[Dictation begins 0:00:20]

Sarah Zaleski: Hello. Good morning. Welcome everybody to the 2020 Better Buildings, Better Plants Summit, a Virtual Leadership Symposium. I thank you for being with us today. We have a really wonderful session prepared and some fantastic speakers that I'm about to introduce in just a moment. Before we dive in there's a few housekeeping points I'd like to cover. Please note today's session will be recorded and archived in the Better Buildings Solution Center.

We'll follow up when today's recording and slides are made available. Next, attendees you're all in listen-only mode. I know we had nearly 2,000 registrants for this session today, so we did have to mute the microphones. But if you do experience any audio or visual issues any time throughout today's session please let us know by using your chat window located at the bottom of this Zoom panel. I'm your moderator, Sarah Zaleski.

I'm a senior advisor in the Building Technologies Office in the Department of Energy where I get to work on a whole portfolio of really exciting projects, not least of which is commercial zero energy and zero energy-ready building. So I've been at DOE for about 10 years now and this is one of my favorite areas to work, so I'm really thrilled to be working with and hearing from and learning from the speakers today. So today we're going to be using an interactive platform called Slido for the Q&A and for some polling throughout, so if you can please go to the link here for Slido.com. You can either use your mobile device if you want or you can use a new window in your internet browser.

Today's event code you'll be prompted for is #BBSummit. So if you can go and take a minute to do that. Once you go in there you'll choose our session, Approaches for Achieving Zero Energy Radio. When I did it it was a purple button there. And so you can use this platform – we're going to – if you want to ask the panelists questions, we'll have some for Q&A at the end, if you'd like to submit something, you know, a question any time through the presentation we'll be collecting those, and we're also going to go back and forth between polls and speakers today, so we may have some live polls and I'd encourage you all to participate throughout so we can kind of make this interactive and also hear from you.

Next I'd like to encourage you to – if you do use social media, if you're into that, we hope you'll join the conversation on social media. There's a couple of links about the event that we're hoping

that you'll use if you do find things that are compelling and want to share. All right. So next we're going to start off by a poll question. So if you can – we're going to launch the poll on Slido. I'll give folks just a chance to put in their responses. The question is what would you best describe is your role at your organization?

So I know at Better Buildings Summit we attract a lot of different professions – engineers, designers, government, consultants, building owners, building operators – and I'm always curious to know who we have in the audience, so please just take a minute to put your responses in there and we'll continue to collect those as I introduce our five panelists. All right. So if you're having any technical issues, again, please message our tech support team using the chat function. They've been very responsive.

So now I'm going to introduce our five fabulous panelists. First up will be Tony Hans. Tony is the vice president and national director of sustainable projects for CMTA where he collaborates with architects and owners to increase sustainability potential for a wide variety of projects. He's been involved in over 4 million square feet of energy efficient – excuse me – zero energy projects. For those folks that don't believe there's a lot of zero energy buildings out there, Tony's been involved in over 4 million square feet of them, including more than a dozen schools, numerous community centers, police stations, corporate office headquarters, higher education laboratories and residence halls, and actually two of CMTA's own office buildings.

After Tony we'll hear from John Chadwick. John has served with Arlington County Public Schools since 2011 first as the director of the design and construction and currently as assistant superintendent for facilities and operations. He has led the district's response to sustain student enrollment and growth through four biannual capital improvement plans and multiple capital projects. Most notably, and what we'll be hearing about today, is Discovery Elementary School, which opened in 2015. Since then, they've started two more zero energy schools. All three schools have been designed to integrate teaching, learning, design, sustainability and environmental stewardship to provide authentic learning experiences for students every day.

After John we'll hear from Paul Torcellini. Paul is a principle engineer for Commercial Buildings Research at the National Renewable Energy Laboratory and is also on the faculty at Eastern Connecticut State University. Paul has been a NREL for over 25 years and has authored or coauthored more than 50 papers or

articles related to energy efficiency and zero energy building. Next up we'll have Stet Sanborn. Stet is a principle and the engineering group lead at Smith Group San Francisco Office. Having both an engineering background as well as his architecture license, Stet focuses on the integration of high performance building enclosures with advanced building systems.

He is a leading voice in statewide departmentization efforts, net zero energy design and research and transformational technology allowing for both grid optimization and electrification from things like multifamily projects to complex research laboratories. And last but not least is Katie Ackerly. Katie is an associate at David Baker Architects, a top multi housing design firm in San Francisco. Katie came to architecture from energy efficiency policy and holds degrees in both architecture and building science from UC Berkeley. As DBA sustainability lead she works to elevate knowledge, tools and best practices regarding multifamily building performance within her firm and beyond.

Thanks to all of you wonderful speakers for being with us today. So we're going to take a quick moment to see the poll results to see who we have on the line, and a mix of professions are represented. All right. So lots of engineers, a fair amount of government, consultant – a pretty good mix here, actually. So, very good.

So I'm thrilled that we have a lot of these folks here on the line today. We have some engineers, some architects, some building owners, and I think we'll just go ahead and dive in. So we're going to start by talking a little bit about zero energy more broadly, but specifically we'll have a few case studies regarding zero energy schools and zero energy multifamily, but I'll note that although we'll talk about those two types of buildings maybe a little bit more, I think most of what today's message is focused on is really applicable across commercial buildings, you know, high performance and zero energy-ready buildings. So with this, I'm going to turn it over to Tony. Take it away, Tony.

Tony Hans: Sarah, thanks so much and thanks for having us. I think you guys have really put together a great presentation today that builds as we go through the presentation. I'll start out talking a little bit about this subject and pass it over to John. You can go ahead and go to the next slide. So, you know, this is a really exciting project and I think this is a subject and I think it's an exciting subject because it's at the forefront of where the industry is headed. The industry has really evolved from design goals to performance-based goals and

this is a paradigm shift for most owners, contractors, architects and engineering groups.

And so performance-based goals are going to include energy, they're going to include carbon, health and wellness goals, daylighting, air quality and resilience. The metrics that are connected to these goals are what owners have been asking for for a long, long time, and as the industry has shifted, those who are able to provide those metrics in true performance is where the building industry is going. So as you go to the next slide we talked a little bit about – go ahead and go to the next slide if you could. Yeah, there we go. So as we go into this slide I think that – yeah, we'll talk a little bit about our experience with these projects at 4 million square feet.

I updated from our database today and we're actually at about 4.5 million square feet of zero energy projects that we're working on, and really we look at zero energy-capable projects, which is more down around 200 projects and 50 megawatts of renewable power. I think the 50 megawatts is interesting to look at because we don't do utility scale power. We're really providing renewables that are net metered as part of the building project, and so as we go from those and look into our goals today, you know, I've asked myself three questions. You know, one, why are there not more zero energy projects?

