole life cycle um assessment and why we want to stop making decisions as a single focused myopic analysis and start folding out um and making these whole life decisions um where the total amount of impact from an environmental standpoint is reduced. Next, so I wanted to share really quickly two examples um to make sure I leave time for uh Ramy and Jamie to chat. Um this is a recent project where um and I in I am showing only the MEP system. So this is a building stripped naked of its structure and its facade. Uh these are just the pipes, the pumps, the all the equipment on the MEP side, including the refrigerant piping. Um to show you that you can actually almost build a whole building with just mechanical equipment if if you want. There's a ton of it there. Um but this is a study where we actually did a soup to nuts whole life cycle of carbon as part of the MEP 2040 pilot project where we studied um every single component on the MEP system and its environmental impact.

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Stet Sanborn: And this is for a built project that just opened. Next um everybody always asks well or they're like I'm not even sure how much carbon footprint all the stuff in my building is. So I just wanted to share for context that um this is a breakdown of the MEP equipment from uh cradle to gate that A1 to A3 uh category of all the equipment that we all the takeoffs from this project um and the field uh weights. Um so lots in the mechanical equipment. Obviously the PV array has a big footprint but also offsets your energy use. Um but you can see the piping down at the bottom. Um that's the footprint of just the copper just the materials in that refrigerant piping and our hydronulic piping where it occurs. Next slide. The real thing, you could skip to the next one. The real thing though is starting to look at that use case. Um, so from A4 all the way through C4, including operations. And I want to highlight the impact as we look at B1.2, which are those are the leakage.

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Stet Sanborn: Those are the assumed leakage that we're going to see in the lifespan of this building. This is a VRF building. Lots of refrigerant piping, lots of field connections, lots of opportunity for future leaks. Um just because from a quality control standpoint a very efficient system you know gets us all the EA points we're like you know rah but as we step up and look at the whole life impact we realized that the fugitive the potential fugitive emissions from refrigerant leakage actually may dwarf some of those savings uh that we are seeing on the energy use standpoint. I just want to point out um that the the we had to truncate the graph. So the B1.2 two on the far left actually goes up far higher, but we had to trim it off so that we could get all the values onto a single chart. Um, but if you look at the actual hard values, the there's an order of magnitude shift in the impact of of the refrigerant emissions uh versus B6, which is the operational carbon footprint of the energy on the project.

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Stet Sanborn: Next slide. Um, one of the key things that you can do as a designer is actually just specify lower embodied carbon or lower um, uh, GWP refrigerants. So this is a comparison if we had been able to do the same system going from R410A which was originally specified and built in the project down to R32 which is one of our the sort of newer class of A2Ls um mildly flammable refrigerants um and then going to 454b which also has a slightly um decreased um GWP. Um but I do want to just highlight for my friends in the a world if you look all the way to the right you might miss it. Um that's the beautiful uh propane. If we had if we were safely able to convert this building over to using um R290 um you can just see that dramatic drop. Now would I do R290 in a VRF system? Let's we'll talk about that at a later time. Um but I just want to show you that actually just specifying refrigerant can have a dramatic impact um even using the same system typology.

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Stet Sanborn: Next. Um, so here looking at the whole life of all the MEP systems, you can just see that the refrigerant emissions um, still dwarfs all the other components uh, from a whole life carbon standpoint uh, in the building. Um and on the next slide you'll see those same results actually now because this is one of the first projects that we've done as a firm where we've done the entire MEP system the entire structural system the entire closure enclosure all the landscaping components and all the civil earth work. So this is our most comprehensive analysis of all the effort that it took to build up this project and showing the relative impact of emissions on the whole lifespan. emissions from refrigerants are still the largest contributor to whole life carbon or whole life emissions uh for this project even and even MEP dwarf structure um in this case um for our study next um so I want to other than that terrifying note that emissions ruin everything that you've been working for for your entire career um uh I do want to give a case of hope from a design standpoint um so this is a really quick case study of a project that we're doing up at Calpoly Humble next slide um where we asked ourselves um instead of specifying quote unquote the right size piece of equipment to meet the load, what if we made a

