*Josh:* Alright, hello, everyone, and welcome to the 2021 Better Buildings, better plans summit. I'm Josh Geyer, the multifamily sector lead for the Better Buildings Challenge and I will be your moderator for today's session called A New Frontier: Electrification in Multifamily Housing. This session will address programmatic and technical approaches to going all-electric in multifamily housing, exploring current challenges in domestic hot water, technologies for space heating using heat pumps, and more. We – just a little more on that, we all know that we're trying to get to low carbon and decarbonization, ultimately, in the next, hopefully, not that many years. And electrification is a key indispensable part of going that direction. We have to stop using fossil fuels on-site and make sure that we are getting as close to only using electricity as possible.

So this is huge, it's going to be huge now and over the next several years. Next slide, before we dive into today's session, there are a few housekeeping points I'd like to cover. Please note, today's session will be recorded and archived on the Better Building Solution Center. We'll follow-up when today's recording and slides are made available. All attendees are in listen only mode, meaning your microphones are muted. If you experience any audio or visual issues during today's session, please send a message in your chat window located on the bottom of your Zoom panel. We will be using an interactive platform called Slido for Q and A and session feedback. Please go to www.slido.com using your mobile device or by opening a new window in your internet browser.

Today's event code is #DOE, once you enter this event code, please select today's session title, A New Frontier: Electrification in Multifamily Housing in the dropdown menu at the top right. You can submit your questions for our panelists by submitting in Slido any time during the presentation. You can also upvote other attendees questions, I'll pause briefly to give everyone a chance to open up Slido and select our session.

*[Music playing from 0:02:03 to 0:02:41]*

*Josh:* Great, if you're having any issues, please message our tech support team by using the Zoom chat function. We are delighted to have five panelists present their work to you today, Jordan Dentz, Andrew McNamara, Julie Klump, Rory Christian, and Edwin Mendez. After we hear from all five panelists we'll end with a group discussion with all of our panelists and a final wrap-up. Next slide, to begin, I'm pleased to introduce Jordan Dentz. Jordan is Vice President of the Levy Partnership Inc., a research and

consulting firm specializing in building performance and energy efficiency.

Dentz has consulted on numerous passive house projects in New York including in 2009 the Hudson Passive Project, the first to be certified in New York state. He has been a lead consultant with NYSERDA's retrofit New York projects, pioneering deep energy retrofit strategies for residential buildings. Welcome, Jordan.

*Jordan:* Thank you, Josh. It's a pleasure to be here. I'm going to divide my presentation into two parts, the first part I'm going to talk about a demonstration that will be implemented with NYSERDA to electrify 20 small single and small multifamily buildings throughout the New York City area. And the second part, I'm going to give an overview of space condition heat pumps, some of the advantages and disadvantages and some new products that are coming to market that will, hopefully, address, well, some of the disadvantages of a current heat pump technology in certain specifically retrofit circumstances. So this demonstration project is done with NYSERDA over the past two years. And we implemented electrification of space conditioners in 20 sites, these were all one to three family buildings originally gas and oil fired boilers and furnaces, generally old buildings, we had limited or minimum insulation.

The objective here was to really understand what costs were, the benefits, and get some experience doing these electrifications. Partners that helped with this on this project were _____ NYSERDA, Frontier Energy did the measurement and verification, and Sensible House was instrumental with recruiting and managing sites. Next slide, please. So the scope, as I mentioned, was full replacement of the heating system with a heat pump system. Generally, these were ductless mini-splits, NEEP-listed which is a cold climate air source heat pump that is designed for providing full heat in the cold climates. Usually, there are three to four outdoor units per building, six to 12 zones inside. And the clients were receiving some incentives but they were contributing a fair amount of their own money towards these retrofits.

And the reasons they were doing that is listed there on the slide, they were interested in increasing their home value, improving comfort results like providing "central cooling", and solving quarter distribution in there – when they're just insistent. Notice that costs, energy costs, savings was not on that list. Next slide, please. So this is some data that we were hoping to gain from this project is what are the costs of these systems to retrofit in these

types of buildings. The project costs ranged from a low of $10,000.00 up to $50,000.00 and there were some incentives as well for the residents. We found that on a – we looked at costs on two ways. One is the cost of the heat pump systems per zone, so that's per room in the house that received an indoor unit. And the other is per ton or capacity of heating.

The per zone system tends to be more consistent on a project to project basis because that's really where the labor is, grind refrigerant lines, putting in the indoor units, connecting them up. Less so the equivalent size based costs and so we found fairly consistent, about $3,500.00 per zone for these types of retrofits. On a per ton, it is closer to $4,500.00 on average. The next slide, please, we'll show some benefits of the results of the measuring verification. And so as I mentioned, we did 20 sites, I don't have data for all 20 yet here, there are a few still outstanding. But you can see here a matrix showing the by site the original fuel for the heating and the savings in terms of energy, carbon emissions, and utility bills. Note that the green cells in turn, in the columns showing plus savings are positive savings. In other words, they're paying less post retrofit. And the red, the customers or the clients are paying more after their retrofits.

It's important to understand the reasons for that, the first thing that jumps out is, of course, natural gas is inexpensive. And so the oil sites tend to have positive savings and the gas sites tend to have negative savings. But, yeah, the other reasons relate to behavioral changes and indoor set-point changes once you're now space conditioning and space cooling more thoroughly and consistently throughout the home there can be an increase in energy use there. But all the sites did save significant amounts of carbon because the emissions related to the electricity is lower than the fossil fuels that were being consumed prior. Changes to the price of energy, of course, will make a dramatic difference on the relative savings and lack thereof for these retrofits. We also looked at an estimate of what the efficiency of these units were and those are the columns to the right, COP counting for envelope would be an estimate of what the efficiency was.

And they're somewhat disappointing in that we're hoping for COPs closer to three, COP stands for coefficient of performance. And we got some coefficient's of performance that were closer to two, in some cases lower. Again, that could be related to some of those behavioral changes and in increase in heating or cooling that was behavioral related. So there's still some work to do there to ensure that the systems are operating to their maximum efficiency. So

those are some of the high level results from that study. There will be a full report on that project coming out later this year or early next year. Give the next slide and I'll go onto the next part of the presentation.

