Hannah Debelius: Thank you all so much for joining the webinar. We're going to be getting started here in just a couple of seconds.

[Silence from 0:00:28 to 0:01:12]

Hannah Debelius: All right, welcome to today's Better Buildings webinar. We are dedicated to bringing you the latest actionable insights from leading industry experts, Better Buildings partners, and webinars, and this is a chance for you to explore those topics, technologies and trends that affect your organization. So, we're glad to have you today with us. Next slide.

Today's webinar is called the Better Buildings Commercial Building Heat Pump Accelerator Goals and Next Steps. But before we dive in, I do have a couple of housekeeping items for you all. The first is that today's webinar will be recorded and archived on the Better Buildings Solution Center. So, if you're registered, we'll follow up with you when that recording is available. It's usually pretty quick and you can share it with all your colleagues who weren't able to join us today.

And finally, you will notice that you are in listen-only mode. All of our attendees are in listen-only mode, but if you have any technology or tech issues, you can use the Zoom Q&A chat and our tech support will be able to help you out with that. We'll also have another way for you all to still engage with us through questions to our wonderful speakers today. Next slide.

My name is Hannah Debelius, and I'm very pleased to be your moderator today. I'm with the Building Technologies Office at the Department of Energy. And I have the wonderful pleasure of working with our commercial partners in the Better Buildings program and the Better Climate Challenge. What we're going to get into today – the agenda – is that we have a packed agenda. We're going to start by talking more about the Better Buildings and a heat pump accelerator. I know this is a hot topic, pun intended, across the Better Buildings industry. So, we're going to talk more about it. We're going to share some of the expertise from our labs. And then, we also have three partners who are going to talk about their experiences with heat pumps and through this accelerator. And of course, we'll save time for questions for all of our audience.

However, we are going to start with some questions for you all. So, this is that platform I mentioned for engagement. So, right now, if you could open up either your mobile device or another browser

and go to slido.com, you can enter that event code DOE. And I'm going to say this again more slowly so you all can do it in real time. Open up your mobile device or another tab and go to slido.com and enter the event code DOE because we're going to do a couple of polls for the audience to get started. This is the same platform we're also going to use for the Q&A, which we'll do at the end.

Okay, excellent. So, hopefully with that, we can go ahead and launch some of our polls – again, slido.com with the event code DOE. And that's how you can interact with these polls. So, we will go ahead and launch that first one.

So, our first question for you all, we just want to get to know who's in the audience. So, what sector best describes your organization? If you're just joining us, again, on the lefthand side, you can see "Go to slido.com, the event code DOE."

All right, a lot of contractors and consultants. Welcome. Strong presence from government. I'm seeing local and federal and nonprofit. We've got some utilities on the line. It looks like maybe some higher ed folks. Strong industrial presence. What's great about today's webinar is that we are talking both from the owner-operator and also the manufacturer sides, so I'm glad to see this diversity of folks on the line.

Okay, I think we're getting a good sense here. So, let's go ahead and move to the second poll on slido.com with the event code DOE. We are just curious to know what brought you to today's webinar on the accelerator?

"I am interested in commercial building heat pumps." That is definitely a common phrase I've been hearing from our Better Building partners for the last couple of years, so glad to see it in this poll as well. A lot of folks looking to learn more. And we've got some great information in store for you. And a couple of existing partners for the accelerator online, which is really great. We've been really fortunate to have some early, super strong partnerships in this program. So, I'm appreciative of your participation and then also participation in the webinar today.

Looks like our answers are slowing down here. So, just two more polls for you and we will go ahead and launch the next one. We want to know how familiar are you with Better Buildings? We at least know you're familiar with the webinar series because we're

glad to have you today. And again, if you're just joining us, you can go to slido.com with the event code DOE. That's where you'll participate in these polls and we'll keep that going for the Q&A at the end as well.

Ooh, I love to see this. Many people are curious about joining as a Better Buildings partner. Music to my ears. All right, but I am going to answer that question, "What is Better Buildings?" in just a little bit. Great. And thank you to all of our existing partners for your participation in the program. We're glad to have you today because we're talking about something brand new – well, pretty brand new to Better Buildings.

Okay. I think we're going to go to our last poll here before we then share information back with you all. And this one is near and dear to my heart. So, I do hope that you will hop on slido.com and have your voice heard. What types of resources are most helpful when learning more about your building's space conditioning systems? This is going to be a super helpful question for us because we are just really at the beginning of this campaign accelerator and your input can help us determine where we want to head with these resources. So, all right, "short guides." That's actually my personal favorite as well. Okay, I'm glad to see strong support for webinars since we're doing that right now. Perhaps a little biased since you're doing this today. And some support for meetings and workshops. I know that face-to-face is always a great option.

Okay, this is great. Thank you all so much. Go ahead and leave that tab or your mobile device open to slido.com because we'll accept questions the whole time through this webinar and then we'll get to them at the end. So, we can go ahead and close the poll, but you audience folks keep that open and submit your questions for us.