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Stet Sanborn: piece of what if we designed a system that was too small and we added some storage. Uh next slide. Um a lot you people don't realize that the peak load that's seen in a building actually only occurs for a very short period of time uh depending on what climate zone and use type you have, but there's an opportunity to not put in a huge piece of equipment just to do a tiny little bit of work. Um so adding thermal storage on the next slide um we can start to see the benefits of thinking about unders sizing equipment paired with storage to u match loads. This is the lifespan emissions from a project uh from that example project for embodied carbon of the equipment just the mechanical uh plant equipment plus refrigerant emissions um using R410A. On the next one you can see the benefit of going to a low GWP refrigerant. So in this case R4 4554B um next slide that's you know roughly an 80% reduction in whole life impact um just making that refrigerant change which is really substantial and then on the next slide um and you can click immediately to the next one um you'll see that unders sizing equipment by half using thermal storage to meet your peak loads now we can achieve almost a 90% reduction so there are opportunities from a design side uh

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Stet Sanborn: to actually be able to make pretty effective change. So with that I think

that was my oh that just a summary you know try to design uh reduce your peaks make a more efficient building try to specify equipment that doesn't have refrigerants um and then if you are using refrigerants consider smaller equipment with storage or at least at a minimum specifying lower GWP refrigerants. So with that, I think I'm going to hand it over to Ramy uh to give you help you develop a plan.
Rami Moussa: Thanks, Steph. Um, good afternoon everyone. I'm excited to have you all here with us. Uh, if we can go to the the next slide here. Um, you know, I guess just to start off, thank you all for being here. Refrigerant and just talking about refrigerants has historically been a very niche subject, right? Whether it's the design community, ownership and operation, it's typically been whatever is available, whatever is allowed is what gets used in equipment. Maybe there's a investigation into what's most efficient. Great.

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Rami Moussa: Uh and even that is a sort of subset of the community. So I mean harmful refrigerants have been used for decades um up until now and fortunately those are being slowly phased out. um phasing out old refrigerants and phasing in is becoming more rapid of how harmful these really can be. Um and with synthetic chemical refrigerants uh the the elevated GWPs that we see u really need to to get a handle around them. So in 2020 uh we set course for the phase out of some really prominent refrigerants. HFC's would be their classification like R410A, R134A. Those are common numericics that we see in equipment uh and have for the last decade uh and they were commonly used all the way up until last year uh where access to this refrigerant now very soon over the next 20 years will be dramatically reduced. uh in 2025 there's a critical landmark uh phasing in the next wave of lower GWP lower impact refrigerants where only this type can now be used in new equipment as well as imported equipment.

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Rami Moussa: Um, so, so why should you care? You know, attendees, uh, heating and cooling systems with lifespans of 10 to 35 years were being designed and installed with these more harmful refrigerants until just last year. And though it's a relatively slow process, these systems will inevitably leak and require replenishment, often as much as half to threequarters of their initial refrigerant charge uh, over the course of their life. Uh so if we can jump to the the next slide here u with the most recent phase out R22 which just hard stop cannot be produced any further starting in 2020 we've seen almost a 10x increase in unit cost for that refrigerant. So replenishment of these refrigerants that are now being phased out is going to become a significant part of the operating expense for a building. We can't let that slide. We can't ignore that impact. Next slide, please. Um, as we mentioned, over the next 20 years, um, Alicia alluded to this phase down of HFC's again like 410A, 134A. Over that course of 20 years though, there are some distinct jumps in reduced or in phasing down of production.

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Rami Moussa: one in about four years and another in about nine years. And so these phaseowns are very likely to trigger increases in cost due to supply and demand um impacts of that phase down. So although we're thinking long term here, there are much more near-term impacts to buildings and operators uh as this equipment that may have been installed last year uh is in operation. Next slide, please. So, you know, what's more, refrigerants are now in higher demand than ever before. Uh, governing policies continue to evolve to address issues of climate change. Uh, and so there are the refrigerant phase outs like the one we're talking about now. But perhaps most pressing is the need to electrify heating sources. This has put the most pressure on manufacturers and their heat pump refrigeration products. uh embodied carbon policy is also in the works. Uh this is in its infancy. Um it's being established just a few years ago in California, but also in Washington state. Um they don't include refrigerants yet, but they will very likely in future iterations.