So I want to just give a kind of an overview what space conditioning heat pumps and then talk a bit about some new technologies that are in the marketplace. We're talking strictly here about electric heat pumps and really focused on air source heat pumps. Of course, there are ground source heat pumps which are appropriate in certain cases. But air source heat pumps are easier, generally, and applicable to more buildings. By that interval, we can divide air source heat pumps into package systems in which the entire heat pump is in one box versus split systems where you have an outdoor unit and an indoor unit. And furthermore, the split systems can be divided up into large central systems where there's one system that's serving an entire building, one we call a VRF system or individual systems with the mini-splits we installed in the previous project I described. There can be anywhere from one to a small handful of indoor units connected to each outdoor unit.

So let me go to the next slide, please. So why heat pumps? Why are heat pumps beneficial for electrification? Why do they – why are they so important in our efforts to decarbonize? Heat pumps today can meet both heating and cooling demand in almost all climates for almost all buildings. They're efficient when installed and operated appropriately, reliable, comfortable, quiet, and there are lot of options out there. Next slide, please. But there's still some drawbacks to heat pumps which is kind of holding them back particularly in retrofits and in existing buildings. Of course, you need electrical – and here's a list of some of those drawbacks there. Electrical service requirements, generally to be higher for heat pumps in buildings with boilers or furnaces, there is labor to install them which is significant. The installation for existing buildings can be intrusive if you're installing refrigerant lines around the building.

There's a fair amount of design work that goes into them, it has to be done well. As I mentioned, the refrigerant lines also can be aesthetically unpleasing and they are potential leaks that could be – leak refrigerants that have a negative impact from an emissions standpoint as well. You need to find places for the outdoor units, but, of course, you don't want to clutter up your roof with them if you want to put solar on your roof. So there's a bit of conflict there. Let's got to the next slide. So I'm going to talk about four new heat pump products that are come to market that can address

some of these challenges. And this is just a sample of a few examples, there are other products out there in the market and technology is evolving quickly. Next slide, please.

This is a new heat pump that is from Healy, it's called the Ephoca HPAC 2.0. And there's a couple products similar to this out there as well. But it's basically an indoor unit that hangs on the wall with two pipes that go through the wall so there's no outdoor unit. This would be a package system. But it contains the same technology that you have in mini-splits so it meets those efficiency levels that are ERF, compressor variable efficiencies. Compressor, variable speed compressor, and fans, and sophisticated controls to achieve those same high efficiencies and capacity in all outdoor conditions. There are no refrigerant lines to run, it's very small wall openings. Next slide, please. There's a few more images of other alternative ways that this could potentially be installed as part of a retrofit in conjunction with windows, perhaps. Next slide, please.

And we project that the costs of this installation could be as little as half of what a VRF system, a typical split system might cost. So this is a really potential, this type of product has a potential to be a game changer for retrofits. Next slide, please. The next product I want to mention is mini-split that fits into a PTAC Sleeve. Next slide, please. So there are many buildings around the country, both residential and hospitality that contain PTAC Sleeves. We have full wall units and this is an example of a building in New York on the right. On the left is a building not in New York but this is one way you could get mini-splits on to a building such as this. If I could go to the next slide we'll see another option. This is something that Fujitsu is coming out with this year.

And again, there's another manufacturer coming out with something that's very similar, I think it will be in the market by 2023. But this product slides into that same sleeve, it's basically a mini-split that has more of a cubicle configuration and you would connect it to an indoor unit such as shown on the left. Next slide, please.

*Josh:* Jordan, you have about a minute and a half.

*Jordan:* Okay, I'll be a bit quicker than, then you close it up and that's what you've got. Next slide, please. So we get a comparison looking at the Fujitsu unit to other alternatives, it does cost more. But given the efficiencies, the net present value of that installation is quite a bit better than those alternatives. Next slide, please. And does it belong at this product is a mini-split that plugs into your hydronic

distribution system. Next slide, please. This is a heat pump that can plug into a building that has a hot water heating system and you don't have to go into any apartments you can just plug it in where the boiler was and it will provide that hot water. Again, this is a new product also from Italy to provide another alternative for that building type. Next slide, please. So this is a schematic of how that would work, it's two parts to it, and then it goes through the existing hydronic distribution system. Next slide, and that last product is a heat pump that pops into your window, next slide, please.

It's basically a window unit, does not block the window. It's kind of a saddlebag type approach. This is a company called Treau out of California. It's got all that same VRF technology built into it, expecting it to be a mass market product and at the same efficiencies as a mini-split. It can provide heating and cooling very inexpensively installed. Next slide, this is an example building that we've analyzed with all four of these products. Just bottom line is they're all saving carbon based on their efficiencies but it's very challenging with the energy rates that we have today. At least with this site, this is New York City rate to reduce energy costs compared to natural gas. So that's still a challenge, next slide. Just a few other products that are also – these are very similar. A lot of products coming out with this VRF technology. So more options coming out every day and I think my last slide is coming up. that's all I've got, thank you very much. We're right at the time.

*Josh:* Thanks, Jordan. Heading right on to our next person which is Andrew McNamara, Bright Power's Executive Vice President of Operations in California, leading the companies California operations. Since joining Bright Power in 2006, Andrew quickly rose to Vice President in 2008 leading the firm's sustainability and solar practices from 2008 to 2013 and the engineering division from 2013 to 2015. He has worked on hundreds of projects from coast to coast including over eight dozen heat pump water heater electrification retrofits in California. Welcome, Andrew.

*Andrew:* Great, thanks, Josh. And hello, everyone, great to be with you today talking about multifamily electrification. Such an important topic, and what a great presentation by Jordan on heat pumps for space heating. Just to draw a distinction, the focus of my presentation is heat pumps for domestic hot water and making sure that we deliver those vital hot showers for multifamily residence. On the next slide, we have a brief overview of Bright Power. My role is to run California operations based in sunny Oakland where I'm speaking to you from today. And on the next slide, just a quick

overview of Bright Power's approach, we act as an energy and water management partner for real estate organizations.