All right. As I mentioned, we have a wonderfully packed agenda today. We are very fortunate to have two of our DOE experts on the line today – Jim Young from Guidehouse, Michael Deru from the National Renewable Energy Laboratory – and then three partners who are joining us. Jeremy Scharfenberg from Columbia Association, Robert King from Target, and Andrew Rhodes from Amazon.

But before we get into all of that, I do want to share just a little bit more about Better Buildings and what we're doing with this accelerator. Next slide.

So, for those of you who said that you were not familiar with Better Buildings – next slide – Better Buildings is a program through the Department of Energy where we work to catalyze energy efficiency and emissions reductions across all sectors of the built environment. This is a voluntary program where we work individually and with huge peer networks and industry with over 900 partners to really advance technology and organizational solutions and progress in general through case studies, webinars, Better Buildings Summit, if you've joined us for that. We have tons of resources available in the Solutions Center, which is our website. We're going to talk more about those today, but we also included these links, which will again be available to you when this is posted – when this webinar is posted in the Solutions Center.

But today I want to talk more specifically about the Commercial Building Heat Pump Accelerator. So, heat pumps in general, if you haven't seen our previous webinars on heat pumps, go check those out in the Solutions Center because there's a lot of great introductory information. But the basic principle of a heat pump is that it is much more efficient, in fact, two to five times more efficient to move heat than it is to generate it. So, we can extract that heat from air, water, or the ground and transfer it or do that in reverse. And that's pretty much at a highest level what a heat pump does and how it works to cool a building.

So, when we combine that with what we are hearing from Better Buildings partners and consider it alongside the work of the Building Technologies Office, we know that the market for heat pumps is not as advanced currently for large commercial systems – and it has been for residential – especially in those cold climates where it's harder to extract that heat and move it. There can be a much bigger temperature difference between the outside and what you want temperatures inside. So, that then leads me to the problem that we are trying to solve here, which is that currently 40 percent of commercial building energy end use goes towards space conditioning. So, we know there's a lot of opportunity there.

There are a couple of big pathways for addressing that opportunity. Some of those relate to strategies for retrofitting large systems. But what we are focusing on is this relatively low-hanging fruit where we can do a one-to-one replacement. And that opportunity is through replacement of heat pumps on rooftop units. So, those that aren't currently heat pumps but could be.

Through Comstock, we conducted modeling that shows eligible buildings nationwide have – excuse me – we have conducted modeling through Comstock that shows that if eligible buildings nationwide that have rooftop units that currently aren't heat pumps that move to heat pumps and that aligned with our advanced specifications, the savings realized could be up to a 50 percent reduction in greenhouse gas emissions and $5 billion in cost savings annually. So, again, we are focusing in on this incredible opportunity here.

So, to do that, we are actually looking to solve this problem through both sides where a framework of supply and demand. We know through speaking with our Better Buildings partners that we've been hearing that they want to be able to make bulk purchases of units that perform at a level of efficiency that isn't currently available on the market. So, you'll hear more about this perspective on the webinar today. So, that's creating that demand. And we also know in working with feedback from the manufacturer side, and we've shown them that that demand is there and we're hearing that, we know that – we show them this demand we're hearing and have had lengthy discussions about what's feasible for production of new units and the fast turnaround time needed.

So, this two-pronged approach of working with owners who want to make these bulk purchases and also manufacturers who are ready to meet that demand, that can create this campaign and what we're doing through the Campaign Accelerator. And that's really the foundation of the work we're doing here. Next slide.

So, through the Better Buildings, the Commercial Building Heat Pump Accelerator is working with stakeholders to accelerate the development and adoption of heat pumps, heat pump-packaged rooftop units to achieve integrated energy efficiency and electrification of buildings. So, in a moment, you'll hear more about the details of that work through the adoption campaign and also the technology challenge.

But the big point that I want to stress about this work is that it really is a cross-sector partnership that is moving very quickly. Through the work with manufacturers, we are targeting testing of that pilot – of those pilot units this winter, followed by cold climate field testing next winter with the goal that products could be on the market as soon as 2027. So, we're moving really fast.

And I also should mention that in the phase of our work with the accelerator we're in right now, it's focused on performance that is possible with available technologies within this aggressive timeline.

So, we recognize there's also priorities around emerging technologies, and we are working on that across the Building Technologies Office and also with consideration of refrigerants. But again, right now we're focused on performance that's possible with available technologies within this aggressive timeline. Next slide.

We are so proud that seven large commercial heat pump manufacturers have come together to collaborate with us through this Accelerator and are participating in the technology challenge. The photo you can see here is from our Better Buildings Summit that was last April and it includes most of those partners alongside our Deputy Assistant Secretary, Dr. Carolyn Snyder. And we couldn't do this work without the input and market pool of these incredible campaign partners you see listed here. These organizations are helping us drive innovation and ensure successful deployment of this technology. So, we'll now hear more about the campaign and technology challenges. Before doing so, I do also want to recognize my colleagues at DEO – excuse me, at DOE: Michael Blunschi, who's our campaign lead. He, I believe, might be in an airplane at the moment. Sam Petty, who's also in the Building Technologies Office. Nate Allen on our commercial buildings team in the Building Technologies Office.

