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Heat Pumps for the Future: Design, Deployment, and Preparing the U.S Market for What's Next - Transcript

**Note that the transcript timestamps do not align with the timing on the video recording, as the video has been trimmed down.*

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Aleisha Khan: But I'm very happy to welcome you all to RE's 2026 quarter 1 webinar, heat pumps for the future, and we're going to talk about design, deployment, and preparing the US market for what is next. Next slide, please. So, I'm Alicia Khan. I'm the executive director of Reef and I will be your moderator for today's webinar. Next slide. Um just some quick housekeeping in case you are new to Google Meet. Um we the way to submit questions is if you look down at the bottom right hand corner of your screen there's these nine dots and if you hover over that um some tools will pop up and one of those is the Q&A feature and you can use that during the webinar it'll be open for you to submit your questions as you're thinking about them.

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Aleisha Khan: You can also use this feature to upvote any questions that you would like to see answered and we'll use this to drive the conversation at the end um of the webinar when we go into Q&A. I also want to mention again that we're recording and we will send you out an email link um to the recording when it's ready as well as to the slides. Next slide. So the lineup for today's speakers is amazing and we are going to cover a lot of territory and tap into a lot of expertise to make us all a lot smarter about heat pumps and the potential for low global warming impact from this important technology. So, we're going to start with Chris Douglas in the center of the screen there, who is a climate policy analyst with the Environmental Investigation Agency or EIA,

which is an NGO that works to reduce greenhouse gas emissions, including both ozone depleting substances and fluorinated greenhouse gases or F gases. And standards and codes involving refrigerants have been part of their work for over 10 years. and Chris serves on uh several UL technical committees and the working group that is harmonizing safety standards and he's going to share some of that information with us and updates um later on in the webinar.

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Aleisha Khan: Well, then um after Chris, we'll hear from Cheryl Winfield from the California Air Resources Board, known as CARB, which is leading the way on progressive policies to address climate change, including um hydrofluorocarbon or HFC emissions. and Cheryl works on the HFC reduction program supporting the development and implementation of innovative policies to reduce HFC emissions in California, particularly from the refrigeration and air conditioning sectors. I'm really excited to have Cheryl here and she'll be followed um by Robert Benjamin who is the founder and CEO of Aerys Hydronics Inc. um which is a vertically integrated green HVAC company based in Milwaukee, Oregon. Robert is the inventor of the thermal plant pod system, a patent pending modular hydronic system develop developing sorry delivering uh heating, cooling and domestic hot water from an air-to-water heat pump platform. And Robert is a licensed general contractor um with over 20 years of experience leading engineering and product design teams. And Aerys is one of the few US companies actively piloting R290 or propane heat pumps in the field um and have won multiple awards including from DOE and the California Energy Commission.

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Aleisha Khan: And they're also collaborating with the Oakridge National Lab on advancing heat exchanger design. So, we've got quite the lineup here. I'm really excited to get into it. Uh, next slide, please. We're going to tackle this topic by starting with some really quick remarks from me on the context for the webinar. And then Chris is going to frame the challenge, specifically getting into the details of code and standard updates for propane heat pumps and other natural refrigerants. And then Cheryl will give us a deep dive into how California's programs are sending policy signals and transforming the market for refrigerants in their state and setting an example for the rest of the

country on what's possible. And then Robert will take us home by giving us a flavor of what this looks like in installation and some of the work that Aerys is doing with propane heat pumps. And we expect to have a good 15 minutes for audience Q&A to wrap us up. Next slide please. So just to keep in mind as we move through the next hour, um our objectives are to provide some insights into the connection between policy deployment and standards and how all of these are moving forward in parallel to transform the market and enable broad use of heat pump technology using refrigerant with an ultra low GWP or global warming potential.

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Aleisha Khan: Um, we also want to demonstrate how um, propane adoption or R290 isn't just theoretical. It's really happening and there are real projects and regulatory signals that are being sent and work underway on safety standards to promote broader application. And then lastly, we want to use propane as an example of how demonstrations, regulatory signals, and safety standards can really move together to build market confidence. Next slide. So, I want to just say a few things about REF if this is the first time that you've joined us. Um, REF stands for the Refrigerant Emissions Elimination Forum. We're a nonprofit organization working to transform the broader refrigerant landscape toward zero climate and environmental impact. And we do this by supporting building owner action on HVAC and by aggregating leading end user voices to drive market demand. As many of you probably know, most refrigerants used today are HFC's and as a super pollutant, their impact can be hundreds to thousands of times more than carbon dioxide. So they're really critical to putting the brakes on climate warming in the immediate future to provide time for long-term decarbonization strategies to work.