Basically, a one stop shop that can take an owner from not knowing where to start through a completed projects. And electrifying domestic hot water is just one thing we do alongside a host of other technologies like lighting controls. And our mantra is find, fix, follow. To find energy water waste and find, fix, and follow that through. Moving on to the next slide, as I get into content here I want to ground us in the diverse perspectives surrounding heat pump water heaters. There are so many important stakeholders in the conversation and we put three of the big ones on the screen here. We often hear from policymakers who want to incentivize the market to scale up and meet carbon saving goals. From property owners who want to make sure their residence will actually get hot showers and want to make sure they have a project that pencils. And then the industry wants to know how many calls they're going to get for complaints. And if it's worth building a business around this technology.

And so let's remember these perspectives as we go through this presentation. Moving onto the next slide, we have some technologies for electrification as I said, my focus is on the first line here on water heating and heat pump water heaters. But this slide shows the context of other technologies for space heating as Jordan shared as well as for cooking, clothes dryers, and pools, which is outside the scope of this presentation but important as well. Moving onto the next slide, we segment the heat pump water heater technology into a few different buckets. So first, we can look at residential, single family, integrated tank style, as well as split systems. And there's these tiny little photos just to give you a little sense. But these are the integrated tank would be your drop in replacements for an existing tank based water heater. As well as split systems which are similar except they have an outdoor condenser style unit.

Then on commercial, you have more low rise targeted products like an integrated tank as well as residential manifolded. And then what I've labeled as high rise, although it could also be useful on campus style installs where you have a large split style systems. Moving onto the next slide, here's a timeline of Bright Power's multi-family heat pump water heater installations to date. And we're so honored to have worked with visionary owners like Mercy Housing, Jonathan Rose Companies, TNBC, and others on pioneering heat pump water heater retrofits at their properties. We

started in 2017 with our first installs with Mercy and have installed heat pump systems serving over 1,600 bedrooms at 16 properties.

Moving onto our next slide, we segment our installations into a couple different categories. The first generation were the residential style Sanden units which we'll get into photos of in a moment. And then the second generation were the Colmac and Nyle, or the Colmac and Nyle style installations which are more of a central single central unit. And then you can further segment those into heat pump water heater only and hybrid installations which we'll get into over the course of the presentation. And this heat pump, the heat pump water heater only verse hybrid, basically the concept there is we'll share projects which are retrofits here in this presentation where existing boilers were already present on the site, right.

So in the hybrid configuration, we leverage a gas boiler, usually the existing gas boiler as a feature plant to reduce the heat pump, required heat pump capacity. Whereas in a heat pump water heater only configuration there's no natural gas backup and we have some experience with both. Alright, so enough on context, let's look at some installs. And moving onto the next slide, in 2017 the journey begins. And on the next slide, our first installs were utilizing Sanden heat pump water heater units. And what we did here was manifold together the Sanden units which are pictured there, about the size of a large suitcase. It's really a single family product to serve – and we manifolded them together to serve the multi-family market.

So this is a 90 unit property, you're on the roof of and there's nine Sanden units manifolded together and backed up by the gas boilers which you can also see in the background on the left hand photo. We did installation similar to this at a total of seven properties ranging from 36 to 151 units. And this work was funded by California's low income weatherization program and we were honored to work with our partners at AEA, the Association for Energy Affordability and also CSD on making these installations a reality. On the next slide, you can see the technical specs for our installations. I'm not going to go through this point by point but these are split systems. The CO2 refringent has a low global warming potential which is a really nice feature of the Sanden units. And the rate of COP of 4.5 is really strong. But maintaining that in practice takes some really strong applications in engineering which we'll get into a little bit later.

Moving onto the next slide, a little bit more detail on the technical specs which we'll move past quickly to get into photos. And on the next slide, you can see one of the reasons we picked the Sanden technology for these properties in San Francisco is that it fits into tight basements. So if you're on the backside of the boiler room and those Sanden's are mounted on the wall and they operate really quietly, they actually are blowing cold air out of them. And they fit into tight basements and boiler rooms in the urban core of San Francisco. On the next slide, you can see another property on the same portfolio where we mounted the units in a breezeway adjacent to the boiler room, still plenty of room for clearances to walk by. And then on the next slide, you can see a key design consideration.

So COP is the operating efficiency or the coefficient of performance, and if the COP drops below about 3.6 in PG&E territory the heat pump water heater will actually cost more to operate than the boiler it replaced. And one of the keys to achieving the target COP is managing the inlet water temperature. And if your property has problems with crossover flow or other distribution issues, the inlet temperature to the heat pump water heater can rise if it isn't properly managed. And the efficiency can plummet which increases your costs, your operating costs. And this was a key lesson learned from our early installations is managing that in existing properties. Moving onto the next slide, you can see a financial illustration. There's a lot going on this slide but the orange line represents your break even COPs. So that's where the heat pump water heater at this particular property would cost the same to operate as the preexisting natural gas boiler.

And you can see that if you don't manage your COP effectively and you end up on the blue line at a lower COP, you could end up paying upwards of $5,000.00 more per year to operate than heat pump. And that's where managing that COP and making sure you have strong applications engineering and good trouble shooting. Because a lot of times these issues crop up during the commissioning period is really important. Moving onto the next slide, you can see a typical system schematic for our Sanden systems. And I'm not going to get into detail here today. But on the next slide, you can see kind of an overview of those distribution issues in a flow chart form of how existing property issues of crossover flow and recirc imbalance lead to needing to operate the recirc pump constantly to avoid complaints, that was a maintenance staff response. Which lead to the heat pump tanks de-stratifying, which lead in turn to return water temperature that was higher, a low COP, and higher operating costs.

So on the next slide, we get into lessons learned and I don't have the time to address them all in detail today. But really number one, I mean the technology really worked, right, on these first installs. We were able to reliably deliver hot water after working out a lot of kinks due mostly to number two. The heat pumps are not boilers. You gotta design them differently and require special applications engineering. And number three, which was the challenges related to those existing buildings I just addressed. And on the next slide, number six is such an important one that hybrid systems where a natural gas fired boiler is utilized alongside the heat pump is really a wonderful transition strategy to maintain up time and reduce up-front costs.