How are these being successfully done and how are we maximizing efficiency and controlling cost to make these possible? And two, what are the lessons learned over the last 13, 14 years of doing zero energy projects? So we'll dive right into that in the short timeframe. You can go to the next slide. Yeah, so first of all I think we start with looking at where zero energy projects are and the growth of zero energy projects. We're showing a 700 percent growth in zero energy projects nationwide and it's schools that lead all sectors, obviously focused on the East Coast and the West Coast.

You can go the next slide. NBI does a great job of tracking this data. One of the things that you'll see from their metrics is that there's been great growth in zero energy-emerging projects, and those are projects that have set the goal to become zero energy, but then there has not been success in growth in verified projects. You know, they've really stayed stagnant in the number of projects that are successfully verified each year, and so one of the things we look at is how do projects start off with these great expectations and then when things go awry where are they going? And we

believe that most are concentrating on the design aspects of accomplishing zero energy, but the process of reaching these performance goals is really the challenge and the struggles, and we call these filters.

If you go to the next slide we've got a graphic of those filters in terms of where the most common filters that pull out zero energy success, the owner project requirements and the request for proposals and qualifications. When an owner sets the zero energy goals in those RFPs and RFQs they're really telling the teams that this is a project goal for the owner that's prioritized, and that's huge. Coming from there it can really drive the estimating and value engineering to look to not pull out and to cut the zero energy goal and then it can drive commissioning and operations to pay attention to those components that really affect true performance. We recently saw a project in the D.C. area where we were in the beginning of design and estimating comes in at schematic design and shows the project at 35 percent over budget, including the MEP systems.

And when we asked where that overage was it was because the project was zero energy. So we were able to go through that and showcase those items that do not affect cost and successfully bring that back in, and I'll talk more about that in a minute. Go ahead and go to the next slide. John is going to talk specifically about our relationship and our growth in zero energy projects with his district, and I'll showcase some of the metrics here from his projects. You know, we really focused on HVAC and lighting energy reduction and then process load reductions and how that then affects the cost of the project and how it affects the cost and the size of the renewables.

Also, Paul Torcellini is going to obviously mention the advanced energy design guidelines, and I can't help but note that this is where the Department of Energy and NREL really gets it right. They're going to look at the process holistically and not only look at the design components but then where are these things that drive zero energy from successfully happening in those processes. All right. Go ahead and go to the next slide. And then the metrics of John's projects, you'll see in Arlington that we've graphed those projects over the last seven, eight years and the size of the project – the size of the bubble here is the cost of the project and then the EUI and the year the projects were designed, and as you can see it is possible to keep these projects under budget or within budget and successfully drive down the EUI to under a 70 percent reduction.

Go to the next slide. So how do we do that? We really look at focusing on the performance-based goals and prioritizing those goals at the beginning. So we'll list zero energy, we'll list health and wellness and education as primary goals of those projects. And on the project I mentioned earlier where they looked at a 30 to 35 percent overage in estimating on the project, we showcased that really the only difference in design on these projects were these items listed here: design charettes, increased building modeling, increased team collaboration, and then post occupancy support and exhaustive commissioning were the things that were added to the design, and none of those items had a construction cost.

We were able to successfully show similar projects and how those projects bid from our database and then able to bring the project back into budget in the estimating phase so that zero energy didn't get cut. We can go ahead and go to the next project. I'll quickly talk on one other aspect, and that is really sealing up the building and the performance metrics of the envelope, and this project which is a first zero energy school in Florida – you can go to the next slide – we wanted to focus on drastic energy reduction and the HVAC system in removing humidity from the facility. So we are over ventilating this facility above code but we're doing it through the dedicated outside air system rather than air infiltration leaking into the building.

So we set that as a primary goal. We looked at performance metrics and good building pressurization tasks set at 75 percent reduction goal and then we were able to hit and achieve a 95 percent in the full testing of the project. If you go to the next slide I'll close up with what I think is an unbelievably great tool and a secret to doing successful zero energy projects, and that is pulling data from past projects, learning about the metrics of those breakdowns and then using that data and applying it to the next project. So we do this in two ways. We've created a robust sequel-based database that tracks our projects and then we use these on new projects and on renovations.

Here we show an example in a new project, and not only are you graphing monthly how that building is performing but you can also break out the plug loads, the process loads throughout – kitchen, elevator, things like that and then HVAC and lighting loads, and this will let you see two things that are imperative. One, during month one, month two, month three, is your project performing in line with the energy model? You can't wait 12 months to determine you're not on target for zero energy. And secondly, in the bottom

right-hand side of this, you'll see how you design that project and then how that project performs. So then digging into those metrics and applying that to the design of the next project has been a true secret.

So let's go on and go to the next slide. I have to touch on Fauci as he mentions that models are good, they help us make good projections, but the data is what's always trumping the model, so pulling from that data is going to be a great piece. If we go to the next slide we'll look a little bit on what we do for renovations on guaranteeing that projects are going to perform, and that is pulling down monthly where those metrics are going. Go into the next slide. From the database I'm able to quickly pull out – this took about 30 seconds. I picked new buildings under a 35 EUI and I'm able to pull out the projects, the metrics, the costs, the addresses of 11.2 million square feet of the EUIs on projects that are performing under that across all sectors and all building types.

And go ahead and go to the next slide. And so on the renovations, we're tying our renovations in but here's a group of projects and renovation factors. Go ahead and go to the next slide and you'll see this is pre and that's post. It shows the energy reductions and renovations. So we're in the process of pulling our renovations into our database now. Two more slides. The next one shows some of the best-performing slides for these renovations on pre and post occupancy with a year of data, and I think what's important about all of these renovation projects that I'm showing is that there is no change in building envelope, there's no change in orientation, there's no change in fenestration, but really just a focus on drastic energy design and then commissioning that came internally from the group that had a stake in these projects performing as they were promised, and I think that's a great imperative and a lesson learned for getting projects to truly perform as well.

And then the last slide I wanted to touch on, just designing for today's new normal. So, you know, the push on health and wellness has been integrated into high-performance design, but also building resiliency and flexibility. On the project John's going to talk a lot about we went back and looked and on a typical day for that project – you can bring this up live – the project's performance with the consumption in yellow and then a production in orange. So during these shutdown times that project's been producing about six times as it's been consuming, you know, with really drastically low energy consumption. So it's really helped on the resiliency and financially on those projects. So with that I'll turn it over to John.