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Aleisha Khan: Next slide. So technology adoption requires a process to ensure clarity, safety, cost effectiveness, and market um reliability. And we're talking about heat pumps today because they're a technology that's central to replacing fossil fueled systems and to electrification. However, instead of generating heat, they use refrigerants to move thermal energy between spaces and leaked fluorinated refrigerants are a major problem and an often overlooked climate risk. So, propane and other refrigerants with an ultra

low GWP or glommy global warming potential offer a promising alternative, but propane heat pump technologies remain pretty limited in the US um despite their widespread use internationally. And part of this is due to unresolved flammability considerations in federal safety standards and building codes. So, that's part of our discussion later. in the hour. Um, this graphic illustrates what an accelerated state pathway could look like to enable propane or other A3 or um referred to as natural refrigerants and how it can align with uh regulatory deadlines. So, it's really about a market transition that brings together stakeholders, develops guidelines, publicizes demonstration projects, and includes training to strengthen practice.

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Aleisha Khan: Um, this graphic and the next one both come from some resources on the reach site, and as I said, we'll share out slides. So, um, you can look for those. Next slide, please. So, this is my last slide. I just want to give you a bird's eye view of what we're talking about here when it comes to market transformation for refrigerants by grouping actions into three categories and each of these um unlocks kind of a puzzle or part of the puzzle and allows markets to shift forward. So at the top basically we want to understand current application and clarify the permitting process understand where authority lays in that process and then we want to enable the market gauging where stakeholders are at making sure we're paying attention to training making sure we're doing demonstration projects that are transparent and sharing information across the industry. And in parallel, we want to create structure and certainty for state regulators and for manufacturers. We want to look at the AIM act and requirements under that especially for refrigerant recovery and reporting and also support the safety safety standards and insurance elements which are really important to this.

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Aleisha Khan: So, with that kind of ground um laid, let's turn to what's happening right now with codes and standards, and Chris will give us an update on the latest in that area. So, I'm going to turn it over to Chris.

Christopher Douglass: Awesome. Thank you, Alicia. Um, all right, we go to the next slide and diving right in with codes and standards. Uh, so as many of you may already be aware of, refrigerants are assessed for their flammability and toxicity based on the

scale where the numbers increase as the flammability increases. And A versus B, B denotes whether the refrigerant is toxic, uh, like ammonia for example. And in the US, the two main standards bodies with regard to AC and heat pumps and refrigeration equipment uh are UL which sets the requirements for equipment design and construction uh and ASHRAE which broadly speaking is the uh equipment installation requirements. So if we go to the next slide, uh here we can compare how the global landscape looks with the IEC standards compared to the US and our domestic UL standards in terms of the maximum charge size for flammable refrigerants, uh specifically A2 and A3 refrigerants.

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Christopher Douglass: The US has this capped right now at 114 g for A3s. And if you compare that to the IEC, uh that's almost one kilogram for the indoor direct systems and five kilograms for the outdoor indirect systems. Um that 114 g cap right now makes it very difficult for any equipment to operate uh at any significant capacity level. So obviously the the primary barrier here is the safety concerns. Now, while IEEC has approved these larger charge sizes for A2 and A3 refrigerants, uh they're already installed in Europe and in Asia, parts of South America. US standards and codes have to conduct and review their own research domestically. uh owing to some of that research not being public. Um in addition to differences with building code and equipment design, uh liability laws and also just a general preference for more physical testing uh to confirm um safety and mitigation methods. So if we go to the next slide, we'll see an approximate timeline. Um, and I think this actually lines up fairly well with the timeline that uh, Alicia and uh, Reef shared earlier.

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Christopher Douglass: And this looks at how quickly we can get this equipment uh, approved in the US context. And it focuses on the three key policy levers of standards and codes, uh, regulatory signals and market readiness. Today I'm just going to focus on these standards and codes, but it's just worth mentioning that there is a lot of other important work going on in these other areas as well. Um, on the standards and code side, the most time-sensitive priority is advancing and expediting research and testing. Uh, so that top left arrow is where we're at right now. And if we go to our next slide, we'll

see a zoomed in uh timeline of just the standards and codes. Those transparent uh extensions represent a lag time which is dependent on what capacity and type of equipment uh testing is currently in the works for. For example, there's no larger charge direct systems that are currently being tested. Um and that makes up a lot of the US market. So there's there's research uh that's still needed to address a lot of the the common US market types.

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Christopher Douglass: The next two years are really going to be critical uh to determine if we're going to stretch into 2033 to update the vast majority of of US system architecture types in terms of AC heat pumps. Um the updates to the the standards and codes need to be con completed by early 2027 to meet that deadline for incorporating them into the 2030 model building codes. And then of course we still need EPA to uh snap them and for state and local building codes to adopt them as well. So there's a lot of work to do on an extended timeline. Uh if we go to the next slide, we can see there is good news. Uh there's ongoing research and risk assessments on residential monoblock airto water heat pump configurations and self-contained AC and heat pumps. um some of the diagrams here and based on this research underway and the work that UL and Ashray have taken on. These are the equipment types with the greatest likelihood of being included in the 2028 UL fifth edition standard and the 2030 model codes update.