Moving onto the next slide, coming out of our 2017 and 2018 installs with the Sanden systems we installed our largest system yet on a Los Angeles high rise called Casa Panorama, it was amazing to work with our visionary partners at Jonathan Rose Companies. And the project received substantial incentives and technical assistance, again, from the Low Income Weatherization Program, and thanks to AEA and CSD. Moving onto the next slide, here are the technical specs. We used a Colmac HPA15 which is 17 times the size in terms of capacity of an individual Sanden unit. So no more manifold of many units tied together. And the hybrid plant design where we reused the existing boiler and the heat pumps were designed to cover about 90 percent of the annual domestic hot water load. Moving onto the next slide, and onto the fun stuff. Here you can see our crews on-site as we craned the heat pumps into place.

And on the next slide, you can see our friends from Colmac, the manufacturer doing start up commissioning on the heat pump. And on the next slide, this shows the preexisting boiler and storage tank which we reused and which act as the gas peaker plant. It provides about 10 percent of the annual load but it's there for those rare moments when everyone happens to shower at once. And really helps to keep the cost down because a lot of capacity that you pay for in your water heating system is just there for safety factor, right. And so the safety factor is basically taken care of by these unit. So the expense heat pumps can just cover the baseload. On the next slide, here's a schematic design with the Colmac system, the design is streamlined with many fewer points of failure than we saw in the large manifolds of our earlier Sanden systems.

And on the next slide, we show another Colmac installation we performed in San Francisco at a TNDC property. Again, this

project was funded by LIWP. And the four photos on this slide show the progression of installation from a preexisting gas boiler to a final heat pump. And shout out to my project management and engineering teams, Jeff Tyga and Amy Nagengast, who worked with the crews to get hot water back up the same night when we need to get all this equipment out of a tight room and all the new equipment installed. Moving onto the next slide –

*Josh:* Andy, you have about two minutes left.

*Andrew:* Great, thank you. Zooming out from the particulars of installations I'd like to briefly discuss what I see as the path to domestic hot water electrification from an ideal policy perspective. For single family and unitized multifamily domestic hot water systems, we're really ready for heat pumps now and as I see it the vast majority of end of life replacements ought to be heat pumps. For multifamily central systems, I'd encourage us to facilitate hybrid installations. Particularly, over the next three years and the reason is that we can get 90 percent of the gas offset, 90 percent of the carbon reduction for about 40 to 60 percent of the cost. And we can do so reliable so we don't give the technology a black eye. Really, every one of our installations that we've done to date has brought new lessons learned and it was so valuable to have a safe place to work through those lessons learned.

And furthermore, hybrids can go in many places that regular systems cannot where you run into electrical capacity issues or maybe there's no ventilation to get rid of the cold air that the heat pump water heaters produce. So while I think hybrid installs should be the mainstay for the short run, we should also look for goldilocks properties that can go all-electric now. Ones that are verified not to have distribution issues, have sufficient electrical capacity and satisfy many other conditions. So on the next slide, to sum up my perspective, we got to follow the model of the Toyota Prius to move from gas to electric. And do the hybrid installations to start before moving onto the all-electric over time. And on the next slide, just quickly show some cost data showing in orange our heat pump water heater only installs. And in blue, our hybrid systems so you can see this represents about half the costs per bedroom installed when we're doing the hybrid installations.

And on the next slide, in closing, I'd like to end with a message for those who are wondering how do I get started with all this? And my recommendation for you is to get your feet wet now first. In a few short years, policy may force you to install heat pump water heaters at your properties. Wouldn't you rather get started with

your design teams and staff exposed to the technology now on your terms and while you're in control? Second, for retrofit projects look for partners that can bring a design build approach. In my opinion, there are just too many nuances that crop up during the course of a retrofit to make a separated design and installation process really workable in most circumstances. Third, seek areas with strong incentives to find projects to pencil. California is a great place to start with programs all over the state.

And last, on new construction consider cutting out gas to your project all together. Studies have shown the savings of avoiding gas service in piping can more than cover the premium of installing heat pumps. And the technology works great in new construction. I actually personally live in an all-electric home and the showers are hot and I love my induction cooktop. So with that, thank you for your time and attention and, please reach out and start a conversation with us.

*Josh:* Thank you so much, Andy. Alright, moving on to our next speaker. This is Julie Klump, Vice President for Design in Building Performance for the Preservation of Affordable Housing, POAH. Responsible for design and energy efficiency of development projects and the owned portfolio. She assists POAH in the building acquisition process and works with POAHs development project managers and asset managers to rehabilitate new acquisitions or POAH owned properties. Julie is a certified passive house consultant and a lead certified architect. Welcome, Julie.

*Julie:* Thanks, Josh. And thanks for the invitation to the panel and thanks to everybody that joined us this afternoon. POAHs making some real strides and towards electrification with our commitment to decarbonization. And we know that electric grids are not perfect in how they make and provide electricity. But we're trying to get ahead of the net zero curve and try to really improve our enclosures and get rid of fossil fuel at our properties. Next slide. So just quickly, where POAHs located we have 12,000 units in 11 states and DC. And as you can see from the map, we're in just about every climate zone, and that sort of makes life interesting when you're trying to incentivize energy upgrades and also install them. And to add, we're a little – we're a bit obsessed with data. We use a third party to process all of our utility bills and create accounting files which gives us raw utility data. And we use a couple energy platforms to weather normalize the data, show us anomalies, show us the impacts of our rehabs, and discreet water, energy and water savings projects. Next slide.

So this is what we're up to, I'm just going to talk quickly about new construction. Everyone's heard about ambitious carbon neutrality goals in cities across the country. And I think getting there with new construction it's sort of the baseline should be passive house. Nearly all of our new construction projects are designed to be passive house certified and we have one in construction right now and six in design that we're committed to certifying. And I highlighted on some of these you can see that they're not all-electric. We – some of these buildings are in locations where gas, the disparity between gas and electric just creates such a burden for our operations that we've had to make the choice to use gas, domestic hot water. Andy, I'll be calling you to talk about heat pump hot water heaters. Because I'm eager to get them into our properties and the properties here that say 100 percent electric are actually that's what we'll use for hot water.

One of these projects is actually – and the ones that are designed all-electric we're at least designing the hot water systems that can easily be converted to domestic – to electricity. Next slide, so I think what new construction passive house we ensure robust enclosure, we get to low load heating and cooling demand which makes it really easy for electricity. We use all-electric ventilation systems, domestic hot water is a question mark depending on where we're actually building. And backup power, we have one building in Boston that is all-electric, it has a battery that's designed for back-up power and we're looking at off-site renewables to just fill a small gap that the rooftop array won't cover in order to get to net zero. And the barriers for us in some locations, as I mentioned, I just the cost of batteries and also the cost of gas versus electricity. Next slide.