Sarah Zaleski: Thanks so much, Tony. I'm gonna jump in really quickly. I really appreciate the presentation. There was a couple things that stood out to me. There was kind of an obsession focus on EUI throughout your presentation. You talked a lot about the importance of, you know, operations, maintenance and learning from watching your projects after they're built to after they're occupied and learning from them. I was also really encouraged to see some of those numbers with all the renovations that you've done as you're heading towards zero energy and zero energy ready.

So really impressive EUI numbers in the teams in the low 20s for renovations. So those folks that think you can't do this with renovations I think those were some great examples. We posted one more poll question for you guys to think about before I turn it over to John, and that is what is the likelihood that your organization will be involved in building or retrofitting a zero energy or energy ready building over the next two years? So I'll let you all think about that while I turn it over to John Chadwick to dive deeper into what exciting things they're doing in Arlington County Public Schools.

John Chadwick: Thank you Sarah and Tony. So if you can go to the next slide please. So we are a school division and our focus is on students, so I always like to start off any presentation with a picture that includes students to remind everybody why we are here. Next slide please. I'm going to talk a little bit about why we reach for zero energy on Discovery, what we achieved by doing that, how we got there and get there on future projects on a reasonable budget and how we are continuing to reach for zero energy. Next slide please.

It's important for me to explain the context of Arlington and why zero energy came about in Arlington. Arlington County is only 26 square miles. We have 235,000 residents. In 2018, we were a certified LEED platinum community, and in 2018 we were first place in the Virginia Energy Efficiency Leadership Awards. The Community Cares is about sustainability, they care about the environment and they get it. So we are in a community that's very amenable and interested in this. Arlington Public Schools is a top-rated school division in Virginia, and we've grown.

We've grown from 18,000 students in around 2007 to 28,000 students in September and we're continuing to grow, though not quite as fast. We have 40 buildings on 350 acres and we have 4.8 million square feet of building, and in the last few years we have built three or four new schools and we are continuing to build new

schools. Next please. So why did we reach for zero energy at Discovery? We started out with this goal of creating a learning environment in which teaching, learning, design, sustainability and environmental stewardship will be integrated to a new level.

It was an open RFP process. We found VMDO and selected VMDO there in Charlottesville and D.C. based on the school they had done in Manassas Park, Virginia which came closest to achieving what our goals were. We challenged VMDO to go to the next level with this new school at Discovery and they actually proposed zero energy and said they thought we could do it and put together the right team to do it, which is very important. That right team included CMTA and Tony Hans led their efforts.

So we sort of lucked into this. I didn't know very much about zero energy when we started, but it was suggested, brought up by the architect, not by the owner in this case. Next please. So we've achieved success. We've achieved culture change among all the stakeholders in the Discovery community, and I'll talk a little bit more about that. We have integrated teaching, learning, design, sustainability and environmental stewardship, particularly through our energy dashboard which I'll also talk about.

We've achieved a school where students love to be and love to learn, and we have achieved zero energy on a reasonable budget, and as Tony just showed you with the charts we are continuing to do so. But we realize – and this is a very important lesson for owners – is that once you achieve it now you have to carry on achieving it, because if you don't do that – and it's not that easy, it's quite a challenge to maintain it year after year – but if you don't do that why did you bother in the first place? Next slide please. So just some examples of culture change in the school.

In the center there you see kids lining up on the stairs by the way in which they arrived at school that day. They actually record that information and they put it into the energy dashboard, so they keep all of the data and understand what that means. We're turning them into little environmentalists, so rather than having a student government they have an eco-action committee, and you can see here what the motto for the students in the school is. They get it, they understand it, and they care about it. Next please.

This is a view of the energy dashboard which Tony already revealed to you. It shows on the left how much power's being consumed, and this, by the way, was on 9:10 AM on Friday, January 27, 2017. So on the left is the energy consumption, on the

right is the power production, and you can see that we were netting 32 kilowatts of power. Two examples of how this is used every day to provide authentic learning experiences. You can ask kindergarteners, you can show them a chart of energy consumption by days of the week or by months of the year and engage with them on why it might be that we're using less energy in summers and why we're using more energy in other months.

As an example of fifth graders working with this, last year during the solar eclipse we were told that the sun would be eclipsed by 81 percent, leaving 19 percent. They used the data from the energy model to prove that there was 19 percent less power production during the period that the solar eclipse was going on than immediately before and immediately afterwards. Next please. We achieved a school that kids love, and I just have to put this into the context of what's going on now, and I'm deeply disturbed that it may be a very long time before we see kids gathered together in the sort of ways that we really want them to be in schools to optimize the amount of learning, so it's sad.

Next please. There was a great deal of collaboration that got us there. Tony already mentioned some of that. We developed a lot of stakeholder champions and we've got better at it actually as we've gone to subsequent schools. We created a communication strategy to build consensus among stakeholders. We connected student learning and success with zero energy and we convinced educators to buy in. We have a new superintendent that started last week. My first conversation was with him about helping us to promote this, to take it from being server based to being in the cloud and to expand it to every school in the school division.

We focused on low energy use intensity without diminishing utilization of the school. What I mean by that is people will say, "Oh, schools are great, they don't use that much energy because they're not used at the weekends and in the summer and the evenings." Not true. If you're going to build a building you need to use it about as much as you can, and in Arlington our schools are used constantly in the evenings, weekends and summer school in the summer. We found lots and lots of design synergies to optimize energy balance, looking at those things that Tony said that don't cost money but actually work together, and then we simulated, modeled and commissioned constantly from the outside. Another thing that Tony emphasized.

So as you do all this you begin to build a consensus and understanding in that everybody who touches the school, every

member of the school community, that they all contribute to achieving and then maintaining that zero energy performance. Next please. RFP requirements. It starts at the outset. This didn't happen on Discovery; it's now happening on every project that we send out an RFP for – maximum EUI, onsite renewable energy generation to exceed the EUI with solar photovoltaic arrays, overall minimum insulation value, obviously thermally broken windows. Glazing percentage is really important. I've had people at USGBC gasp when I put a 40 percent maximum number in.

But for us that transparency into and out of the building, the lighting conditions, are really, really important. We do not want to design schools that look like jails because that's how kids behave when you put them in buildings like that. We work on air tightness, cubic feet per minute per square foot. Really important. Distributed outside air systems obviously, as Tony just mentioned, and then ground source heat pumps with dedicated outdoor systems worked for us in our climate. And when we did Discovery, LED was not ubiquitous. It is now, but it makes a huge difference to cooling loads. Next please.

Another aspect of getting there is to have an integrated project team. Now we know that you have to plan for zero energy or zero energy ready for the very outset. You have to right that zero energy or zero energy into the RFPs. You need to find a passionate expert and tenacious team. You also need to have a dedicated construction team that understands the quality needed. You have to integrate all three of them with the owner and you have to design for that full building utilization I just mentioned, and you will find that your budgets will shift from some of the categories.