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Christopher Douglass: This of course assumes that research is concluded in time, the standard committee can review it and that it favors the development of uh A3 technology in certain applications. If we go to the next slide, we can see that there are a few different pathways and right now we are in this top blue one. This can this covers about 20 to 25% of US household AC use and it's the most likely outcome at at present because that's where the research is happening. Um standards bodies understandably aren't going to move until they have some data that they can review. Uh and these larger charge direct systems that makes up so much of the US market uh have not um had any testing started. Now that second green box would would enable a much larger uh portion of the market. That would be if we harmonize with IEC fully in terms of their

charge sizes. Uh that would be almost 80 to 90% of the US market. However, larger capacity systems above 50,000 BTUs would still remain outside of R290 feasibility in a direct system.

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Christopher Douglass: Um so those would need indirect or other alternatives. Now that third box could open up a pathway that gets nearly all US uh equipment able to transition to R290 or other hydrocarbons. This would of course require a deep examination of safety and feasibility of allowing greater charge sizes uh for direct systems uh between 1.5 and and 3 kilograms. So if we go to the next slide, uh these are the architecture types that that orange box could enable. Um the the common types in in the US and these differ substantially to what's used uh globally in other regions. A much higher portion of the US building stock is constructed with these ducted or direct split AC and heating. Um, and all of the most common types of heating in the US are this direct or direct expansion system, single loop refrigerant that physically enters the indoor space. Um, of course making a greater safety potential hazard if that is a flammable refrigerant and there is a a potential ignition source. Um so the good news is again some of these direct systems for hydrocarbons have already been commercially introduced elsewhere although to a lesser extent as the indirect systems.

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Christopher Douglass: There are a number of companies that have developed R290 ductless minilit models in China and India and are in the process of introducing those in the European market. Um so going forward what does the US need to do to to catch up? Uh if we go to the last slide. Well, this is obviously a big opportunity to do the right thing for the climate and the environment, but it's also a big chance for OEMs to drive innovation and to lead the global market. The research has begun on that what I'll call lowhanging fruit equipment um of that indirect equipment and some of those smaller charge systems. But if we want to reach the whole US market, we're going to need to invest in additional research for direct uh mini split systems, ducted residential and and rooftop systems. I think that will do it for me.

Aleisha Khan: Thanks so much, Chris. I really have to say I appreciate the the graphics, especially this is um as you as you were running through this is a very complicated or

there's a lot of moving pieces, I guess, to this picture for codes and standards.

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Aleisha Khan: So, um again, I appreciate the graphics um in explaining all that. And you know, you touched on that it's not just the refrigerant gas, it's also about indoor versus outdoor. It's about charge size. It's about equipment design, which I think is all a great segue over to Cheryl to talk about what California is doing to answer some of those questions. So, over to you, Cheryl.

Cheryl Winfield: Thanks Alicia. Um all right we can go with the next slide please. Um so yeah I want to start with sharing about um California has you know a strong legacy of reducing greenhouse gases and has been a national leader in reducing HFC's or hydroflorocarbons uh from the early days of climate action. Uh California is particularly committed to reducing short-lived climate pollutants like HFC's uh because of their disproportionate climate impact in the near term. A carb has adopted uh several early action measures to reduce HFC emissions under AB32 which was passed in 2006 including our refrigerant management program established in 2009. SB 1383 passed in 2016 focused on short-lived climate pollutants and specifically mandated a 40% reduction in HFC emissions from 2013 levels by 2030 and meeting this target is one of the main drivers of our HFC policy work.

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Cheryl Winfield: Since then, uh, ARB has adopted, uh, regulatory measures and additionally, the California legislature has passed new bills focused on HSC's, which I'll discuss in a bit more detail in my following slides. Um, additionally, our FG gas reduction incentive program or FRIP has received a total of \$66 million from the California legislature. and I'll share some more details about how we're using FRIP funding to support a market transformation for the re refrigeration and air conditioning sectors. Finally, I'll highlight that uh this brings us to California's long-term goal of a achieving carbon neutrality no later than 2045 as directed by AB1279. All of our HFC climate work is directed at achieving a lowcarbon future. Next slide, please. So, as I mentioned, uh, California has been directed to reduce HFC emissions and, uh, to make progress to, uh, towards our SP 1383 emission reduction target. CRB passed a firstofits-kind HFC regulation in 2020. Uh this places GWP or global warming potential limits on the

refrigerants used in stationary air conditioning and refrigeration equipment shown here on the left. Um these are the largest sources of HFC emissions in California.

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Cheryl Winfield: Also in 2020, Congress passed the AIM act which lays out a national HFC phase shown here on the right. uh also directs the US EPA to adopt rules to implement this phaseown and this national phaseown also aligns with ongoing international phaseown of HSC's per the Kaggali amendment to the Montreal protocol ultimately resulting in an 85% reduction in the production and consumption of HFC's in the US by 2036 carbs regulatory work uh paved the way for federal adoption ion and the US EPA adopted similar GWP standards in 2023 in their final technology transition rule under the Act and a national transition uh for all HVAC equipment was completed in 2025 to meet these new GWP requirements. I'll also note here for context that uh these requirements apply to space conditioning heat pumps only. So there's currently no refrigerant standards for heat pumps that uh are solely used for water heating like heat pump water heaters or pool and spa heat pumps. Next slide please. So next I want to highlight California's SB206 which was passed in 2022 which lays out the future of HFC's in California.