But we have more existing buildings than we do have the opportunity to build new. When I started at POAH, all we did was acquisition rehabs. And I think I've been in some committees in Boston for their carbon neutrality goals. And everyone pushes the passive house on the new construction which I feel like is kind of it's becoming more and more no brainer. But what about the existing buildings and what about historical buildings? And so when I started at POAH, what the lenders wanted to see is how many kitchens and baths are you going to rehab? And nobody wanted to talk about energy efficiency unless there was some incentive to do something with it. And before that, we were even converting electric resistance heat to fossil fuel gas, boilers, and furnaces.

And so we've come a long way as early as five years ago, we've convinced a lender to let us improve the enclosure over kitchens and baths with the argument that we can't do – we can't replace windows during unit turns. And we just feel like if we can get the enclosure right while we have a bite at the apple, we can ensure durability of our buildings. We can create healthier housing, we can save energy, and we can also provide some resiliency. Next slide. So ideally, our retrofits, we update the enclosure whenever – especially when new cladding is needed. We've done foam injection on some projects where it was masonry cladding which is another way to beef up your enclosure. We convert to electric heating and cooling, all of our ventilation is recovery with it's all-electric. Again, domestic hot water, we're still working that. And again, backup power.

And then I think the big issue for us on converting to a heat and electricity which people can probably relate to is that if you don't invest in a robust enclosure in a northern climate where the heat – the design degree for heating is well below zero, you might not be able to accommodate the loads, the heating loads that your buildings and residence want without – with an electric heating system. You at least lose a lot of the efficiency of that heating system. Next slide. So I'm going to talk quickly about one project that I'm super excited about. This is a 283 unit building in Salem, Massachusetts which is north of Boston. It's two ten story towers built in 1973. Fortunately, for the energy folks in my office, the bricks are not stable and 1973 building codes allowed you to build brick cladding systems that literally support themselves from the ground up with a few brick ties holding them back.

Well, the brick ties are rusted and so it's time to reclad. So what we're going to do here is improve the enclosure and about a year ago, or two years ago, the utility paid for an entirely new heating and domestic hot water system that is fossil fuel. So let me tell you what we're going to do and you can see how we, hopefully, will eventually not even need that system. Next slide. So you can see on the far right, the existing enclosure. It's brick, it's got – there's cavity insulation and that's about it. What we're going to do is we're installing Armorwall which is a structural insulated panel over the studs. And then we're going to have an open rain screen with aluminum panel. And what the Armorwall gives us, it's a build in air and water barrier. And it also allows us to attach the cladding with a thermally broken cladding attachment.

We're installing new triple pane windows that have pre-manufactured jamb, sill, and head extension which makes the

details really clean and easy to install. And you can see the roof on the left, we're installing six inches of insulation. So we're really beefing up this enclosure. Unfortunately, I've been told it's going to – it would take 50 blower door tests and probably 100 people in order to do a blower door testing at this building. So we're not going to be able to do a pre-blower door test but I'm really counting on some really robust improvement there on air tightness. The gas savings we've modeled what that savings for that system, and it's about it's just under 20 percent for that. We're expecting between the enclosure and some of the other upgrades that we'll be at 60 percent better than we currently spend at this building. Next slide.

So on the theme of new technology for heating and cooling and ventilation, we looked at rooftop units that would distribute heating and cooling or ventilation air to the units through ductwork down the hallways. Which would have eliminated – which would have added ventilation but we still would have had to keep the cooling system that was there which is basically a through wall unit. So what we laned on was we landed on a Minotair unit. And some of you may have been introduced to these systems at energy conferences. But basically, it's heating, cooling, ventilation in a box. So we're building a closet in an exterior wall, we're installing the Minotair, we have an exhaust and supply that go to the exterior high and low, and then we're creating soffits that will sort of disguise and, well, conceal the ductwork. There's a lot of asbestos in the sheetrock. So we're having to do everything below the ceiling.

So the – I think you can sort of see that in that axio in the drawings. We did an install in one of the – in the property management office which was a former unit. And after three or four months, it was really – it didn't help, I mean it didn't hurt our conversation with pursuing this because the staff were just over – they couldn't believe how fresh the air was, how quiet the unit was, and how easy it was to control. Next slide. So as well as the Minotair system for heating, cooling, and ventilation on the existing heating system that will supplement the Minotair when the heating can't be met by that, we are also – we have in our base budget to do a wall-mounted PV system on the south wall of this building. We need probably 200 KWH or KW per year so this will be half the energy that we need for electricity.

If we do the rooftop, which we hope we get to do as well we'll be way over what we need on the electric side. And so, hopefully, if our enclosure can allow the Minotair to provide the heat and we

don't need the heating system, the fossil fuel system, we'll just have to tackle the domestic hot water.

*Josh:* Julie, you have about two minutes.

*Julie:* Okay, perfect. Next slide. So how close are we? We're like I said, we're just hoping the Minotair can accommodate the heat which we'll see, we'll start to see next year. And I look really forward to sharing the results of this maybe next year. Next slide. So just really quickly, I'll talk about some historic buildings because I think they provide some real challenges given the historic oversight for upgrading enclosures. This is a building that's two properties that we've just acquired. Obviously, a lot of three way structural masonry walls and then we – there's one that has wood cladding. The wood cladding one is a little easier, we pull the wood off, we do exterior insulation over, everybody gets a new window, they're not great windows, but they're good windows. And just because of the historic constraints. Next slide.

The exciting thing here that we're doing is it's as a way to minimize refrigerant in our buildings is we're going to install the Mitsubishi hybrid. So it's basically a BRF unit with refrigerant that runs to let's call it a – this is calling it a branch controller. And from the branch controller, it becomes hydronic. So in each unit, there's a vertical fan coil which is not unlike what they have now so distribution of cooling and heating in the units will be the same. But we've minimized refrigerant, we've gone to all-electric, and so we're super excited about this. It comes with a heating booster that we're going to install mostly for the masonry buildings because we're not quite sure without a robust enclosure upgrade there that this will be able to accommodate the heating with the efficiency that we want.