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Rami Moussa: So, these are all policies that are coming together to really dictate what we can and can't install as designers and where we should be advising uh our our owner and our clients. Next slide, please. So, what can we do about it? You know, this this sounds like a lot uh and I can't say we have all the answers, but there are things that we can do now to prepare and reduce risk with these refrigerant transitions. So I you know I we've talked a lot about how great an impact refrigerants are but I first want to just emphasize that building electrification and shifting to the use of refrigerants in lie of combustion is still a far better source or case for the world less harmful than continuing to use those combustion fossil fuel based sources. uh refrigerant emission impacts unfortunately just are not being considered as critically as they should be by many in the industry on both the design and building operators side. So they've been a bit like that sneaky monster under the bed uh that nobody really wants to look at and we just kind of run with what manufacturers give us.

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Rami Moussa: Uh so how do we really start with assessing this risk? And the first step is just understanding what do you own and how much? Um where is this refrigerant and what type is it? Uh that will dictate you know how challenging it may be to come by in the near future. Uh and how much of a risk it should should be contributed to that. We need to identify where the equipment is with the greatest consumption and where are the greatest opportunities to improve and reduce refrigerant consumption uh by monitoring uh whether it's recharge or actually having a clear picture of that that history creating a register of that use. Many property managers this isn't quite on the radar yet. It's been just a minor operating expense. Uh so we want to keep this in you know clear eyes wide open uh as we go forward when we're installing new systems or considering retrofitting existing uh systems we really need to consider the full life cycle cost. I think there was a question actually a great one that we'll touch on a little bit here and Jamie will get into as well about you know how do we include refrigeration cost and escalation in our life cycle analyses for cost for operating cost of the building that's got to make its way in and oftentimes is neglected in life cycle analyses and for the assets that remain with these older refrigerants in the years to come Where

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Rami Moussa: will you gain as an owner the best value? Is it in banking that uh phased out refrigerant to be able to continue operating it until that equipment needs to be uh replaced or do we simply replace that piece of equipment with something new that is compatible with lower GWP refrigerants? These are assessments that that can help us develop a plan uh and reduce risk uh of cost escalation uncontrolled uh going forward in our our capital planning efforts. Next slide, please. So, as I mentioned, it was just earlier this year where this new wave of GW low GWP refrigerant has been required. It's just now being applied and installed. Um and as we've done that with this new wave of lower

GWP equipment u there have been some lessons learned and want to share that with you all u and really these we need to share as an industry more to adapt to these rapid changes uh as as much as possible. Um so first you know when we were investigating what are these new products what can we apply we did a market survey of 10 of the most prominent heat pump manufacturers um with this new wave of refrigerants whether R32 or 454B um and honestly none had their full equipment lineup available to ship on day one of this transition and that is very likely to be the case going forward.

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Rami Moussa: So we need to be aware of what is the most realistic lead time for the applications we have at hand. Is it a large package unit which may be farther out on the development timeline and less common manufacturers don't prioritize it? Uh or where where is the availability for the type of equipment we need during these transitions? Another consideration here is that highly technical and test data for every operating condition that we need to make uh thoughtful prudent design decisions for this new equipment won't be available on day one either. So we need to ask the right questions. Uh getting into really some significant details that we don't think about until later like equipment staging and part load operating conditions at temperatures. How does the system react to those conditions? Uh that won't be published on day one most likely. Uh we also need to very rapidly get up to speed with new equipment. So seeking out training from manufacturers, manufacturers reps or seminars like these uh can help us as an industry get up to speed more quickly uh and make again informed design decisions so that we don't have catastrophic failures or uh sunk cost when applying this new equipment.