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Cheryl Winfield: There's two parts to SB 1206. Um the first prohibits the sale of bulk or newly produced high GWP HFC's on a phased in timeline and requires the use of reclaimed HFC's uh to be used for servicing the existing equipment as shown here on the top of the slide. Uh the second part of SB206 directs ARB to write an assessment report specifying how to transition all HFC sectors in California to ultra- low GWP or no GWP alternatives no later than 2035 and then initiate rule making to achieve that transition. The assessment will uh include an analysis of the refrigerant reclamation industry from the California Energy Commission. It'll also include uh recommendations for workforce development and training, how to increase the adoption of new technologies and also the role of incentive funding to support a successful transition of the market. Uh we plan to release a draft report for public comment later this year and then a final report would be released after that. Ultimately SB 1206's message is that California's future is ultra low GWP and HSC free. Next slide.

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Cheryl Winfield: So now I want to transition to into sharing a bit about our incentive program FRIP. Uh so finan uh financial incentives play a really important role in transitioning the market beyond regulatory measures. Right now we are currently implementing round two of FRIP with a total of \$65 million in funding from the legislature to promote the adoption of climatefriendly technologies and alleviate market barriers. uh with the North American Sustainable Refrigeration Council or NASRC as our thirdparty administrator. We chose NASRC because of their valuable knowledge about the refrigeration sector and they've helped us develop many of our subprograms for FRIP. Um FRIP is really taking an EF an emphasis on a holistic approach to truly supporting a market transformation in California. This includes um grants for the adoption of new climate friendly technology using ultra low GWP refrigerants. This also includes funding for workforce development programs as well as funding for research to support the refrigerant trans uh transition. And lastly, also providing funding for a circular economy of recovery and reclamation of refrigerants from legacy equipment as they are decommissioned at their end of life.

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Cheryl Winfield: This is really important as it uh helps reduce emissions and it also prevents uh stranding existing equipment still using these higher GWP refrigerants. Next slide, please. So with these funds, we've currently launched several uh subprograms for FRIP highlighted here. Uh an important subprogram is focused on reducing emissions from industrial and commercial refrigeration systems and alleviating cost barriers for the adoption of new ultra- low GWP refrigeration equipment. Um this is currently a this is a first come first serve program um which uh is still currently accepting applications through March 31st and so far we've awarded uh \$19 million across 61 projects in California. Uh next uh Cal FRIP is also supporting um a successful industry transition for the refrigeration sector by pairing the installation of these new ultra low GWP refrigerant technologies with targeted workforce development. Uh, FRIP has also funded uh, two literature review projects uh, so ARB can best understand the current science on the environmental and health pro impacts of degraation products of next generation synthetic refrigerants. Uh the goal of this is to avoid the unforeseen circumstances of

synthetic materials that have happened with previous generations of refrigerants like CFC's and HCFC's which were ozone depleting substances.

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Cheryl Winfield: Uh recent research has shown that some of these next generation refrigerants like HFOs can degrade into highly mobile and persistent chemicals such as TFA or other high GWP gases such as HFC23. Um, next, uh, we're using FRIP funding to help increase the recovery and reclamation of high GWP materials from the residential HVAC sector, where refrigerant recovery rates are low, through our refresh pilot program. The refresh pilot is being conducted in partnership with the California Energy Commission's equitable building decarbonization statewide direct install program as well as two national uh US EPA certified uh refrigerant reclaimers uh a gas and Hudson technologies. Uh CEC's program is replacing fossil fuel burning water heaters and furnaces with heat pump technologies. And we anticipate that this program alone could remove over 10,000 furnaces and refrigerant containing air conditioner units. FRIP funding will be used to support the refrigerant reclaimers and also uh buyback values of the rec recovered refrigerant that's paid directly to the contractors and technicians participating in the program who are recovering this refrigerant from retiring air conditioners. And then our most recent subprogram uh very relevant to today's topic is for a complete risk assessment of residential monoblock airto water heat pumps using A3 or flammable refrigerants.

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Cheryl Winfield: And this will be used to inform the codes and standards uh setting organizations in the North American market. I'll share a little bit more detail about this on the next slides. Um, but also want to point you to visit our website, uh, fripfunding.com to, um, keep up to date and learn about new subprograms coming. Next slide, please. So, back to the risk assessment. I'm excited to share that Carbat recently awarded a research grant to the air conditioning heating and refrigeration technology institute or AHRTI um in partnership with AHRI Oakidge National Lab and also very importantly fire service representatives. Uh this risk assessment project was identified as a high priority research topic from a working group which carb participated in established by the white house and the US department of energy in 2024. The working

group included a wide range of participants and industry experts um which worked together to identify necessary research projects and topics needed to support uh a successful advance of the adoption of next generation um ultra- low GWP refrigerants in HVAC technologies. Um this risk assessment uh project so um was looking at residential A3 monolock airtowater heat pumps.