So you will spend more on additional quality assurance, quality control and commissioning to make sure that the building really is performing as it's being designed to perform. You'll have some savings in other areas but this is one where you cannot cut money. And because of all that integration you understand that removing or altering any one single component will threaten achieving and maintaining the performance because it is integrated. Next please. On a reasonable budget, we started with an energy goal at the outset of zero energy. We stated goals in the request for proposals, we selected the right A/E team, and we selected collaborative construction partner.

But before adding those renewables a zero energy-ready building should cost no more than a normal sustainably designed building if you start from the outset and if you integrate every member of the

team and the work that they do. We are now purchasing our solar arrays through a power purchase agreement which we have for nine schools of which two are new. We are – through that we are actually saving. We're paying a little bit less for that power than we're paying to the utility company, but our rate is fixed for 25 years.

Solar power agreements are working in Virginia. They're in other states but you have to look very carefully at the legalities around a public institution taking advantage of them. Next please. So Arlington continues to reach for zero energy. On the left you see Fleet Elementary School, which opened in September of last year, again by CMTA and VMDO. The solar panels are now working and we're beginning to gather the data to demonstrate our energy for the first year and we will go for certification when we're able.

In the middle there is Lubber Run Community Center, which will be completed this summer. That's also by VMDO and CMTA. It's zero energy ready and we are pushing our colleagues at the county to get that solar on the roof. And then under construction on the right is the new elementary school at the Reed site, which will be completed in August 2021. Also already we have a solar power purchase agreement in place for the solar arrays on that building and we are on schedule to complete it in August of 2021.

Next please. So that is a little bit on they story for Arlington, and I'm going to pass it over to our – back to Sarah.

Sarah Zaleski: Thank you so much, John. Such a compelling story. I'm so happy you were able to share it with us today. I know sometimes I've heard people question if building a very high performance building would come at the cost of occupant comfort potentially, and I think you've really shown that not only is that not the case but it can really enhance the occupant, in this case, the student experience and their learning experience most important.

John Chadwick: Absolutely.

Sarah Zaleski: So thank you so much for sharing this with us. And great to know that it works so well that you're continuing and you're making it more of business as usual in Arlington, so that's wonderful. So I'm going to just turn quickly to our second poll results. So we asked what the likelihood of your organization building a zero energy-ready building in the next two years, and it looks like we have a group of folks involved and hopefully a lot more zero energy buildings in the next few years, so that's great to hear. In terms of

guidance on how to get there, we've heard some great tips from Tony and John, and I'm about to turn it over to Paul to talk more about some of the resources that DOE and other organizations have been behind to really kind of show pathways of how to go about achieving zero energy from both a programmatic perspective and a management perspective as well as the technology perspective. So with that I'll turn it over to you, Paul.

Paul Torcellini: All right. Thanks, Sarah. Yeah, a lot of the work that Sarah and I have focused on is working with many of the panelists through the school's accelerator and really learning from them and what the experiences are, hearing what the barriers are and trying to think through those. I'm scanning through some of the questions during the previous presentations. A lot of those are similar questions and we hear these over and over again, and we'll see if hopefully some of these resources help capture that. So, next slide. Next slide.

So Tony had mentioned this earlier, one of the places that we've captured a lot of these processes is through the Advanced Energy Design Guides. Really we talk about the definitions, the processes. There are different definitions for zero energy and those are changing and evolving as we get better understanding and even better data. You know, right now really it's about a balance between how much energy the building consumes and whether we can provide that energy with renewable resources. We're very quickly moving towards looking at some time-of-day dependencies on that in order to even further reduce the environmental impact of buildings.

But the design guides provide some of that. They provide solution sets by climate zones, realizing that there are differences. They're really designed for architects and engineers. We provide guidance on strategies, whole building integration approaches as well as recommended energy targets, and one of the things that we have found, especially from the owner perspective, is that setting energy targets is really important. If you do nothing else put energy targets in the RFPs going out to teams and ask the teams even very simply what kind of energy performance are you expecting out of your buildings even without setting necessarily a threshold.

But these are the energy targets we feel that on the efficiency side you really need to get to to be able to call yourself zero energy ready; that is, so energy efficient that renewables then can make up the remaining of the load. We mix that with real performance data from buildings. Tony talked about some of those case studies – Discovery School is in the K-12 version – and getting those

achievable targets. We currently have two advanced energy design guides out there for K-12 schools and small to medium office buildings, and we are working on multifamily to be produced this fall, released this fall. Next slide.

And so here's just kind of a background. We started with 30 percent guides, moved to 50 percent guides. You can see the different types of spaces that these guides were designed for. Each of these had modeling done so that – by the National Labs – to show that the pathways were achievable and that the EUIs were achievable, and then matched that up with case studies of actual buildings that kind of hit those EUI targets. And like I mentioned, we've had two zero energy guides now published. This is a very popular download from the ASHRAE website. It is really put together by a team of folks representing some of the major professional societies that you see listed at the bottom of the screen here, and it's really an industry partnership with DOE and the National Labs.

Next slide. You can get copies, hard copy versions also, if you would like a hard copy version. There is a cost from ASHRAE associated with that. And I did not put on that slide, but ASHRAE.org/AEDG is where you can find this. The bulk of the guide is made of how-to strategies involving things like site planning, envelope, daylighting. You can see kind of the different category areas that we provide guidance on.

We've also added some additional pieces. Really the focus is on new construction for the guides. However, there's so much interest around the renovation and reducing energy and energy costs on renovation that we've started identifying tips that apply for renovations specifically. We also highlight tips that are available for things like resiliency and also tips that really don't cost any extra money up front to deploy. Next slide.

From each of these – this is from the office guide – we develop energy targets, but on a site energy basis and a source energy basis by climate zone, and so you can see examples of those. In general, the site energy numbers tend to be in the low 20's for most of the climate zones, and so that's kind of a good rule of thumb to think about in terms of how buildings should be performing. Next slide. One of the interesting things that often comes up is this notion of how much energy efficiency can you squeeze out of projects, and so we did an analysis that looked at the different codes or actually the ASHRAE 90.1 standards that are out there. I show three of the different releases, and you can see that with time those standards

are getting better and better, and then matching those up with where we were with the Advanced Energy Design Guides.

And so in particular you can see the K-12 guide is roughly half that of – it was actually half of the 2004 standard, but it's pretty close to half of the 2007 standard, and we're like – you know, we worked really hard to get to 50 percent when that guide came out a little more than a decade ago, and as we put together the K-12 guide, one of the things that we realized is that technology has gotten better, integration has gotten better, design teams have gotten better at implementing these things, and that we can still achieve a 42 percent savings over the current energy standards that are out there. You know, as things get better, technologies and ideas get better, we can translate those into real savings for our buildings. Next slide. One of the things that we had heard a lot of through our school's accelerator partners was providing more guidance for owners, and so a lot of the things that you've heard from both John and Tony are captured in this owner's guide.