So gets rid of the through wall ACs which maintenance likes and that historic commission likes. So next slide. So we obviously haven't solved for all our loads in terms of the ones that use fossil fuel but we were psyched about better technology that's coming out in domestic hot water and economics for solar storage. But with that, I'll say thank you and I look forward to questions.

*Josh:* Thank you so much, Julie. So now we move, last but not least to Rory Christian and Edwin Mendez from the New York City Housing Authority. Rory is principal of Concentric Consulting Group, focused on the intersection of energy efficiency, environmental justice, and affordability. He previously lead the New York Clean Energy Program for the environmental defense

fund and prior to EDF was energy director at NYCHA where he spearheaded NYCHAs efforts to integrate and standardize energy performance contracts and the capital planning process.

Eddie Mendez has worked with NYCHAs energy department in a variety of roles for 15 years where he managed the installation of NYCHAs first remote heating management system. Currently, Eddie oversees more than $300 million in energy efficiency program construction including energy performance contracts, weatherization assistance program, and add and retrofit NY projects, and electrification pilots. Welcome, Eddie.

*Rory:* Thank you, Josh. So I'll kick things off and I'll transfer over to Eddie about halfway through. So the presentation I'm going to share with you today documents what a little bit about NYCHA and the pathways that we've developed towards our decarbonization goals. So we're going to be talking about a portfolio approach to addressing these issues that's going to incorporate many of the different technologies and applications discussed thus far today. And before I go on, I want to wish everyone a good morning, good afternoon and thank everybody for being here. So as you can see from this slide, NYCHA is the largest landlord in New York City and by many counts, possibly the nation. Second only possibly to the US Military.

We are a major economic driver of the city of New York with over half a million New Yorkers calling our either public housing or section eight housing home. Almost 80 percent, actually more than 80 percent of our families are fixed income, which for about 13 percent receiving public assistance. And 40 percent of our families are headed by seniors 62 years or older. NYCHA housing is prized and it's hard to come by, we have a turnover rate of roughly sub three, six – three percent turnover rate and a vacancy rate of roughly one percent, and a waiting list of roughly 300,000 families long. So, ultimately, there's a strong need to make sure that our housing is maintained and continuously available. And right now, when we evaluate our capital needs, they're roughly in the ball part of about $40 billion simply to replace in kind.

So we haven't even begun the conversation on what it would cost to upgrade. And so now I'll get into that. Next slide, please. So this is just a small overview of some of the many reports that NYCHAs put together over the last few years documenting a variety of challenges and opportunities we face in addressing climate change. One of the underlying most important parts of our plans, we want to improve the quality of service to our residents and the overall

condition of the building stock. And much of what we have come up with is with those two considerations in mind.

Now, the climate and mitigation roadmap, what you see front and center, was developed over the last several years and examines options for NYCHA to reduce emissions by 80 percent from prior levels. We're talking from a starting point of about 8.7 metric tons of CO2 per thousand square feet with a goal of achieving around 1.7 metric tons CO2 per thousand square feet. So this plan outlines a pathway to achieving that and rests on the foundation of NYCHAs 25 plus years of experience pursuing energy efficiency work, much of that by Eddie, myself, and our peers and collaborators. Now, through the passage of local law 97, that threshold, that 1.7 metric of CO2 per thousand feet threshold has been established for NYCHA buildings over 25,000 square feet. This is not a instantaneous requirement it's the end goal.

So over the next 20 to 30 years, NYCHA must move forward reducing its emissions from that 8.7 figure to that 1.7 figure by 2050. Now, this is a difficult process for the owner of a single building as you've heard from our prior presenters. But for NYCHA the scope and scale's a little bit different. The roughly 13,000 plus buildings under ownership by NYCHA and when you think of that number and the goal of doing this by 2050, that's a little over 40 buildings a year every year for the next 30 years, massive undertaking. Next slide. So we put together these plans in part to make it clear the significance of the undertaking NYCHA must move forward with. The thing to keep in mind, they're not static, they are far from monolithic, they're simply considered a pathway based on available technology, funding mechanisms, and laws that NYCHA can move forward with towards achieving its goals.

The new approach aligned with broader national and state efforts leverages 21st century technology and practices. And if NYCHA is to achieve the reductions required in the time allotted what we're about to present to you today takes into account what's commercially available, best practices, towards doing so. Josh, next slide, please. So what we have here is business as usual. This is simply continuous retro commissioning, replacing boilers of kind, steam system optimizations. And if you can see at the bottom, each column represents a steppingstone along the path towards what an emissions reduction pathway could look like. The first column is the 2005 baseline showing the 8.7 metric tons CO2 per square feet, thousand square feet. And then our reference here

is 2007 and then the first strategy is, again, retro commissioning, strategy two, energy performance contracting.

But again, all of these approaches are replacing equipment in kind. And what you'll note as we move forward with each of these tried and true tested approaches, and this is not the full $40 billion in scope that I mentioned earlier, the best NYCHA can do is achieve the 2030 goal established by the city of New York of 5.1 metric tons CO2 per thousand square feet. So if we continue doing what we've been doing, we'll certainly make some significant reductions but it'll be far below the target goal of 2050. So what does that mean? We can continue investing in these infrastructure upgrades to maintain quality service. But in reality, we need to consider an entirely new approach that redefines what NYCHAs done historically and prepares us towards meeting that 2050 goal in the future. Next slide, please.

So we look at this in two parts, the main thrust will be examining basically our heating and hot water. And the second part of it will be looking at end unit energy consumption and understanding what we can do to address costs associated with unmetered residential consumption. Ultimately, when we look at these two things they're all dependent on the state's current plans to decarbonize the electric grid. Right now, the grid is cleaner than it has been in a very – ever, some would argue. But it stands to get significantly cleaner over the next 30 years. And the improvements we have planned will piggyback off of those state level initiatives, thus accelerating the pathway towards that 1.7 number mentioned prior. Next slide, please.