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Cheryl Winfield: Um it was actually previously funded by the US DOE. However, that funding fell through and with the change of administration and fortunately carb through our FRIP program was able to step up and fund this research quickly and released an RFP so that way we could award this grant and keep this really important research moving forward. uh carb and other California state agencies like CEC uh we are generally we talk technology neutral in our approach and supporting research like this and uh we want to make sure that there's a you know suite of technology options for the ultra low GWP transition and we see that supporting flammable refrigerant research like this helps make sure that uh the future of the HVAC sector has options for an ultra- low GWP future. Uh, next slide, please. So, finally, I'm just going to go over some key tasks about the research um, uh, risk assessment project. Um, these are all available in the solicitation on our FRIP website. Uh an important part of this project is the advisory panel and this is uh to be able to solicit really technical input from key organizations throughout the project timeline and ensuring that the project objectives uh align with our expectations and the safety standards uh setting organization st um expectations.

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Cheryl Winfield: The panel will include uh manufacturers, trade groups, environmental organizations, and safety standard setting organizations and fire service personnel. Uh the research um is going to consider at least two uh representative products and installation configures as well as uh to be used for computational fluid dynamics or CDF modeling. and there will be at least 20 different modeling scenarios to be considered. The risk assessment will also include a complete risk analysis including the effectiveness of potential mitigation strategies for any risks identified during the project. And this technology type, as Chris mentioned in his presentation, is currently being deployed in Europe um and other parts of the the world right now. And so this risk

assessment is really intended to inform the codes and standards setting organizations here in the US so that the safety standards can be updated and allow similar technologies to enter the North American market. Finally, as Chris also mentioned, the timing of this research is really important and our goal is that the study informs the current revisions of the fifth edition of the UL2-40 standard which is currently underway.

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Cheryl Winfield: Uh carb's goal is that the results of this risk assessment feed directly into the safety standard process. And next slide has uh contact information for my team. So feel free to reach out if you have questions. We're always happy to connect with stakeholders. Thanks.

Aleisha Khan: Cheryl, thanks so much. And I I just really appreciate how California is really looking at all the pieces of that market transformation and and tackling it at all. So, it's fantastic work. Um, I just want to remind people to put their questions into the Q&A as um as you think of them and um we'll pull them all up at the end. And then I want to quickly um pivot over to Robert. I'm really excited to hear about Eris's work and hear how some of this technology is actually getting deployed right now and um uh all the information, Robert, that you're going to share with us. So, thank you. Over to you,

Robert Benjamin: Uh yeah, thank you very much. I'm I'm happy to uh to be here today and and yeah, this is exciting uh times to be able to kind of share some of the work that Aerys has been doing, but also to see um all the other people out there that are really working towards this this goal.

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Robert Benjamin: I think from my perspective, I'm going to give it more from um a manufacturer, also a designer and deployer of technologies and what this means for us and why we're really interested in it. Hopefully that'll give um give another perspective um rather than just was this tremendous amount of great information about sort of the pathway that we're on and why. So first I want to stop and talk for a moment about uh air to water heat pumps so that uh anyone that's not clear on what that technology is and then how we're able to utilize um different refrigerants in a different way I guess. So an air to water heat pump is essentially like other heat pumps if we're talking about air source heat pumps um in the sense that we are either extracting

energy out of the air um or we're taking it from inside the building envelope and putting that energy back outside. Um but the big difference is is that we are going through um in monolock configurations a plate heat exchanger and so we're using a hyd hydronic loop that we then transfer energy inside the building envelope which we can do a lot of amazing things with that.

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Robert Benjamin: We can do combi systems that do heating cooling and hot water from the same outdoor unit. Um you can use all the kinds of different heat emitters that are available when you have water. So from a system point of view, there's lots of reasons to do it this way. But from a refrigerant point of view, one of the uh byproducts of this is that it's considered an indirect system. Um and so that we are the refrigerant side of things. Uh the compressor and uh and the refrigerant itself is wholly contained in the outdoor unit. Um and so that's the basis of again a lot of what we can do. It's also the basis of why Europe has been able to transition to um A3 refrigerants at a much faster rate because uh air to water is actually the dominant form of heat pumps in Europe today as opposed to uh the United States and North America. Next slide. So why why R290 then? Why R290 in air to water heat pumps specifically?

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Robert Benjamin: And we'll talk about comparisons against other uh refrigerants, but there's a lot of reasons. um as again someone who's putting these systems into buildings into homes um that we would like to use this refrigerant in our heat pumps. Currently we use R32 which is a a very very decent refrigerant and there's a lot of reasons that you know I I believe that that it really is the right choice for some things but when we look at R290 it has a couple attributes um that go above and beyond just it being an ultra low GW refrigerant. um it is a single component refrigerant and I think that just looking at that and the complexities around mixed refrigerant blends and if there are any leakage and the way that the systems react to it um having one source one single component um really does help. It also helps that it's not a proprietary blend that may be hard to get at some point. Um also because of its ability to soak up energy as it as it were. um we can use less of the refrigerant and especially if we're using an air to water, we're using it in a way that's less prone to leakage.