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Rami Moussa: Um additionally this is new equipment for everyone. So whe the technicians, manufacturers, they are going to have growing pains as these new products are being applied and we've got to account for that in our startup scheduling uh and in the support or the planning efforts for commissioning of this equipment. Lastly here just these are not the historic boiler systems that you know just kind of run and we don't think about and we just look at bills. uh we need to really be conscious about how are these equipment operating. We need to monitor them uh to get the best value out of them. So having the correct instrumentation and ideally a monitoring based commissioning plan especially for larger systems so that the system can operate as intended and continue to after the first year or two of operation. Next slide please. Okay. So what can you do um after this session? Everyone has a part to play in this and and can be proactive about this this adaptation and transition. Owners, facility managers, start assessing the risks um that we're discussing in this session.

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Rami Moussa: There are things that we can do to to prevent surprises in the future and make some proactive plans. manufacturers. Really, we need your help to allow owners uh and design teams future flexibility with equipment and not have planned obsolescence of equipment that we know will not be able to be supported in less than a decade uh or will be far more expensive to do so. So having some proactive plan within products for these future, everybody hates the word drop in refrigerants, but what are changes that can be made without complete equipment overhauls or replacement. Um, and although engineers need to really take the reigns and take the lead on educating clients, architects are not off the hook. We've got to make sure our owners are aware of these risks and can make perhaps the investment in looking at things a little bit more deeply uh than the the conventional you know what is the operating energy cost only uh to dictate ROI something that to that effect and again engineers really we need to ensure that these risks we're talking about today have sufficient guard rails for successful product applications ations in our projects.

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Rami Moussa: This is new equipment again for everyone in the industry. Uh and we have to acknowledge that it can't just be business as usual uh as it has been for decades. Next slide, please. And lastly, just want to wrap it up here with a a positive note that this stuff can be done. There are products out there being developed, being tested. Um this is one particular application um where I sit on an advisory board for a CEC grant application. This is a CO_2 so carbon dioxide refrigerant heat pump. So it is extracting air from the heat or heat from the air around it and pulling that into the heated water that's supplied to a building. CO_2 global warming potential with one um it is a a commercially available refrigerant R744 and again it actually another piece we we're not talking about too in depth today but um it is not a a forever chemical it's not PAS um so it is even more beneficial u the list kind of goes on with the opportunities with CO2 and this is just a a technology that is being adopted by the HVAC industry very recently like last year recently.

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Rami Moussa: So, um exciting to see these uh this type of technology grow uh and and become a bit more prominent. Okay, thank you.
Stet Sanborn: But Jamie's up. Yeah.
Rami Moussa: Oh, we can't hear you, Jamie.
Stet Sanborn: Yeah, no sound yet, but we do accept interpretive mime. Um, which I I do think Jamie is actually quite good at. Um, as Jamie I I think I was going to try to call in um and get the the sound going. I do want to encourage everyone again to go into the Q&A. Uh, feel free to enter your questions um in there. You'll also notice on the far right hand side there's a chance for you to upvote any of the questions that you're like, "Oh, that's a great question. I wish I would have asked that. I really want to make sure that they cover that. Um, so this is just a a chance to hop over into that Q&A. Um, and make sure that we when we do get the back and forth, we get a chance to answer some of the questions that you're dying to ask.

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J'aime Mitchell: St.
Stet Sanborn: Sure. Yeah, happy to. Um, I can kind of take them in order from um, highest up vote. Um I know the first one is actually one on um for my uh the leakage that was assumed in the study that we were doing. Um those were per ashray 228 uh leakage rates. So um there's a whole range of leakage rates assumed for different equipment type um everywhere from 1% to in catastrophic cases 12% per year uh depending on system types and age of equipment and use patterns. Um but there is an ashray uh study coming up soon that's going to take a really deep dive into very large portfolio scale uh leakage data. Um so we should be getting better refinements on real life uh examples uh soon. Uh still no sound. Jamie, do you want to do a sound check? Not sure, but I can um I can definitely take another couple questions um as we try to get Jamie. Oh. Um, for Jaime's call-in, um, Jamie Mitchell, I'm not sure if, uh, you can allow

his call-in person to be a contributor or else he's automatically, uh, muted.