This is a huge priority for Better Buildings and the Building Technologies Office, and so we have a strong technical team supporting it. So, with that, I'm thrilled to actually turn it over to another member of our team, Jim Young from Guidehouse, who's going to talk a little bit more about the overview of the campaign's work. Jim, take it away.

Jim Young: Thank you, Hannah. And thank you for joining this afternoon. So, as Hannah mentioned, there's kind of two parts of the accelerator. The first one of the campaign, which is aimed to kind of highlight the current technologies, both kind of electric-only heat pump rooftop units, as well as dual fuel models that may use natural gas or another fuel as a backup heat for colder regions. So, the campaigns, we're trying to highlight those that are adopting these products today to help meet their sustainability and

decarbonization goals, but also bring along other organizations that are starting to look at what options are available for our buildings.

So, at Guidehouse and in partnership with NREL, DOE, and some of the other national labs, we're working to develop a series of resources and guidance documents to support those groups to better understand what the opportunities are for their region, for their building type, to share that information internally about how the procurement may work financially, and then ultimately, what we want to do is to highlight those successes and develop a few case studies around how groups have either in the past already made heat pump rooftop units as kind of their basis of design or standard specification or how they're working towards that in the future. So, some of the resources that we are – we have together already that are on the website or under development, things like decision trees and guidance documents to help you understand what the considerations may be for upgrading to heat pump rooftop units. Estimates on energy, economic, and emissions comparisons coming out of that Comstock modeling analysis that Hannah mentioned.

On the next slide, we'll get into two case studies that we have to date, and you'll hear from Jeremy with Columbia Association. But we're also interested in hearing from you all about what are your questions? What concerns do you have? Because we can tap into our manufacturer and our national lab experts to provide those quick fact sheets or four-to-six-page documents to help support your teams explore this opportunity.

So, as I mentioned, ultimately, what we want to help show is that this is not something that is pie in the sky or it only works in certain regions. What we want to showcase is that heat pump rooftop units have been sold for decades but have limited adoption to date. But there are those leaders across the industry that are saying, "Yeah, we're adopting them for sustainability goals" and you'll hear from three of them today. But I just want to call attention to on the accelerator website today, we do have two brief case studies, the first kind of with Los Angeles Unified School District out in California. They have really made this kind of a key part of their decarbonization strategy and have, yeah, rolled this out as their standard specification where feasible across their both new and existing school portfolios. And then, Columbia Association – Jeremy will fill you in on that and what they've been doing in the past and in the future related to heat pump rooftop units. But, yeah, we just want to call out that the case study is

available on the website. So, with that, I'll turn things over to Michael Deru with NREL.

Michael Deru: Thank you, Jim. And welcome, everyone. And as Hannah mentioned earlier, this is a – we're looking at a multi-pronged approach here. And this is the second part of that, the challenge, looking at how do we develop, how do we push the next generation of heat pump rooftop technology to perform at a higher level for these colder climates? So, we're working with the building owners to understand what their challenges, what their needs are, what will work for them, what won't work for them. And then, working with manufacturers at the same time to develop a specification that pushes the technology to have better – improved cold weather performance, and while at the same time understanding we want to – we need to minimize those electrical capacity impacts and the peak demand impacts. And we realize there's some other issues around. We really want to minimize the impacts of refrigerants and the high GWP refrigerants that we're using today. And so, we're working with DOE and the other national labs to really push this technology, be able to test it in our labs, and then test it in the field and validate those performances.

And then, as Hannah said, we're trying to push these available as quickly as possible. It does take a long time to develop new technology, but hopefully by the – 2027 is our timeline where we can actually have these available for purchase. Next slide, please.

And so, here's a proposed milestone for phase one. Phase one is we're looking at what can we do with today's technology, basically, just putting it together in a way that pushes the envelope as far as we can. And then phase two, we're looking at what we can do with advanced technologies, where we're giving them more time for research, things that are under development now, but a few years away from being market – from being available on the market. So, we're hoping to have available systems that by next winter that we're field testing those systems, and then by 2027 having those available for purchase in the market.

Now, this is a proposed milestone – or, a proposed timeline. Don't take this as we will definitely have all these available, but we're working very hard, and the manufacturers are working very hard with us and moving as fast as they can. So, stay tuned. We're going to have a lot of information coming out between some prototype units and some lab testing and some field testing over the next couple years. So, yeah, we – and we'd love to hear any input you

have on the specification. We will have this available later, hopefully by the end of August or early September, that we can share this with everyone, this specification, that is. So, I am going to turn it back over to Hannah now for the rest of the speakers.

Hannah Debelius: Great. Thank you so much, Jim and Michael. We're going to get right into it. I am very glad to welcome Jeremy Scharfenberg. He serves as the Vice President of Community Operations for the Columbia Association, where he is responsible for managing a diverse portfolio of commercial facilities in Columbia, Maryland. So, Jeremy, if you want to bring your camera on and go ahead and dive in?