This one in particular is for K-12 schools, but there's a lot of guidance in here that's really applicable to any building owner, and we've listened to what a lot of the key barriers are. Really the question asked, and I found that last survey very interesting, is what is stopping you from designing zero energy buildings today? What is stopping you from procuring a zero energy building today? And those really become those key barriers. A lot of those we've addressed in this guide, really providing questions for owners and things like how to find design teams, what questions to ask design teams during interviews.

And I mentioned there's many parallels to other building types, even though the front of this says K-12 schools. Next slide. That is available as a free download, by the way, off of NREL's website. One of the things that we've more recently worked on and starting to pull together data, Tony talked about, you know, they as a company have made a real commitment to collect their own data about their performance in order to learn how they're buildings are doing and just, you know, internally they've got this incredible resource of data that's available. But other companies have been doing the same, and so we've been working with a lot of organizations, both schools and design teams, to try to bring together some of this data.

Again, one of the things that we hear most often is that there's this concern about cost, there's this concern about being first, that there's not a – you know, I don't want to be the first person to

design something and some fear about will it be harder to maintain. One of the things John didn't mention but we can talk about it a little later is just the maintenance concerns around some of these buildings, and I know in talking to John he feels that a lot of these schools are easier to maintain and actually are operating better at less cost even on the maintenance side, so maybe we can circle back on some of that. But on the cost piece of this, you know, looking at where those costs are, you get a lot of scatter in the information, and so the first thing is there's a lot of people building schools with data or proposed measured data that are between 15 and the high 20's and that it is no longer kind of out of the ordinary.

In fact, one of the things that we're seeing is that as design teams spend more time thinking about this they really tune their how to put these together and that their EUIs are decreased with time as we go on. And the other part of it is that the costs are very normal and that we cannot find – for many of these schools, for the vast majority of them, that there's a distinguishable price difference either higher or lower for actually setting aggressive energy targets and then going and meeting them, that the design teams will rise to the challenge with the budgets that are there as long as they're typical in order to achieve these EUI targets. And so at the end of the day there's really little evidence that these buildings are costing more. Next slide.

Finally, I want to just bring together that a lot of the information about the accelerators, the school accelerators and links to these references, there's actually a video on this website that talks about what is a zero energy building. It's a two-to-three-minute kind of cartoonish video that's very effective in communicating to a wide range of audiences on what is a zero energy building, and so I would encourage you to look for this for resources or reach out to us if you have questions or barriers so that we can point you to appropriate resources to really get you to owning, operating and designing these zero energy buildings. So I think that's the last slide.

Sarah Zaleski: Great. Thank you so much, Paul. So I think, you know, great to hear about those resources. You know, I think we did case studies available in the Advanced Energy Design Guides. We have the technical kind of tips and design strategies around specific technologies, some kind of guides about how you talk to leadership about zero energy and what are some of the procurement steps that you go through, so hopefully folks can check out those resources. Thank you so much for sharing them with us. I am about to turn it

over to Stet who has been really critically involved and a key player in developing the most recent zero energy Advanced Energy Design Guide, which a mouthful, for multifamily buildings, but before I do that we have one last question up on Slido.

So the question is what research, resources, tools would be most helpful for your organization in overcoming barriers to zero energy-ready buildings? So please let us know. We're all ears on that here at Better Buildings and DOE, so that's really great feedback for us to receive. Thank you. So I am going to turn it over to Stet to present a bit more about his work in multifamily buildings I think specifically, so thanks, Stet.

Stet Sanborn: Yeah. Thanks, Sarah. So I'm actually going to be building on what Paul was just talking about, and I've had the benefit, as Sarah mentioned, of working on the last zero energy design guide for multifamily building that's coming out this year. If we go to the next slide, what I really want to do is start to share some of the information that's embedded in those guides. There's a lot of value and it's an incredible resource, so I just wanted to share some of the tidbits that have been coming out through our sort of exhaustive modeling process and workshops with professionals for the multifamily guide.

Go to the next slide. For those of you who work in multifamily you probably already know this. It's all about hot water. *[Laughs]* And this is where this design guide is quite a bit different from previous design guides, so small office and the K-12 schools. Really the crux of this one is looking at the building type of multifamily, and if you go to the – click to the next slide, really when we start to see apartment complexes or condo buildings that go above five units, all of a sudden you start to see that domestic hot water is a third or more of your energy loads, and so there's a lot more attention in this guide on how to achieve zero energy via hot water than there have been in the previous guides. Next slide.

So with that, we modeled pretty much every domestic hot water system that's available on the market and even some that aren't. *[Laughs]* So going from a traditional gas boiler central system, we modeled all the way through in-unit heat pump water heaters, distributed heat pump water heaters, split heat pump water heaters, you know, where the condensing unit might be outside like a Co2 heat pump, and even some of the most innovative systems, so those include wastewater recovery heat pumps, so literally heat pumps that steal energy out from your waste leaving the building which actually has a phenomenal relationship for multifamily

buildings between a supply of hot water and a demand call for hot water. So you can see immediately looking at those heat pump strategies it has a really strong impact on reducing our total EUI.

If you go to the next slide – and building on that, we want to make sure that we're getting those systems right, and because this is probably one of the biggest transitions within the technology piece of buildings within the systems there's quite a bit of guidance in there on how those systems should be deployed and developed. Heat pumps are far more sensitive, like air-source heat pumps are obviously far more sensitive to outside air temperature and also in the way that you set up the storage tanks with the heat pumps in whether they're single-pass or multi-pass systems. So we go into far more depth on the engineering side on the systems to make sure those are right, because when they're done wrong we don't get those efficiency gains, and because this is a critical transition in technology for multifamily buildings right now we want to make sure that we're not tripping over ourselves immediately and we want to make sure that the technology has been deployed well.

And so we resourced a lot of information from practitioners in the field who have already done these systems and failed, and so there's a lot of lessons learned that we used to deploy those. Go to the next slide. The other big difference is that multifamily buildings tend to have – already fall into the alphabet building shapes. Because of the need to access light and air we don't see big, sprawling buildings like we might in an office building with deep cores. You know, we're typically limited to 65 to 75 feet for depths which is great from a building data lighting standpoint. Go to the next slide. The other big difference in this guide than with other ones is that multifamily buildings come in every sort of size and density that you can imagine and are very different in urban contexts where sites are very constrained than they might be in suburban or rural contexts where land is more available.