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Robert Benjamin: One of the ways that is exciting for this technology though is that we can produce higher supply temperatures than a lot of other refrigerants. Um and it's still reversible. So we can still do cooling with the same equipment um as opposed to let's say CO2 which can also produce very high supply temperatures um but has difficulty in incorporating systems where it's reversible or easily reversible. Next slide. Um there's a little field here that doesn't seem to be showing up on the slide. Um that we do compare uh R290 against um all the different refrigerants out there. And I'll just kind of give you the long and short of it is it's superior in almost every way. Uh lower GWP, uh high higher ability to soak up energy. Um and then there's other things that we have to think about and that is important to us as putting the equipment out there and is that do they contain uh other chemicals that again can break down and um pose a PAS or POS risk and so across the board uh R290 really stacks up really well against a lot of other refrigerants.

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Robert Benjamin: Next slide. Oh, looks like this is the slide. So we'll go to the next um next one. So what Aerys has been doing because we are a startup and because we are um I would say a little more nimble than a lot of the other uh companies out there, a lot of the other OEMs, we also have a different um structure. We're vertically integrated. So we uh not only are working on the manufacturing side, we're working on specifying all the equipment, but we're also doing the design and engineering for systems. And um we are taking that even further in certain markets. we're doing the installation. So, because of that, we have a lot more um inherent control of the components that go in and how we put it in. And that's allowed us to really move a lot more rapidly in um and basically developing a dual path. Today, we are releasing or preparing a commercial launch of our R32 heat pumps and systems. Um but in in the same time, we're actually uh making them so that they are easily swappable for R290 systems.

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Robert Benjamin: And to my knowledge, we're the first company in North America to do a full um demonstration of an R290 heat pump system, HVAC system uh for residential in North America. And we actually did it on the National Mall uh first um where we sent out a kit and put it together on the National Mall for part of the innovative housing showcase in DC. So that was a really amazing experience and we had a lot of of interest in both air to water, hydronic HC and then um R290. We also did it for an event in Verge in San Jose. And right now I have a system that's installed in my house that is actually a dual system where I can monitor the differences between R32 air to water heat pump and an R290 heat pump and really over multiple seasons see uh any differences in performance and comfort and all the things that are super important. In the end, we're delivering an experience to uh to homeowners, to occupants, and that's the most important part of this, not necessarily all the little building blocks that go in. And then, of course, it matters our impact um uh to the the outside environment.

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Robert Benjamin: Next slide, please. So, another couple really exciting projects that are coming up um is one of them is actually in progress right now is that we have a few grant-f funed projects with a lot of amazing partners involved. uh including one that's um been an ongoing project through a while, but now is um a air to water system with R290 heat pumps that is going into a demonstration site in um in Vermont. And this is a a really interesting project because it is not taking on the full load of the system. So, it's a you know dual fuel system. Um so, we're all going to be able to get a lot of data out of that, but we are adding things in like cooling, which wasn't in the property before. Um, so that project is actually in the installation phase. And so we really learned a lot um with working with our researchers um and and uh partners on that one on all the things that it takes to be able to do a demonstration project in North America right now.

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Robert Benjamin: Um especially one that is multispace, multif family. And then we have another uh project coming up that is um in contracting stage with NARETA as the as the the funding organization and RMI as the prime um with uh wind companies um which is

which is an amazing property owner that is really interested in new technologies. U this will be happening in the state of New York. We have a couple um sites that have been identified but we're going through the sort of feasibility stage of identifying the right fits for this project. Next. So along the way and over the last uh few years there's been a lot of learnings and this is just a short sort of summary of the things that we um that have come into view and I think I just wanted to highlight as as important which is as we talk about refrigerants and I know a lot of organizations um are focusing on the refrigerant itself for good reason. Um, one of the things that I like to say is that the equipment, the system is as important, if not more important in some ways, which is to say that what air to water offers you is you get to use a lot less refrigerant, whatever that refrigerant is, and you get to ultimately maintain it in a more controlled environment with less potential for leakage.

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Robert Benjamin: And so just identifying that if anyone's at the state level looking at implementing cleaner technologies, heat pumps are great, but air to water is really an unsung hero in the way that we can bring heat pumps into the market that has a lot more benefits. Uh other lessons are when we talk about risk, which you know, I'm super happy about what carb is doing. It's it's been actually a long time in the works for for I've been expressing the need that we need an independent organization while UL and and um and HRI and Ashray are all working on steps forward and what this going to mean officially into the marketplace. Um there's a lot of learnings and demonstrations and partners that want to work on this. In the meantime, there has to be an objective guide to do this the right way. Um we're we're we're doing a lot on our own, but it has to come from other sources. So that's what that's going to allow for local AHAs to be able to look at something that's really informed and and backed by science.