Jeremy Scharfenberg: Excellent. Thank you, Hannah, and thanks for the opportunity to sort of speak to the group this morning on Columbia Association's experience with dual fuel heat pumps in particular. If you can go ahead and advance to the next slide?

So, just a quick background on Columbia Association in terms of who we are, for some context for our building portfolio. So, we have about 600,000 square feet of commercial building space in and around Columbia, Maryland, ranging from a 100,000-square-foot athletic club to a 1500-square-foot daycare, essentially a residential application, very small facility. Primarily packaged or split HVAC systems, mainly packaged. We don't really have any chillers or any type of high-end industrial cooling or HVAC equipment. It's primarily packaged units throughout our building portfolio on the larger facilities.

We've been very aggressive in our energy management program over the last decade, really working proactively with DOE and the Better Buildings program, as well as the labs on continuing to push the envelope around energy efficiency, and in the last couple years shifted to the decarbonization focus, both for space conditioning as well as water heating. Next slide.

And so, from our perspective, when this sort of electrification push sort of came to be the priority a couple years ago, what were our solution requirements and our objectives within our building portfolio to advance this decarbonization priority? So, maximize heat pump use for space conditioning, minimize electrical service upgrades. Again, our primary use scenario is retrofit of a packaged HVAC unit on an existing building. We don't do a lot of new construction. We don't do a lot of major renovations. So, it's for the most part one-for-one replacements of equipment.

We're trying to minimize the electrical service upgrades due to cost concerns, both getting the power there and then the constraints of the existing buildings' distribution system in terms of just being limited with the power that our existing buildings have. And then there's also lots of competing demands, as everyone well knows, around electrification of water heating, electric vehicle charging stations. All of a sudden, there's a ton of demand on that old 40- or 50-year-old distribution panel in the basement of some of these buildings, for example.
Retaining duct work for air distribution. I think that's sort of a key constraint that often gets overlooked around how these packaged units operate. They're supplying air to multiple zones at the same time, and there's some static pressure concerns around how much air you can actually push through that existing duct work. You've got to maintain your outdoor air requirements. Again, that's sort of key realities around how we manage these buildings to make sure we have all these objectives met. In addition to space conditioning, there's fresh air requirements that can limit some of our opportunities. And then, try to reduce or eliminate natural gas as much as possible. And next slide.

So, what are some of the tools that are out there to sort of achieve that objective? So, there's the standard heat pumps with electric auxiliary. We had a handful of these units in our existing fleet where the buildings themselves were fully electric. And then, the heat pump package units with gas auxiliary. So, these are the dual fuel heat pumps. It's not very common but can be high-efficiency in terms of the product that's available that we've been able to utilize. Then, ductless split heat pumps are sort of where everything's going now in terms of ultra-high efficiency, ultra-low ambient performance, getting into negative temperatures and still generating heat, which I find to be almost a magic thing that's happening where it's minus 5 degrees and you're still getting heat out of some of this equipment, which is fantastic. And then, the other tool that's out there is the dedicated outdoor air systems and energy recovery ventilators, which I think both of these pieces are sort of going to be key tools going forward to really make heat pumps viable in this space. So, those are the tools. And next slide.

So, when this sort of came to be a priority a couple of years ago – again, in working with the Department of Energy and the labs around really pushing electrification – we really mainly pivoted in terms of our basis of design units, which had been a very high-efficiency unit that came out of the previous advanced rooftop unit

program from probably over 10 years ago now to immediately a dual fuel. It's like, well, okay, if we have to get heat pumps in place, we can't immediately afford to handle the electrification component, so let's use the heat pump for our sort of base load of heating and then have the gas as the auxiliary for those coldest times when the heat pump can't keep up.

So, we switched to this, the dual fuel units, as our standard about two years ago. We've put in 10 of them now at this point from two different manufacturers. We've been very successful. There's no sort of changes in terms of electrical service or ductwork enhancements. We don't need to absorb those costs. And then, the other pieces of it to think about in terms of the design constraints, at least here in Columbia, Maryland, where we are, the heating and cooling load differential is basically a factor of two. So, the heating load is double in terms of BTUs per hour required relative to sizing for different equipment.

And then, I mentioned the existing ductwork constraints, especially in our applications where we're trying to do this in existing buildings, working within our existing electric supply systems, working within our existing ductwork. The dual fuel heat pumps were a really good option for us to pivot to for the last two years. And you get meaningful reduction in your natural gas usage because, again, in Columbia, Maryland it's somewhat temporary. It does get really cold at times in the winter, but above 30 degrees, for example, there's a lot of heating load that happens throughout the winter season that is now captured by heat pump as opposed to gas on the existing conditions because we switched to these dual fuel heat pump units. Next slide, please.

So, this is just sort of a base case example. We're actually doing this right now with one of our neighborhood centers where it's an existing DX cool gas heat with two seven-and-a-half-ton units sort of serving two halves of the same building. We're switching to the dual fuel heat pumps in this application. It's cost-effective. It's actually a little bit cheaper because we're sort of stepping down in terms of the grade of unit that we have been using historically and a significant gas reduction. Some of the cons, you're not getting that really low ambient heat pump load and there's still a chunk of gas that remains. Next slide, please.