The other piece that sort of came out in our modeling is we wanted to understand and be able to share how energy use targets or EUI targets change for those different scenarios, and so one of those big drivers is just understanding the impact of that ground floor. So oftentimes multifamily buildings are mixed use. They have a commercial or retail element on the ground floor and then the multifamily sort of portion above. If you go to the next slide, what we ended up doing is actually modeling a prototypical building and then adding addition floors on top to sort of look at what the impact is of height as we look at these multifamily buildings to give designers a better idea of what the impact of density and

height is. And so what you can see in this graph is that diminishing impact of that ground floor retail or mixed use.

So the very top line at the very top is a four-story building, so three stories of residential over a commercial ground floor, so for every climate zone from zero all the way to eight in the arctic. As you add additional residential floors the impact of that high EUI commercial floor is diminished, and so the overall building EUI is driven down as you go up with height, and so we wanted to make sure we included these sort of factors so that when teams are picking their target they can understand how they might need to adjust their EUI target based on whether they're doing a rural site, a suburban site or maybe a really dense urban site. So there's a lot of really sort of juicy tidbits in the guide to get you a little bit more information because we understand that multifamily buildings can vary quite a bit.

So on the next slide we also – and this is actually really great feedback that we got from a lot of our participants in our workshops, including Katie, who you're going to hear in a little bit, but the idea that unit mix has a big impact on multifamily energy use. So, you know, when we look at dense urban multifamily buildings there may be a lot of studio units, you know, very small studio units, and maybe not as many three bedrooms. As we look at family housing though, there's many more one-bedroom, two-bedroom and three-bedroom units than you might see for a studio. That has a big impact on total energy use because of that big driver of plug loads.

So more so than in office buildings, more so than in schools, multifamily buildings, once we do all of our other efficiency measures, are driven by plug loads. So if you imagine a studio unit, everybody generally has a lot of the same equipment. They have a TV, they have electronics, but now it's just put into a much smaller footprint, and so that impact of those plug loads is much higher on a studio than it is on a three-bedroom typically is what we found in sort of site data. But we don't want to give the impression that if you're going with a high-density, multifamily project, because you're trying to get as many people housed as possible that you should be facing a penalty from an EUI.

So we wanted to give an idea of what the impact of unit mix is on EUI again so clients or owners can help target the EUI but without a penalty by the fact that they're housing more people. So if you go to the next slide you'll start to see what that variation can be when we go from the lower yellow line is a low density mix, so these are

predominantly three-bedroom and two-bedroom with a few one-bedroom and studios mixed in, versus an all-studio mix. So the high density at that top line is actually showing for every climate zone what that impact is if you actually did an entire studio mix for your multifamily building, which is quite common when we're looking at sort of urban affordable housing projects. So you can see that, you know, four to five EUI delta pretty much across the board for every climate zone just by playing with the unit mix.

And so again, we wanted to provide that information to give owners a guide as to how to target those without penalizing them and trying to convince, you know, 100 percent affordable housing, all-studio unit project that they should be getting an EUI of 18 in the Bay Area, in 3C, because in reality they should have a little bit more leniency because of that high plug load mix. So if you go to the next slide, once we've dealt with hot water, which was the big one, here you can actually see that impact of plug loads. So internal equipment, that lower sort of gray bar across the bottom can easily get upwards of half of your total energy use, and this is the area is my sort of call to industry for innovation, is in plug load management and more rigorous standards around equipment that people bring into their homes.

So, you know, we have wrung out every BTU that we can out of envelope, glazing, mechanical systems, hot water systems, and now you can see this sort of holy grail at the bottom. It's really a lot of advanced energy needed on the plug load side. So if you go to the next slide, the other piece is that energy use targets, especially for multifamily, because of the density, is that they have limited roof area, and so we also wanted to just give an idea of how much energy you could produce on your roof for certain building types to help see how close you could actually get to onsite zero energy. So when we typically get to four, five and above stories onsite zero energy with just your roof area is very challenging, and so the guide includes some strategies, including doing sloped roof, doing canopy systems, going to higher efficiency panels, and also getting equipment off of your roof is actually one of the key areas to provide more space on your roof area for PVs and consolidating things as silly as plumbing venting, which can actually disrupt your PV layout quite a bit in multifamily buildings because of so many plumbing stacks.

So if you look at the next slide, you can start to see on a project that's trying to get to net zero energy all the competing forces on the roof, and in urban areas this actually often includes green roof space and/or amenity space. You know, multifamily buildings, at

least in the market rate sector and sort of luxury sector, it's all about roof amenities and things that you can add on. So there's a lot of competing factors fighting for that real estate, so I would argue that one of the most important plans in a multifamily building is your roof plan if you're trying to get to net zero energy. So if we go to the next slide, I wanted to quick share some of what we did to give targets for designers around U values.

We actually did full parametric modeling – or by we I say NREL *[laughs]* – so a shout out to our partners at NREL who did a phenomenal job, but looking at every climate zone, looking at three building orientations, multiple roof and wall constructions from ASHRAE standards all the way to near Passive House Standards, window constructions and then window-to-wall ratio, we understand that each of those parameters actually impacts each other. So if you go to the next slide, we ran all of those, and hopefully the video starts here. Yeah, there it goes. So we actually had to make our own interface to be able to hop between climate zones and look at the impact of rotating the building, window-to-wall ratio, and envelope constructions to get our EUI targets on the left.

So we were able to hop around. We can look at – so some climate zones, the window-to-wall ratio is not that big of a driver, so climate zone 3C where I live, it's not a big driver. The EUI numbers are practically on each other. But for other climate zones more extreme, window-to-wall ratio's a big driver. So anyway, we had to develop an interface just so that we could understand those interrelated elements for different climate zones. So on the next slide we did the same thing with mechanical systems, and I won't spend too much time on this, but looking at each climate zone.

We looked at probably six different mechanical systems to find out which one again pushed that EUI the lowest, and those recommendations are included in the guide. Next slide. So at the end of the day all those strategies from envelope to hot water systems to building enclosures, orientation, all fell in together to provide these guides, as Paul mentioned, to have an EUI target that we think is very reliable and repeatable. So we were actually able to achieve numbers lower than this through our modeling efforts, but we actually think that these are really responsible targets for each climate zone for multifamily buildings to be considered a net zero or near net zero. Next.

So our big takeaways here, it's all about hot water heating, *[laughs]* so love your heat pump, and we have suggestions for

almost every climate zone. Unit mix does impact the EUI targets so you might need to adjust those. Building height as well. Window-to-wall ratio can impact the effectiveness of your opaque wall R value for certain climate zones. So there's a lot of information that we teased out of the data to hopefully make this guide really useful for both owners and designers. And I think that's it for me.