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Robert Benjamin: Um and so one of those things that come into view too is that look, every site has risk. And matter of fact, what we're finding is that that we're walking into most sites have a a major amount of risks that were there. They were just not identified. And so when we put new equipment in and new projects, we have to take into account the risk that's there. And then whatever new risk that we're introducing with our

equipment then we take very seriously. Um so and then you know a lot of this is just again things that you'll learn along the way that you really need a lot of design intelligence. You cannot do any new technologies unless you really incorporate a lot of design intelligence into the process. So that's very important. Contractor training of course is very important um overall. But what we're finding with air to water, which is the exciting part, is that the skill set to install the systems, they're not actually working with the refrigerants. So the the really the risks for that side is actually a lot more minimal than split systems.

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Robert Benjamin: And when the time comes for technicians that need to be able to handle the refrigerant side, um then they will be trained to do so. And so the the leap to go from where we are with split systems where pretty much any HAC technician is going to handle refrigerants to where we could be with air to water is actually a really really uh great opportunity. Permitting is, you know, one of these things that people just have misunderstandings about what you can and cannot do because a lot of there's a lot of local enforcement of certain things. But what you find is that there's not a lot of you can't do this. There's a lot of what do you need to do if you're going to do it in a certain way? Are you demonstrating? Are you doing this for a permanent? are you doing it for a temporary installation? Um things like that and we're navigating this um site by sight right now. Um so it's it's been a lot of learnings there and in the end we're a small organization.

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Robert Benjamin: It's just we're we're a startup but we're taking a lot on in in really blazing trails. So, we're looking for collaborators and ultimately, you know, I think that in the end that there's a lot of other manufacturers who are very interested in uh both Airwater and with um with R290 and I know some that have already uh been looking to do demonstration projects and so we we'd be happy to share learnings with them and collaborate with them and so that would be great. Uh next slide, please. So, I'm just going to leave with a little um I guess funny little anecdote story, at least from my point of view, is this is from a family vacation. Um you know, we co-t travel from the Pacific Northwest uh out to Montana every year usually and um you know, a lot of the

conversations that happen at the sort of official arena and with, you know, we talk about safety, we talk about all these things, it can get very heavy and it's very important to look at any new product and existing products from a point of view is how to make them safe.

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Robert Benjamin: For sure. Um but it's just interesting because we also live in a world where a lot of things out there are used that you know their safety factor if you were to try to bring them into products today um you they may not happen but one of the interesting things that I think about is just utility like what are the reasons that we should be adopting new things um we should get more out of them that's one of the reasons we should get a better experience and so and yes we should make the world a better place and not a worse place for sure but you think about you know passing this truck and and ultimately And I did the um did crunch the numbers finally because I knew that there were some interesting numbers here. But look, if you took the propane that is in this flatbed trailer that again, it's a whole lot of of potential energy right there and and you put it into furnaces and you used it once through combustion. I mean, you'd get a lot of BTUs.

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Robert Benjamin: You get 410 million BTUs of of energy out of it. I mean, that's one of the things that that we can't deny is that there's a lot of potential energy um in some of these fuel sources. But if you look at it a different way and you actually were filled 5,400 air to water heat pumps with each of them about 1.6 uh kilogram, you can actually produce 80,000 BTUs an hour by utilizing that that refrigerant or that gas in in the heat pump. And if you calculate that over over 15 years of of life, even though even after 15 years, you could recycle that, um, you're ultimately able to deliver 16.2 trillion BTUs of of energy. So that's, you know, 40,000 almost 40,000 times the the energy delivered. Um, so that's what I'll kind of leave you with is that really I know we all want to get to the same place. even people who who I think are on a different ideological viewpoint of things is that we all want to make uh the life better for for people that we love and and and a more stable uh place to um to thrive in and in the end of the day everybody I think appreciates better utility, better use of resources because we're going to need that and

and it's also going to help us with other problems like the cost of energy.

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Robert Benjamin: So I'll leave it there and and turn it over to everybody. Thank you.

Aleisha Khan: Thank you so much, Robert. This is my new favorite stat. I think it's really good and thanks for, you know, really just taking us grounding us in the implementation and what it looks like from your perspective. Um, we just have a short time left. Um, apologies for the the shorter time for Q&A, but I think what we'll do is um we can take the slides down. Um, Jimmy, thank you. and then we'll just have the speakers on in. I'll just do a quick round of a question for each of you um to wrap up today. And so these are coming from from the audience here. And starting with Chris, I think this is best suited for you. Um the question is asking if you can compare a current A3 refrigerant capacity limitations in the US um and Europe. So you had some of those slides showing talking about charge limitations. Um it's asking what changes in charge limits can we expect in the future in the US?

01:00:09

Christopher Douglass: Yeah. So I think two things here. The one is uh there's capacity and there's charge size which are different but related obviously in terms of uh you need a larger charge size to have a larger capacity. Um equipment in Europe is typically a little bit smaller because their home size and footprint is just typically a little bit smaller. So there is some differences there between US and um Europe just in building design and equipment design. But to the charge question, uh the US currently has a cap at 114 grams for any system, whether direct or indirect. Uh whereas in Europe, they can go up to 988 grams for a direct system and almost 5 kg for an indirect system. Uh like the t like the kinds that Robert was talking about. Um right now we are headed for a path which is I would say probably uh going to enable indirect systems to be around that 5 kilogram charge limit but that's obviously dependent on some of the testing that Cheryl and other folks are uh kicking off as well.