Now, if we were to do that, here is a scenario that, again, is contingent upon grid decarbonization where we can actually achieve the 1.7 metric tons CO2 per thousand square foot number. And what's interesting about this is this need not be done to the entire portfolio. If you look at strategy one, which is hot water electrification using some of the methodologies discussed in prior presentations if we were to apply that to the entire building portfolio you see we get a very significant reduction in emissions just from that alone. Strategy two, adopting air source heat pumps and, again, this would be done I believe at roughly 60 percent of the portfolio. So this need not be done through all of NYCHA, just the buildings where it's most feasible, the goldilocks buildings so to speak. We get another significant shock.

And then finally, we continue doing retro commissioning and energy performance contracts, this is strategy one and two that we

mentioned in the prior slide. So electrification need not be the sole driver but it will be the key driver towards achieving these goals. Because as you can see in the last column, once we do the hot water and the space heating for strategies five and six, as the grid gets cleaner we get even greater benefits as we move forward. So I'm going to stop there and pass it onto Eddie who will talk a little bit more about strategies.

*Edwin:* Sure, thank you, Rory. So I'll focus on implementation of some of the items that Rory had mentioned. So NYCHA is diverse in our portfolio as Rory explained the size of our portfolio is quite large. And we understand that what may work at a six story building will likely not work at our 20 story tower in the park type buildings. So many of the electrification methods and scenarios that other panelists have discussed are all being looked at here at NYCHA to further electrify our – or to electrify our buildings including the VRF systems and package thermal heat pumps. Next slide, please. This is to reiterate the point that for us to achieve the carbon emission reductions, the whatever scenarios we choose it has to include electrification of our heat and hot water systems for us to achieve those goals. Next slide, please.

So here I'll get into some specific projects that we have going now. One of them is an R&D project in which we're partnering with both NYSERDA and NYPA to develop a window unit heat pump. We see this as a game changer in that we could electrify our heating systems by just like installing a unit similar to an air conditioner. And this would be a great benefit to NYCHA. They could be installed in an emergency situations as well. Next slide, please. So here is a – but not as that – excuse me, as that unit is being developed, we're still moving forward with electrification at our buildings. In particular, we have targeted our first complete building for electrification. This building happens to have a C-Sleeves that we can use current existing through the wall heat pumps that can be placed in there and address the heating as well as cooling. Identify a method for hot water electrification and then install induction stoves so it – we, NYCHA will have its first all-electric building. Next slide, please.

And lastly, we realize we can't just focus on the heating and cooling systems but we need to work on our envelopes as well as that will assist us in our electrification methods. Looking at systems as panelized cladding or EPHUS and we currently have a building as a part of the NYSERDA retrofit New York program that is in design for panelized cladding and electrification upgrade. Thank you.

*Josh:* Thank you, both of you. So thank you all, both of you and all five of our panelists. We're going to open up the floor for a group discussion with our panelists. So I'm going to pitch some questions at our primarily to one of you but any of you can then chime in. So the first is to Jordan. Jordan, how do you account for the air change requirements for a heat pump water heater compared to electric resistance water heaters in an apartment?

*Jordan:* That might be for Andrew, it's about water heating.

*Josh:* Interesting, the air – so, yeah, I guess so, yeah *[laughs]*. Sorry.

*Andrew:* Can you repeat the question?

*Josh:* So there's a question about how you account for the air change requirements for a heat pump water heater compared with an electric resistance water heater in an apartment?

*Andrew:* Yeah, it's a key design consideration. So every heat pump water heater makes the air around it cold. And you've got to manage that cold air, it really – the way I look at it is you should always start with creativity and trying to find the easiest pathway to reject that cold air. Sometimes we've located the heat pump water heaters in a boiler room where there's tons of extra heat already. Sometimes we've located them near a trash chute where there's a lot of fresh air coming in anyway, fresh make-up air. And sometimes in a unitized scenario, it's as simple as putting on a louvered door if that is in a place where the cold air can be exhausted efficiently.

So it's just – but it's absolutely a consideration and sometimes it's more challenging than others. But the worst was in a downtown San Francisco environment where exhausting the air we ducted and created a noise issue. Had to come back and retrofit that with a VFD fan that operated more quietly. So just there's no cookie-cutter answer, I think there's just a lot of different cases that you run into in retrofits.

*Josh:* Great, so I'm going to – the question just came in on the chat that I think is for either Jordan or Andy or both could take. So what are the benefits to a heat pump in a box versus one that's split?

*Jordan:* So heat pumps in a box, I assume we're talking about a package system. And the main advantage there is ease of installation, lower labor costs, the split system requires a place to put the outdoor unit, maybe on a roof or a balcony or on the ground. We run refrigerant

lines to connect them to an indoor unit, that's labor intensive, it's disruptive, there's also the risk of refrigerant leaks. The advantages of a unitary or a package system is it doesn't have any of those disadvantages. You do need potentially more space in the apartment, you're going to have a penetration in the wall for air exchange.

But those are the main considerations, that's the main advantage of the package system. And now the package systems are coming out that have similar efficiencies if they perform as well as they're supposed to then there could be some big advantages there.

*Josh:* Julie, so you actually you talked about one of these. Do you have anything to add to that?

*Julie:* We have it installed in one unit, we're about to install it in 283. All we've heard is that it's comfortable, it does minimize the refrigerant, and I think the unitized system is also something that people think about in terms of air crossing and in a more central system. So I'm looking forward to results.

*Josh:* So this is primarily for Andrew. So, but others, please chime in. Electrification usually requires either electrical service upgrades or much more complex logic and controls that spreads load and use timing. Could one of the speakers please address this challenging to scaling electrification?

*Andrew:* Yeah, I can take a first crack at that. I wouldn't say in our cases it usually has required electrical service upgrades. We have found that to be a limiting factor and have used the hybrid installation technique that I highlighted as a way around that. Also, a lot of times what appears to be a limiting factor when you just review the electrical capacity by looking at the panel sizes and breakers sizes with a more detailed load study. Particularly, if you actually put CTs on there and actually monitor the amount of power being drawn, you can find that you're way under capacity. My favorite personal story is I live in an all-electric house, as I was mentioning, and had to install a 200 amp service because we were redoing the whole place.

And but that was way delayed and so on day one when I moved into what is a two family house that was meant to have two 200 amp services we ran the entire thing on a single 100 amp service. And we turned every – to test it on the day we moved in we turned everything on, all the water boiling, all the dryers running, and we could only pull 50 amps. And it just goes to show there's a lot of

safety factors built in. And so if you have an existing property and you actually monitor how much electricity you're using, sometimes you find what appears to be a limiting factor actually is not. And then if it actually is a limiting factor, then I would use a hybrid design to put in as much heat pump as you can. And then have the gas boiler carry the difference.