Paul Torcellini: Sarah, I think you're muted.

Stet Sanborn: Yeah.

Sarah Zaleski: Thank you. Sorry about that. I was just saying thank you, Stet. It was nice to get a little preview of the AEDG coming out later this year on multifamily buildings and some of the unique aspects to be considered and a lot of the impressive analysis that's there that hopefully people can not have to recreate the wheel but take a look at some of that analysis and put it forth in their projects. So, thank you for sharing that. So thank you also for those folks that weighed in on the third poll.

It looks like we have a lot of responses, so I won't try to pretend to read those right now, but we will take a look at those after the presentation and integrate that into our planning going forward. I want to introduce our final speaker, Katie from DBA architects, who's going to talk a little bit more about zero energy design in buildings and even share a bit of a case study with us. So, take it away, Katie.

Katie Ackerly: Great. Thanks. That was awesome, Stet. That was the first time I was hearing some of those results, too. You can go to the next slide. That's great to see some of that work when you really look at the density, how that impacts EUI. So we're David Baker Architects located in San Francisco, Oakland and Birmingham. Next slide.

We do housing. Next slide. *[Laughs]* I usually have control over these. Yeah, so we're known as sort of excellence in housing. That's really our wheelhouse. We do some hospitality as well. And I just wanted to kind of give some perspective of just some transparency here. This is our portfolio going back a few years and including unbuilt projects that are in working drawings that have been modeled – we have a whole bunch more that have not been modeled yet – and to see some of the trends.

You know, these are modeled numbers. They're not predicted – I mean they're not real performance. The real numbers are probably several points higher, but you're seeing two things. One, how low overall our EUIs actually are in sort of the grander scheme of things, and again, just how much more important that kind of operational side is to meet these predicted performance numbers, and then the other trend is the shift to all-electric buildings. Next slide.

We have three kind of feature buildings that have driven this trend. One, our first all-electric building to open a few years ago. It was our first central heat pump water heating project. The project I'm going to be presenting today is the second bubble, which is a six-story attempt at zero net energy, and then we also have a zero net energy hotel in our portfolio, and the only reason that number is not zero is because there's a part of a block, a mixed use block of development and the ZNE part was a convenient border that we drew around the hotel. *[Laughs]* So it's all very – it's interesting, our experience with this question of how you achieve ZNE, how you define it.

Next slide. This is Coliseum Place. It committed to being net zero for funding purposes and then actually dialed back to a lower offset commitment. Next slide. It's located in Oakland, near the Oakland Coliseum. And before I kind of jump into that project, I wanted to take a step back and offer this perspective and this layer of the relationship between housing and climate change. Buildings and climate change, you know, there's especially in this forum a ton of focus on energy, but we're also, you know, I think well versed in a lot of the other kind of resource streams focused on emissions reduction overall, renewal energy.

We thought maybe a little bit about ecological impacts. Next slide. When you start talking about housing there are a whole host of dimensions that intersect the kind of standard parameters we're designing toward when we think about a high performance building. And it's funny, it's like in very real ways if you become too focused on a singular goal, for instance, you know, meeting 100 percent of your energy use with onsite PV, you may be making the problems of climate change harder to solve as you're solving them. That's the trick with housing that I really think is true.

So for one clear example is what Stet already mentioned, this tension between density and providing dense housing in sort of urban centers and all of the kind of climate mitigation and benefits

of that. But there's human dimensions too, and I'll sort of touch on some other things that are important not to – *[laughs]* are important to remember as you go through. If people – for instance, you know, if people feel unsafe in their homes, if they're not able to shelter in place during an event, if they have to be displaced, if there are comfort, isolation issues, then that puts a strain on our ability to meet this challenge. Okay, next slide. And that is why I kind of have started thinking about zero net energy as much more of a powerful process than kind of the technical specificity of the goal, although that's very important.

What I've found to be really powerful is a goal like ZNE is something that is a strong vision that drives decision-making in a way that is very different from the way we usually make decisions. In California, we have this – you know, we're blessed with this very ambitious energy code that has been – that has driven a lot of transformation in the industry, but when it comes to decision makers and the design process, what I've noticed is that decision-making is still all about what is the easiest perceived cheapest and easiest way to comply with the-the code and there isn't the same sense of starting with a goal that makes sense to the value of the owner to the long-term thinking of the owner. What this slide really shows – I mean I've put it up not to kind of dwell on the details but to show a principle that to meet code here, to bring your baseline design to 0 percent, there are a number of measures, and they're listed here by our energy consultant from kind of efficiency first down to renewable energy. And you can see a lot of the low-hanging fruit don't quite get you there and the remaining items sort of points to solar thermal and to offset water system as being kind of the most attractive solution in terms of cost.

That's what we tend to see and it's kind of reverse of what you would hope, right? You'd hope the investment goes into the envelope maybe. Okay, next slide. So on this project, Coliseum Place, on really strong I think asset to it was that it started off with a very strong vision about being a high performance building – next slide – and that that high performance had two sides of the coin, right? It had the – it had some architectural expression of it being a zero net energy building with a big, exuberant PV canopy and a shade screen on the southwest façade and a simple geometry, and so we had an interest in expressing that in the building but we also had a really strong interest in meeting the kind of social needs of the community, so really keying into architecture that connects people to each other and to nature as much as a building like this can. Next slide.

This is just another section showing that central core that connects open space and active living and community space. Next slide. And so, you know, as an alternate to the first slide I showed, showing the kind of decision-making process with the Title 24 energy code compliance, this chart is supposed to represent the kind of alternate way of thinking about your building. If you can characterize, you know, the full building, where the loads are, what your baseline EUI is, you can identify what the opportunities are and what the payoff is of addressing those opportunities. It seems kind of straightforward; it seems like something I've heard and taken for granted for years in kind of green building industry, but it's surprisingly something that we actually don't get to do a lot of in our multifamily projects, in part because the projects are complex and in part because the tools that we're given don't point to it.

Takeaways from this chart include, you know, what Stet has already kind of shown us, the relatively small impact that envelope and HVAC systems might have in the climate that we're dealing with, the relative large impact of plug loads on the building, and then the big opportunity which is central hot water. So this is a baseline showing a building that's already moved from a conventional gas to an electric system, and in a couple slides I will show the one step further that we took in this particular project to bring the loads down even further. I did want to take a little bit of a sidestep to note that the plug loads is a little bit of an elephant in the room that's something I'm not going to talk much about, and in part because I happen not to be a fan of deliberate sort of plug load management technologies, interventions in – for residential spaces in particular. The notion that I think these devices end up sort of either policing or trying to outsmart residents.