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Christopher Douglass: um on the direct charge systems, the only testing which has been looked at so far is the smaller charge um systems I can't remember exactly the size off the top of my head, but it's less than a kilogram for sure. Um so that charge that testing needs to get underway if we're going to get anywhere close to um getting those larger direct systems in in the US.

Aleisha Khan: Great. Thank you. Okay. Um over to Cheryl. Cheryl, this is a very specific question, so I'm going to give you an out just from the beginning. We can certainly get back to people um uh after this webinar um with answers. Um the question is about the uh computational fluid dynamics the CFD modeling that you talked about and is wondering if um what's being modeled represents units that are sitting on stands of at least 12 inches in height. So it's looking for you know that positioning of the

Cheryl Winfield: Um,

Aleisha Khan: unit.

Cheryl Winfield: yeah, I I will say I don't know off the top of my head.

01:02:32

Cheryl Winfield: Um, I will I I can share that, you know, we're looking at um I think maybe six or seven different installation scenarios right now. Um, but we're still working out kind of the final details of the entire project scope and what's actually going to be included in the modeling because as you can imagine there's so many different scenarios that we could model but there's you know only so much funding we have. So thinking we're being trying to be really strategic about thinking about what installation configuration and then what potential leak scenarios uh we'll be considering. So yeah, that's that's what I can share at

Aleisha Khan: Yeah, and that's really helpful to understand where you're at.

Cheryl Winfield: least.

Aleisha Khan: And I think it also brings up a question that we do not have time to get into here, but it's on some kind of standardization between testing so that you know there aren't any gaps left and there's some agreement on what's going to cover it all. So maybe we can get into that in

Cheryl Winfield: Yeah. So, we're we're going to be working Yeah.

01:03:40

Cheryl Winfield: I'll say we're working, you know, really closely with um an advisory panel that we've set up with, you know, experts in the field that have a lot of technical background on this topic and making sure that we are considering the most relevant installation configures. So whether that's yeah looking at you know 12 in of height above the ground but then also proximity of windows, doors, egresses, walls. Um we might be considering a rooftop installation. So we're we're looking at sort of all of the options right now and then prioritizing what is most important for for this project.

Aleisha Khan: Great. Thank you. And Robert, I'm going to give you the last word. Um, you know, you're working, you do a lot of things, as you explained, but you're also working directly with end users, and of course, that's, you know, Reef is working with end users, too. So, I appreciate that. It's really important um to make sure that they're educated, they understand, you know, in your case, you know, what you're offering to them. And I wonder if you could share some insights into that piece of your business.

01:04:55

Aleisha Khan: Like, how do you do you feel like you have to do a lot of education for homeowners? Is it a pretty easy sell?

Robert Benjamin: Yeah,

Aleisha Khan: What are the things that matter the most to them?

Robert Benjamin: I'll answer that and I'll probably I'll be able to hit two of the questions that are up there right now, too, which is that we're not we're not selling directly to homeowners to be like,

Aleisha Khan: Okay.

Robert Benjamin: "Oh, someone wants an R290 heat pump. Come and, you know, hit us up and we'll we'll shivy out one." We're not actually doing that in our regular system anyway. We're working through usually builders and or contractors, but making sure that there's a a little bit more involved because we're doing it a little bit differently. That's this stage. So I I would say that that the partners that we're working with to deploy our technology. Yes, there's a tremendous amount of education involved about the total of what is going on there and of course around anything related to well we are using this specific piece of technology also within the system.

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Robert Benjamin: Here's our objectives. Um and so yeah that is a big big part of it and I would say that that we're more open to those more of those projects. So that's how we're treating R290 is that look if there's if it's a research project and again that could be localized could be a smaller project doesn't have to be these bigger ones that are you know big grant funded projects but there has to be some learnings involved and everybody has to be in it for those reasons um that they they are really motivated by all the learnings that can come from it um and those are the projects that we take on and that way that we're all we're all in the boat to educate each other on all the things that we need to do and do it right. Um yeah, so I think that someone had a question about cops and whatnot and I'll say yeah, you can hit me up to get any detailed stuff, but I will tell you just offhand that under those same conditions, um you know, existing refrigerants and R290, there isn't huge differences. There's just more differences in in how you can push temperatures and those will also affect the cops.

Aleisha Khan: Great. Thank you so much. Yeah, I see some questions came in late, so apologies not to get to to everything, but it's it's helpful to understand what your model is, Robert. So, that's great to know that there's other players involved and that is like how you do it. So, that's that's awesome. Um, we are going to wrap up. Um, like I said, we will um share with everyone a recording and um a link to slides and so forth and we had some resources on our website. So, we're really happy that you joined us for this conversation. If you have any feedback, feel free to share that. And I really want to especially thank the speakers.

Transcription ended after 01:08:08

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