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J'aime Mitchell: I will do my best while you answer the next Q&A.
Stet Sanborn: Okay, sounds great. Um, as we work on that, um, oh, the upbow. Okay, so what about VRF? I'm going to throw this one to Ramy. I'd love to because I have I have some feelings about it. Um but um Ramy, I'd love to hear because you you you guys do a lot of work with clients advising them on um strategies around system selections. Um what are you guys uh saying uh these days around risks around VRF?
Rami Moussa: Yeah, ARF is a is definitely a a hot topic and a challenge with managing refrigerant volumes. There's no way around the quantity of volume that is used in VRF systems. um as historically applied. There are some interesting adaptations of BRF to reduce refrigerant um where they're actually hybrid. They are partially hydronic and partially uh refrigerant distribution where essentially the main riser would be refrigerant and that would then tap into um what would be the branch selector or whatever we want to call the box.

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Rami Moussa: the refrigerant header and distribution center that actually transitions to water and so all of that distribution downstream of the riser could then be zero GWP.
Stet Sanborn: Ow.
Rami Moussa: Um so that's that's one kind of adaptation or upcoming change. There are efforts to also um not necessarily retrofit but develop the VRF systems now with lower GWP refrigerants.
Stet Sanborn: Thank you.
Rami Moussa: Uh so R32 is being um applied in one particular case. Uh but the manufacturers are more slowly adapting unfortunately and are giving the leeway to more slowly adapt to those changes.
Stet Sanborn: Yeah, we can I'll definitely say that um with the code requirements around refrigerant um and um space allowance and charge within spaces um VRF will continue to um was uh continue to be a challenge. Um but I Ram's totally right. The the hybrid units definitely give you a pathway towards uh doing still getting really high efficiency without um the push on on the total refrigerant charge. Um a great question is what do I

do with all the systems I already have? Um, I'll throw in um to echo what Ronnie said earlier, this is the time to actually understand what you have and get a full inventory of the systems that you have um and what some of the um potential options for um doing end of life replacements or preemptive uh before equipment fails uh replacements um because it's a huge challenge.

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Stet Sanborn: Um most of the new refrigerants are not drop in uh replacements uh for existing systems.
Rami Moussa: Yeah, but like we said, we certainly don't have all the answers and and uh manufacturers really need to step up to ensure that these do not become stranded assets and that different refrigerants can be used uh within these
Stet Sanborn: Yeah.
Rami Moussa: these future systems. So this is something that the industry is certainly pressuring VRF manufacturers on. Sorry, Jimmy.
Stet Sanborn: Still no still no Jamie sound. um we'll we'll keep going through questions and just see if there's a a potential uh connection. Um so to the anonymous question on can I just swap out refrigerants I have in my system for most cases? No. uh the the new uh requirements for leak detection um in A2Ls from a safety standpoint um and uh even just the performance of those refrigerants with a compressor and a coil size and the pressures that they operate at uh they tend to be different um and so as Ramy mentioned most of most of these systems do that are legacy do not have a drop in refrigerant swap out that you can just do and move on your merry way um so a lot of it is putting a plan in is um over time that you're going to do a a replacement and that whole life cycle cost of the cost of refrigerants over time as

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Stet Sanborn: it goes up for some of these assets. Um it it's a great time to put a plan to how you're going to transition. We'll try again to Jamie version two.
Rami Moussa: Looks like you're muted on your other device right now.
Jamy Bacchus: I'm on like five devices.
Rami Moussa: There we go.
Stet Sanborn: There you are. There you are. We we hear you. So, um, with that, I will, uh,

love to hand it over to Jamie.
Jamy Bacchus: I don't know where I'm looking. Um, all right. So, next slide. I should have kept the beard on. All right. So we have all these refrigerants and they have a global warming uh potential and we talk about them in CO2 equivalents and we can talk about them in 20ear potentials or 100year potentials and most of us have probably been talking about a hundredyear global warming potential equivalent without mentioning that or referencing it, but realize there are two different ways. And it's the radiative forcing equivalent of these gases.