*Josh:* Anyone else have thoughts on this?

*Jordan:* Yeah, there are some devices, smart panels, and switching devices that can be used to shuffle loads automatically that can potentially solve that problem. And furthermore, if you have a building that is maybe already set up for air conditioning with sleeves, probably okay in terms of your load on heat pumps. They're going to pull about the same amount of power. So a couple other considerations.

*Josh:* So there's a question that some of you started answering but I think it's worth raising for the group. It says it's important to engage the residents in decision making, particularly in _____ housing where many residents are opposed to electrification, concerned about increased costs or potential impacts from power outages. Any thoughts on this?

*Rory:* I'll start off, one misconception is you'll – the power goes out you'll still have your heat. That's not entirely true for natural gas that is, electric outage will affect gas systems as well. So it's – when the electricity goes out, you're going to be losing your heat in both cases. Second, I do think it's a viable concern, the cost implications on tenants. And I think the beginning of this conversation could start around rate design. When we look at natural gas, there's rates for natural gas cooking which are fundamentally different for natural gas heating. But generally, your electric rates aren't as varied for specific applications and I think an ongoing conversation both in California and New York is going to be questions about what kind of rates should be created to not only minimize the cost impact on individual customers and landlords but to also make sure that you attract the right usage of electricity given the increased amount of electricity that we're going to be seeing through electrification. Making sure that it's spread out at the right times and incentivized to be used appropriately. So I think rate design is going to be a big factor in that.

*Jordan:* Just I'll add on that from the tenants standpoint, electrification will often bring them much more control and comfort than central

systems that are poorly controlled and for which residents have little to no control. So that's a big selling point for residents.

*Josh:* Yeah.

*Andrew:* If you eliminate – I'll just add if you eliminate gas entirely you can also eliminate those minimum monthly charges which a lot of times is I always remember when I lived in New York and I had a gas stove. I think I paid $10.00 or $20.00 a month for the hookup and about $1.00 a month worth of gas. So there can be that benefit too.

*Josh:* Later point, so similar to ask, this is to Julie primarily. Can you discuss how hot and humid climates affect how building enclosures meet passive house infiltration rates?

*Julie:* Yeah, I think I answered that one in there, but I'll just say that the requirements for passive house, the airtightness is it is what it is, right. So your fresh air supply is going to – it's going to be designed to go through an energy or enthalpy recovery system. So it'll recover some of the humidity there but on every project, whether it's in a hot humid climate, we have dehumidification designed in. We don't put dehumidifiers in the unit. We sometimes have a bypass on the ERVs so if that – if the air pre or post the ERV has not be dehumidified to the level we want it to be, then it goes through some dehumidification or cooling in order to bring the humidity down. So its if residents open windows it's harder to control the humidity. But if the building's airtight and the systems designed correctly you shouldn't have an issue.

*Josh:* Any other thoughts on building envelope insulation? Okay, cool. So and then there's this question that some of you have already engaged with but the incentives available for electrification retrofits at the federal and local level, what do these look like for affordable multi-family housing units?

*Andrew:* I can speak for California, I'm not aware of much of anything at the federal level presently. In California, there are some statewide incentives like the low income weatherization program which we utilized on most of the projects I reviewed. And then there's also the BayREN in the bay area offers electrification incentives. And in Sacramento, SMUD is also offering electrification incentives so it tends to be at the state and local level, my experience.

*Julie:* In terms of federal I think the only thing, Andy, out there, right, is the solar incentive, the investment tax credit. Each state has

renewable energy credits to help, also help offset renewable energy which is sort of can be really key when you're trying to electrify your building. Massachusetts, someone asked about that the leadership in this space seems like it's mostly low income developers not market rate. And I think in Massachusetts at least the incentives are equal. Market rate developers can also utilize the incentives, so I know there's great incentives here that the utility gives based on maybe levels, passive house. And then there's also there was a grant that one of the Mass Clean Energy Center gave design challenge grant for passive house.

So we've been able to sort of move the market a little bit with some help because the premium for passive house in a new market, we've been able to sort of offset, bridge that gap with some of the incentives. I'm not that familiar with other incentives, I know there's some foundations in Illinois that the Illinois Clean Energy Foundation has some money. They have a pretty high bar for what performance you have to hit. But like Andy said, I don't know federal incentives for building better buildings or electrification or decarbonization which would be nice.

*Josh:* So – go ahead.

*Rory:* Sorry, was going to add to that. In New York City at the state level, NYSERDA has a clean heat program which provides incentives for heat pumps as well. And at the federal level, I know there's something with ground source heat pumps that's been tossed about but I don't know the details of that. So that may come up.

*Josh:* Great, so that concludes our group discussion. Before we go, I'd like to do a final wrap up, first of all, again, thank you so much, this is an incredible session and you guys have all done amazing work, and looking forward to what you're doing going forward. We'd like to highlight some of the resources mentioned today by the panelists as well as some additional resources available on the Better Building Solution Center. When the slides are made available, please click on each resource to learn more. The Better Building Solution Center has over 3,000 solutions to help you find proven and cost effective strategies to help you reach your energy, water, and waste reduction goals. Let's check out this video to learn more.

*[Music playing from 01:12:55 to 01:13:36]*

*Josh:* Alright, we'd like to invite you to attend our Better Buildings summer webinar series starting in June. Partners will discuss some of the most pressing topics they're facing and share best practices and innovative new approaches to sustainability and energy performance. To register, go to the Better Building Solution Center and click on events and webinars. Next slide, with that, I'd like to again thank our panelists Jordan, Andrew, Julie, Rory, and Eddie for taking the time to be with us today. We've launched a short feedback survey and Slido asks that you please take a couple of minutes to give us feedback on this session. Your answers will be totally invisible to other attendees, we rely on your feedback to design webinars, future summits, and more.

The poll will be open until tomorrow morning. If you'd like to learn more about the resources discussed today, please check out the Better Building Solution Center or feel free to contact me at the e-mail shown. Thank you, everybody, have a good rest of your day.

*[End of Audio]*