And then, we've – as we've been sort of evolving in this scenario and coming up with different challenges, we actually have an application in one of our facilities where we left an existing – well,

it's actually – we've since converted it to a dual fuel heat pump package unit, but we added ductless split units to the same zone. So, it's – we retained the package unit, converted that to a heat pump. We were able to even downsize it, and then within the same space, retroactively go in and add ductless split heat pumps. And then, what we've done is we've staggered the set points. So, the ductless split units, which are super high efficient, are actually sort of the first stage, if you will, of heating and cooling because of the way we've set up the set points. And then the package unit will come on if the ductless units can't handle the load. So, we try to get sort of creative in how we solve these issues and push the envelope around, getting as much of that heating and cooling load to a super high efficient, low ambient heat pump technology. And next slide.

So, in terms of our perspective of where the advancement needs are and why we're really excited about the accelerator program with DOE and the Better Buildings team is we need more equipment options and we need equipment that has some of the higher-end features like enthalpy control, demand control ventilation, ECM fans, continue to drive heat pump performance to lower ambient conditions. I think some of the units can go pretty low. Some of the more common units only go to 30 degrees, for example, before they switch over to the gas.

Simultaneous heat pump and gas section operation. I think this is sort of something that would be fantastic to have where if the heat pump can't keep up with the load, both heat pump and the gas section would fire at the same time. Demand control ventilation, again, is sort of gonna be key to really making the heat pumps effective. And then the energy recovery wheels, I really see these as being a key piece in driving performance of heat pumps into temperature zones and conditions that they might not be able to achieve and achieve performance because the energy recovery wheel really enables some of those temperature differentials and reductions in load that are covered by the energy recovery rather than the heat pump itself. And now it's – in addition to the efficiency gain, you're also offsetting potential electrical upgrades by adding in the energy recovery wheel. So, I think in my mind, that's sort of a key piece going forward to success of the heat pumps. And then next slide – this is my last one.

And then, explore combining package units with ductless. I mentioned that we just did this sort of on our own by staggering the set points, but I think long-term strategically, if you're constrained around power at the side of the package unit and the

duct constraints, adding the ductless heat pumps in the zone, and then actually integrating the controls so that the unit itself is running the ductless and its package operation at the same time and effectively using the ductless as a first stage of heating and/or cooling, and increased modulation of the gas section. If you're going to have to keep gas as the auxiliary, make it as efficient as possible to better complement the heat pump operation. So, those are sort of key advancement needs that we see in deploying this technology. And that's all I got.

Hannah Debelius: Great, thank you so much, Jeremy. We appreciate all those insights. Before I go to the next one, just a reminder that we are going to take questions throughout the whole time, or rather accept questions. So, you can go to slido.com with the event code DOE and input your questions there, or you can also kind of upvote other questions by hitting the thumbs up, and those will reach the top so we're more likely to be able to get to them at the end. So, with that, I am glad to have Robert King joining us. Robert King is the lead mechanical engineer at Target in Minneapolis. Robert has been in the engineering department for 27 years and is a professional engineer registered in 47 states. So, with that, Robert, you can turn on your video and go ahead and take it away.

Robert King: Thanks, Hannah. So, I'm going to talk a little bit about how a large building portfolio owner is partnering with the accelerator to help meet some of our sustainability goals that we have. So, next slide.

So, like a lot of other big corporations, we have – Target has some sustainability goals with some definite milestone dates. Part of our goals are greenhouse gas emissions reduction. And on the slide here, you just see something from our Target.com website, some clips from our Target 4 goals. So, as we talk about greenhouse gas reduction, we're mainly concerned with what we call scope 1 and scope 2. And scope 1 emissions is emissions coming directly from our building, and that includes burning natural gas or leaks in our refrigeration system, be that HVAC or market refrigeration systems. And then scope 2 is emissions that are generated as part of generating the electricity to run our stores. So, by 2030, we have a couple of goals. We want to source all our electricity from renewable sources for all our operations. And we want to achieve 50 percent reduction in scope 1 and 2 emissions from a base year of 2017.

And then – those are the two main ones for 2030. We're doing pretty well on those goals. We're – I think we're 60 percent of the

way there. Getting scope 2 emissions, that seems to be the leader right now. That is the leader right now in our emissions reduction. But then we go to 2040. And by 2040, Target wants to have net zero greenhouse gas emissions, scope 1, 2, and 3. So, when we talk about net zero, scope 1, that's all building-generated emissions. And that means we need to get net zero around our HVAC systems, that – a lot of them are burning natural gas, and also from our refrigeration system leaks. So, next slide.