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Jamy Bacchus: Um, and if you're really interested in pushing or promoting or showing the impact of refrigerant leakage on greenhouse gas effects, you would use 20-year because some of these are really short-lived once they're released into the atmosphere. And so we might be thousands in the hundredyear time frame, but multiply that in in uh 20-year time frame. Next slide. Um and so we touched upon this a little bit earlier. We have emissions from buildings that are scope one when you burn fossil fuels, but refrigerant leakage is also a scope one. And then your electricity, if you have district chilled water, heating, hot water, steam, that's a scope two. And scope three is kind of everybody else's stuff. Uh, next slide. Um and then taking that and overlaying it with the EN5978 as Ste was saying we have B1.2 too that we think of fugitive uh leakage remissions and C as the end of life but you have as Rammy said this equipment lasts 10 years 15 20 35 so you have multiple replacements over let's say a 60-year typical life of a building um and then all these have inter relations with the the energy and the water use.

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Jamy Bacchus: Um, next slide. So, there's a couple new ashray standards that are to consider that are quite exciting. Ashray standard 228 that came out two summers ago looks at net zero carbon for existing or new construction buildings, but it only looks at one year. That's it. So, you don't get that end of life. You just get what were your leakage? this year. Um, and so it's a little narrow. Two 240P looks at a 60-year reference study period and the leakage that occurred during installation over the course of that 60 years and then at the end which is again that C1 uh next phase. Next slide. Um, so there's some tools which is great because we don't want you to leave this without thinking that you you're on your own. Um, CIPY came out with technal memorandum uh a few years ago and they made a North American version with ashtray that recently came out. So this is great. We have a new resource that sort of looks at refrigerant leakage and the MEP carbon that step was also showing for all of our systems as mechanical engineers, electrical engineers, plumbing engineers.

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Jamy Bacchus: Uh MEP 2040 also came out recently, this past June maybe of a free uh embodied carbon guide for beginners. you have to pay ashray for theirs, but this one's free to download. CC scale um is also a free tool to use. Um next slide. And so back to those 20 and 100year GWPs, this gives an idea of the difference. So if you were looking at R410A and you were thinking it was around 2,000ish, well it's in in hundredyear GWPs, yes. But if it's almost double if you look at it in a 20-year because it's a very shortlived uh uh greenhouse gas. Um and the top rows are the different IPCC reports. So AR6 is newer and slightly different than AR45, but they shift very little. So don't get caught up on memorizing these. If somebody says R410A is 2088, that's because they're using something from a decade ago, but it's still relevant. All right, next slide. One of the things that you also have to kind of consider when you're designing systems is and the quantity of the refrigerants, are they centralized or are they decentralized?

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Jamy Bacchus: And if they leak, where would they leak? So we can get into this on the next slide but it is something to consider. Um let's somebody asked in the chat about what leakage rates you were assuming and it's almost anyone's guess 228 ashray standard that is will only give you the annual leakage um ashray 240p will have an installation annual and end of life and so we have these various things from California Resources Board. We have them from Australia. We have them from the UK and we have them from LEAD. They all sort of disagree but are closeish. And this is a problem for our industry that we have peacemeal studies that are done on a specific type of equipment in a specific region at a moment in time that may have been CFC's and then somebody else may have studied something in the 90s and early as that was H CFC's and now we're looking at as Rammy said H FC's and so can you extrapolate some of these lower pressure system leakage rates with higher pressure hard to say and different construction practices and even if you look at 228 it's using a French study and their description of a DX equipment is not necessarily what we would think of as that same DX equipment.

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Jamy Bacchus: So don't lose hope but realize this the citations behind the data are lacking and we collectively need to do better whether it's ashray uli aimsa we need to better understand this next slide um and so real quick if you're just doing some refrigerant counts you might have as we We're seeing for P factory charged equipment maybe zero leakage in the first year um or 1 to 2% in that initial and then something 1% 5% perom and then something assumed at the end that you still might have 80 to 100% of the refrigerant charge left and then you were able to reclaim name 70 to 90% of that. And so you can then and then you have the service life. And so you can then just easily plot those of just like okay so I lost 1% of my refrigerant charge and then 7% per atom and 17 years later 80%. So that's what these numbers are coming from and how they how you would how you would add them up. Next slide. And that's what it graphically it look like just every year for different types of systems.

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Jamy Bacchus: And next slide. And so this is what it looks like cumulatively. A a giant question for all of us is that after that bump up, do you reinstall the same refrigerant or something that's now zero GWP? And so that could just plateau because now you've moved on to something with natural refrigerants and has zero GWP. Next slide. And this is no surprise. If you assume VRF has four to six pounds of refrigerant charge per cooling ton and has the highest leakage rates, it's going to look the worst. Whereas if you assume you have package rooftop units with only one or two pounds of refrigerant charge per cooling ton and they are factory charged, don't have any initial leakage and then a slower over their life, they'll look better. The weird part to keep in mind is that if you have centralized systems and you suddenly make them 100% redundant, then you've just doubled the refrigerant charge of that system. But it's probably in a refrigerant machinery room and so the leakage less and it's more controlled because you have all of the requirements for that.

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Jamy Bacchus: Next slide. And uh again as as step was saying this is only a small part of the big picture but it's an important part.
Stet Sanborn: Yeah.
Jamy Bacchus: Next slide.
Stet Sanborn: Well, and Jamie, I might I might um pause you here um just because we're at the top of the hour.
Jamy Bacchus: Yeah I know.
Stet Sanborn: Um but if you um if you would have one closing statement um for to charge and go forth with of of hope and inspiration, what would it be?
Jamy Bacchus: I I think the good news is with the AIM act and the global consensus around Kaggali is that we are moving past this. The the challenge is what happens with all this stuff that we've already installed over the past decade.
Stet Sanborn: How about you, R?
Jamy Bacchus: And that's that is the that's our own albatross for all of us that did these um early VRF systems or even just package rooftop.
Stet Sanborn: Yeah, that's the the challenge.
Jamy Bacchus: Yes. The good news is for the simple systems, they just pull it off and reclaim it because it's going to be worth something to somebody else.

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Stet Sanborn: Yeah. Yeah.
Rami Moussa: Yeah.
Stet Sanborn: And Ramy. Yeah. Yep. And Ramy, any big closing thoughts to charge charge folks out with?
Rami Moussa: Yeah. I think you know one area one area of hope I suppose is that cooling systems in large part have had low GWP refrigerants available now for years. HFOs are becoming pretty common in large refrigeration equipment for cooling. Heating is one area where we have the most challenge and most nuanced design considerations. So as we move forward towards more electrification within buildings, we need to build up our familiarity with operating regimes for heat pumps and how we can best as you touched on Ste right size and how do we get to the best value system

uh that has lowest environmental impact.
Stet Sanborn: Um, and I'll just close us out with um we're in the wild west right now uh with the transition uh with equipment replacements with refrigerants um in a phase down, but you're not alone. Uh we wanted to share these resources with you. Uh Jamie mentioned it uh as well, but the MEP2040 group uh is a group that's obsessed with uh on the practice side of designing and engineering uh to try to reduce total emissions.

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Stet Sanborn: The project that I showcased was actually one of our pilot projects with MEP2040. Um so you can do a deep dive there. Um both CYP and Ashray have a ton of resources that are have come out in the last year and will continue to come out with additional resources for designers for engineers um to target strategies uh to reduce those emissions especially on the design side. So with that I think I can hand it off um over to Alicia for the maybe the final final wrap-up for Reef. If not, um, if you have any questions for Reef, um, we have our contact email and a QR code there. Um, we're always looking for volunteers to join, um, our meetings, uh, speakers and partner organizations that are allied along with Reef's mission to reduce fugitive emissions, uh, emissions at end of life. Um so please reach out because we would love to partner on initiatives um and and outreach.
Aleisha Khan: Thanks to Ann and sorry I couldn't get off of uh get my video on and get off of mute.
Stet Sanborn: Yeah.
Aleisha Khan: Um I really want to thank all of you for your time and energy um to put this webinar together for everyone. It was really um fascinating and so much more good information I think to come. Um I do want to say that the questions are fantastic in the chat and we really do want to answer them and like Stat said make help you feel like you're not alone because you're not. Um so we will be collecting those.

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