So, as we look at our assets at Target, we have approximately 2000 stores. And on those stores, we have – we own about 40,000 RTUs and about 5000 gas-fired unit heaters. And those are all producing greenhouse gas. So, most of our RTUs have – I just want to average it out, it's about 20 RTUs per store and primarily DX gas-fired. And we have buildings throughout the United States, all climate zones, and so we have challenges everywhere, in warm climates and cold climates. So, we have a couple of – when we're looking at how do we reduce our greenhouse gases from HVAC assets, we have a couple of principles. First one, Target is a for-profit company and we want to try to reduce our emissions at the best possible return on investment. And we also want to make sure that we're running our assets all the way through their useful life. And for RTU, for Target, that's – somewhere between 15 and 25 years is the useful life of a RTU, and then we'll replace them with a new piece of equipment.

So, I mean, with that being said, if we have a 20-year useful life on a piece of equipment, that means that any piece of equipment we're putting on the roof today is going to be there in 2040. So, we need to be focused on – even though 2040 sounds like it's a long way away – on what we're doing today to help meet those climate goals. So, as we look at the technology that is most cost-effective for us, and that's going to be replacing our RTUs with heat pumps. And in warmer climates, that's not too heavy of a lift. In climate zones one, two, and three, you can buy pretty well-proven heat pump technology that we just replace our unit with. It'll satisfy both our cooling needs and our heating needs. It's when we get up into the colder climates, zone four through seven, and that's starting with places like Tennessee and such where it gets more challenging because the heating that we get off our heat pump is not sufficient for our building loads. And the challenge with air-to-air heat pumps is the colder it gets, the less heat you get out of the heat pump. And it's like swimming upstream. The colder it gets, the more heat you need out of your heat pump.

So, what that means is, like Jeremy had talked about earlier, is we need to have some kind of auxiliary heating in those colder climates. And how do we do that and make sure that we're staying within our electrical service capacity and we're delivering heating and cooling that is equivalent to what we were doing with RTUs that were DX and gas-inspired? So, let's go on to the next slide.

So, when we're looking out at the – at heat pumps that we can purchase today to satisfy our replacement needs, so we're finding that most manufacturers have pretty well-developed heat pumps for warm climates. That's just a reversing valve in the equipment and it provides heat in the winter or in the colder months and cooling in the warmer months. Most of them have the ability for emergency electric heat when the heating capacity of the unit is not equal to what the heating load needs to be. And that's just an electric resistance heating coil within the unit. Some of the manufacturers offer dehumidification options. Some offer dual fuel. VAV, which is an application that we need for some of our areas. And electric demand control. I mean, they're all available out there, but not all the manufacturers are providing those. And right now, as we look at our strategy, we're – in warmer climates, we can deploy heat pumps, and also in cold climates we can deploy all-electric heat pumps because we can – we have the ability to install the electric service size that is needed for all-electric.

So, when we go over to some of our challenges, and Jeremy mentioned this, when we want to replace an RTU in a cold climate across the store, we often find that when we put the heat pump in and add the electrical resistance heat required for the heating load that our electric service is not large enough to accommodate that. So, being that we want to try to execute this strategy at the lowest possible cost, replacing an electric service gets a little bit challenging for us.

When we go into cold climates too we have to do defrost. And that means that when the coil, the outdoor coil starts frosting up because we're taking a lot of heat from the ambient and that coil becomes below the dewpoint temperature, then we start – it starts frosting and we have to run the heat pump in the cooling mode to defrost that coil. And so, how do you do that when it's 10 degrees out and you want to deliver 90-to-100-degree discharge air and you're operating your equipment in cooling mode? So, that's a challenge.

We also, like Jeremy mentioned, really would like to run our heat pump simultaneously with electric heat or gas backup heat so we can kind of achieve that 90-degree discharge air temperature across all outdoor temperatures. And then, also we find that heat pump performance data, it's only – heat pumps are only required to be rated at 47 degrees and at 17 degrees. And, so below 17, I mean, the manufacturers have data, but it's not readily available. So, those are the challenges we're facing.

And when we look at how can DOE and NREL and the accelerator help us out, so they're working on testing heat pumps in cold temperatures and providing us with – eventually with better application guidance so we know when we can deploy heat pumps with electric versus no auxiliary heat. We'll know whether we should size our heat pumps for cooling or maybe we need to size them for the heating load.

And I've been in the engineering industry for a while and my whole career it's been about you size your RTU for the cooling load, you look at your heating load, you put a safety factor on it, then you buy the next biggest heat exchanger, and then you don't worry about having the heating capacity. With heat pumps, it's a whole different ballgame. Some applications, you really need to perhaps upsize your units so you can get the heat that you need.

The other thing that we're hoping that the accelerator helps with is just establishing standards. And it's all around controls. How do we control defrost? How do we control electric resistance heat? How do we make sure that across all our units on the roof that we can prioritize which units go into defrost and when so we're not overloading our electrical service? And in the end, just better information on how we can deploy heat pumps across all climate zones, including some of the colder ones where it's really a challenge. That's all I have. So, I'll send it back to you, Hannah. Thanks.

Hannah Debelius: Great. Thank you so much, Robert. I appreciate all of the details there and then also even just going through the emissions scopes. That's really helpful for our audience. One more wonderful presenter to get to before we switch over to Q&A. So, we are pleased to welcome Andrew Rhodes. He's a Principal Sustainability Engineer on the Sustainable Buildings Team, part of the Worldwide Environment Organization, and is a six-year Amazonian, which is a new term for me in this context. So,

Andrew, welcome. Go ahead and turn on your camera and take it away.

Andrew Rhodes: Good morning, Hannah. Can you hear me okay?

Hannah Debelius: Sure can.

Andrew Rhodes: Yep. Great. Okay. Wonderful. Well, thanks to Rob and Jeremy for their sections. I'm going to try and not repeat information that they provided. I'm really going to try and provide some additional context to why this issue is important for Amazon and kind of how we've learned through our five-year-plus decarbonization process how partnerships are really the way to go. So, yeah, if you can move on to the next slide, please, Hannah?

And so, why is this important to Amazon? Well, if you didn't know, Amazon and Global Optimism co-founded the Climate Pledge, a commitment to reach net zero carbon emissions by 2040 in 2019. So, this has been one of the – this is one of the pillars of our sustainability work, and it's really a north star for all our work at Amazon. We've really got to consider the Climate Pledge and what – any decision that we make, how any decision that we make impacts our emissions. Next slide, please.

The Climate Pledge is a really simple commitment, net zero carbon by 2040, but it's not a simple solution. But there's really three steps in achieving this. One is regular reporting. We encourage all Climate Pledge signatories to measure and report their greenhouse gas emissions on a regular basis. If you don't know what you're emitting, how can you possibly hope to reduce it? Carbon reduction, carbon elimination. So, the next step is to reduce your emissions through real business changes. And then, the final stage is credible offsets using carbon neutralization to achieve net zero annual emissions by 2040. So, this is the master plan for getting to net zero by 2040. Next slide, please, Hannah.

So, really what Amazon's been doing is applying those three principles to all aspects of our work. Being on the Sustainable Buildings Team, obviously we've been working to apply those – apply that strategy to building decarbonization. And we recently published our building decarbonization guideline based on our work over the last five years. The roadmap that we've proposed is eliminate fossil fuel use onsite, prioritize efficiency, utilize 100 percent carbon free energy, select natural and low impact refrigerants, invest in lower carbon materials, enhance your ability

to collect and leverage better data, and prioritize sustainability in all your decision making. And I think you've heard in the last two presentations that a lot of what we need from the next generation of rooftop units is really aligned with this strategy. We've talked about electrification, decarbonization, and efficiency.

So, Amazon has some notable goals related to this. We recently announced that we are 100 percent renewable for our electricity, six years ahead of our original target. You all know about our commitment to electrification in other sectors like transportation, our purchase and investment in Rivian, and then really trying to decarbonize our other industries through partnerships. So, we're involved in partnerships for sustainable aviation fuel, sustainable maritime fuel, and our work in buildings is no different. So, next slide, please, Hannah.

Just going to check on the time. Sorry. Okay.

So, what kind of equipment do our buildings use? So, Amazon has thousands of facilities. We're still a young company relatively and we've inherited a lot of our buildings from previous owners, so we really run the full gamut of systems. So, our logistics, you can see the different systems used by our different building types, but then you can also see there's one common thread running throughout, and that's the rooftop unit, package rooftop unit. So, when we were thinking about where are our hotspots, what actions can we make that are really going to move the needle for all our business types – next slide, please, Hannah – getting a better rooftop unit really seemed to be a single action, a big rock, as we call it at Amazon, that could move the needle on our emissions for all our business partners and across all our company types. In our experience, we found that it's much easier to do these things, it's most efficient to do these things on new buildings. So, don't put a fossil-fueled piece of equipment on a new building knowing that you're then going to have to replace it with an electric one.

Next most efficient is trying to align your replacement strategy with end of life. That way you're not accruing a financial premium for replacing a piece of equipment before it's needed, and then – and there's also an embodied carbon penalty to that. And then comes just replacing equipment as needed. So, we'd identified RTU Advancement as this big rock strategy that benefited all our customers, both our internal business partners, but also Amazon's customers as a whole in our path to the Climate Pledge. So, we started our strategy to address this. So, next slide, please, Hannah.

So, this is a bit of an old meme, but we got some really great feedback from our partners, both OEMs and other retailers, where talking about the Climate pledge is really helpful, everybody wants to understand the background, but the manufacturers in particular were like "Well, what do you actually want? What can we build you that helps you move the needle to this goal?" So, yeah, so we told them – so, here's a very, very brief outline spec that we shared with OEMs two years ago. Some of our building templates are based around these 25-to-30-ton modules, so we want a 25-to-30-ton unit, we want it to be all electric, eliminate those fossil fuels, and we want it to operate efficiently in low ambient temperatures so we don't need to keep using those backup fossil fuel systems. We want a higher – highest efficiency possible. We want to use low-GWP refrigerants, even though they might not immediately be available. Like, this is the way that we want you to go. Integrate controls and metering. Obviously, I've mentioned how important data is to Amazon. Comparable site weighting connections to the existing units that we own so there's not that big infrastructure upcharge where possible. An EPD, an environmental product declaration. We want to know more information about the embodied carbon that we're incurring by using this equipment. And then, obviously, we need these things – 2040, as Rob said, 2040 is not a long way away. We are buying the rooftop units now that will be on our buildings in 2040, and so – and we want to get rid of those legacy fossil fuels along the way.

So, I guess the number one lesson – so if we, next slide please, Hannah. So, the number one lesson that came from all of this was scale brings efficiency for all parties. Manufacturers wanted to know that it was just not Amazon that wanted these units, that this was something that the broader market wanted to be available. So, the DOE Commercial Building Heat Pump Accelerator really is the perfect catalyst for what we wanted to do. It's brought manufacturers and owners together to develop the units that we need to meet our climate goals but also give some security to the manufacturers that this is what their customers actually want and want to install. So, yeah, just one more slide.

Thanks. Thanks, Hannah. Next slide.

So, Amazon loves to move fast and we love to learn by doing. So, here's some pictures of an all-electric 700,000-square-foot fulfillment building that we have in Liberty, Missouri. This opened about 18 months ago. You can see pictures of the custom all-

electric system that we use. It's an AAON air handling unit with an LG VRF condenser. And this is climate zone four, I believe. And so this building's been operating all-electric since it opened 18 months ago. And really, this gave us a good starting point for what we want from our future rooftop units. And obviously, here you can see this is field-assembled, so it's not ideal. You've got two boxes that you then need to connect with controls and refrigerant and with power. We want all this on a single skid in the same way that we get a packaged rooftop unit right now so that gives us comparable installation time and construction experience. So, yeah, that's the last slide. Thanks very much, Hannah. I think I was on time, so…

Nate Allen: Andrew, you did a great job. I think my microphone's working. I'm going to chime in quickly. Hannah mentioned earlier – Nate from DOE. I just have to comment, because Andrew has been tireless in working with us over the last several months, really longer than that, on this topic and in the best way. He's helped us –

Andrew Rhodes: Great. Thanks.

[Crosstalk]

Nate Allen: Thanks so much, Nate. We really appreciate your support. And this is – yeah, when you get told that Amazon's not big enough to do this themselves, it's – you go out and find the best partners possible. So, thanks to everybody that's been involved.

Nate Allen: Well, and in that vein, I remember Robert and I were on the phone hourly in the lead-up to the launch of this effort and couldn't have been more helpful at that point. And Jeremy's long been a stalwart of this program. So, we are lucky to have such fantastic panelists sharing their experiences with us. I know we have very limited time here for Q&A. I'm just going to jump in, since Hannah's computer is actually doing, conveniently, a forced restart at this moment. But two things that have popped up, and I've been watching the chat and the questions coming in – Michael Deru, I'm wondering if you can talk a little bit – I'm going to tee up both of these right now, because I think we're probably going to run out of time. Michael Deru, I'm wondering if you can talk a little bit about how the national labs, because there's a group of national labs that you all are leading right now, are working together to support manufacturers. And – this is a two-parter – if there's anyone on the call who's interested in getting involved in field testing, some considerations they should think about and how to get in touch. So,

that's one for you, Michael. And then, Jim, I recall that Robert mentioned the considerations around selecting a heat pump. And I'm wondering if you can close us out with talking about some of the resources that we're working through on the campaign to assist building owners in that process.

Michael Deru: Yeah, so –

Nate Allen: Got it handed back now. Great. Okay.

Michael Deru: – labs – as Nate mentioned, there are several National Laboratories, DOE National Laboratories, working together on this effort to bring together expertise at the labs and also capabilities in the laboratory, experimental capabilities that we have available to work with manufacturers to really accelerate the development and validation of these systems. And then, if you – and we are looking for this winter and next winter for opportunities to test some of these units, especially this winter, looking at some of the dual fuel systems that are available today on the market. And next winter, hopefully, we'll have some pilot cold-climate heat pump units available. And please reach out to any of us on the call and we'll be happy to work with you on those field test opportunities. And we'll be sharing all the results, too, obviously. So, look for those results as well.

Hannah Debelius: Great. Thank you so much, Michael, and to all our panelists, and also for Nate for stepping in through my tech issue. Speaking of reaching out to the campaign, if we could pop back over to the slides. You all – thank you so much for joining today. You can reach out to the Better Buildings Space Conditioning Technology Research Team through the mailing list listed here. And again, the recording and all the slides from today are going to be available on the Better Buildings Solution Center and you'll get an e-mail notification when that's good to go. Next slide.

This was actually the final installment for our summer webinar lineup. Hard to believe summer is almost coming to a close here. So, all the webinars from the summer are available to watch on demand. You can find those on the Solutions Center, and we look forward to seeing you in October for our next series. Next slide.

So, with that, I would like to sincerely thank all of our many panelists on this for not only your time today and all of your insights, but also for your deep partnership on this program. I am personally so excited to see what can come of this in the next

couple of years and working towards 2027. And it's thanks to all your expertise and partnership. So, thank you all so much. I encourage you all to follow Better Buildings on all of those options on the left. Reach out to us if you have questions, and have a wonderful rest of your day. Thank you all so much.

[End of Audio]