It's very hard to deploy them in a way that is actually – authentically meets resident's needs. I'm very much in favor of technologies that give people feedback that they can do what they want with. I think that's very empowering. But outlets that are occupancy controlled are such I think they get – people will end up running their household the way they want to anyway. Okay, next slide. So one point I wanted to make towards my first framing is that the HVAC system, again, when you pile on all of the things that your heating and cooling and ventilation system have to achieve for a home and on top of the fact that in our climate it tends to be relatively a low-impact decision in terms of the overall EUI, efficiency ends up being pretty far down the list of selection criteria.

Oh, also not to mention that your systems options for these buildings are really not great. *[Laughs]* There's always something to be desired with the options that we have out there. What we landed on for this project was actually a product that ended up being too new for this particular project. It's since taken off and we're specking it on all of our projects. What's nice about it is sort of shift from a traditional PTAC, which we're, in our practice, have pushback on PTAC a lot because they tend to be leaky, loud, take up a lot of space, ugly, not very efficient. They don't make people feel a sense of pride maybe living in their home with this big, clunky PTAC under their window.

This product, and there's a couple of different versions of it, solves that problem. The only thing you have to deal with is the fact that it doesn't have a lot of distribution, so you're either putting one of these in every room or figuring out a way to supplement conditioning in the bedrooms. Next slide. So this is the kind of big EUI opportunity that we targeted, was eliminating central hot water, and we moved to this model of shared sort of residential-type water heaters with home runs to every unit. Next slide. This was a lot cheaper. So in addition to saving energy it also saved a lot of money, but there's a lot of cultural resistance to doing this because it's just not typical, and whenever you're doing anything that's not typical you encounter a lot of resistance that you need to take seriously because that could turn into an operation of things not going quite as planned.

So I think that's really something serious to contend with. And then just the design hurdle of needing to really minimize hot water times and doing performance calculations on your plumbing sizing rather than prescriptive plumbing sizing. Next slide. And so there you can see in the red bar what that did to our overall energy use from a central to distributed hot water. We got within spitting distance of a PV canopy that we could presumably put on a roof area. Next slide. What we ended up with, when it comes to actually meeting ZNE, was a really interesting lesson learned. It was a windfall and also there's a major barrier I'll try to explain.

So a typical kind of just roof-mounted PV array would've offset, and will offset – that's what our final design is – about 40 percent of the total building loads, which ends up being about 100 percent, a little bit less, of common loads. If the owner had invested in a large, exuberant canopy, a lot of structural steel, we would've gotten up to 70 percent. To get that 100 percent offset that would've meant putting structural steel in the parapets and actually extending the canopy over the building, over the property line,

which seemed to bring more risk than benefit in terms of that detailing. So I'll try to do the bottom line sort of quickly here. Because of the federal tax credit and tools that we have in California to shift your assumptions of a resident's utility cost to their rent, the owner actually had a lot to gain from doing a PV canopy that primarily offset the residents and not the common loads.

So that was the tradeoff; a smaller array offsetting the common loads, a large array offsetting the residents that yielded this big financial return for them, and while that financial return was real and the larger array would've been cheaper the return would've come by mechanisms outside of the construction budget. So as a construction item, budget item, this particular owner was not keen on $1 million cost item that put them at risk of going over their cost containment limits. So it was a really interesting scenario that made me think a lot about how we can remove some of these barriers to integrating PV onto affordable housing projects. Next slide.

I want to finish off with just a quick other side note of, again, not getting to focused on a singular goal. I noted my low overall EUI numbers in our portfolio, and one thing that that also flagged for people is that, okay, maybe we should be also looking at embodied emissions because over, you know, the next 10 or 15 years there's sort of pencils-down moment; the operating emissions reductions that we're targeting might be quite comparable to some opportunities in materials. And so I can't help myself; if we're talking about zero energy and decarbonization of mentioning, there's one lesson learned. Next slide. Actually, if you *[laughs]* – I'll do this, it's fine. It's sort of an animation.

So go through the next slide. So here you see – yeah, that's fine – you see there a jump from going all electric and eliminating that central hot water. That makes this huge impact on site emissions because eliminating fossil fuels. Okay. And then continue to the next two. So that baseline was just the carbon in the concrete. This is a wood frame building. There's one layer of concrete. But the embodied emissions are so potent that doing an achievable cement replacement with specs that were in the previous slide would've had this level of reduction, which is, you know, over 10 years almost equivalent – going in the future still, kind of order of magnitude similarity.

So that was really eye-opening for me. It's obviously a both and, that we can't sort of be – we sort of need to keep our eyes open of

all the opportunities in housing that can yield results. Okay, next slide. I think that's it. Just – okay. *[Laughs]* Sorry, I forgot about this slide. Moving the practice forward. Again, I think ZNE is more about the process in my experience, what I've been focusing on, and so in terms of working with partners, moving from compliance thinking to whole building and lifecycle thinking and your energy model scope and consultant selection, that becomes really important.

Similarly with engineers, having the experience of doing some of these more emerging heat pump systems is useful. Water proofing consultants become building envelope performance consultants. I didn't focus on the envelope much, but the key with envelope in our area really is focused on commissioning that envelope and making sure that the insulation and the air sealing is well done, and so doing testing as a part of our standard Green Rater scope, which is something we've started writing into all of our RFPs regardless of what certification the owner wants to do. We just sort of sneak it in. *[Laughs]* And then again the structural engineer and how engaged all consultants are really in focusing on the big picture. Okay. Thank you.

Sarah Zaleski: That's great. Thank you so much, Katie. It was great to dive a little bit deeper into one of your specific projects. So I want to thank all the speakers again. We do have about 10 minutes left so we're going to transition over to our final piece of today's session, our live Q&A. So thank you for those folks that are using Slido to submit their questions. We've been keeping track of them and noting them down and I'm going to try to get through a couple of them right now.

So there was one question about who bears the risk of zero energy building performance? So as this becomes more of an industry standard who's on the hook if the building doesn't perform at zero – you know, doesn't hit the zero energy mark or whatever performance mark there is? So do any of the speakers want to take a quick shot at some ideas here? We'll try to keep the answers pretty quick so that we can get a couple questions in. So Paul, I think you might be speaking but you might be…

Paul Torcellini: Hi. Yeah, I can address this a little bit. NREL had looked at this for some of our own buildings and did something called performance-based procurement where we put the energy goals into the document but it is very difficult to hold design teams and contractors responsible for long-term performance, but what we did do was held them responsible for meeting an energy target and

outlined what that meant at the day of occupancy for the building. At that point it's then up to the owner to try to maintain that. I think long-term there are some programs, a couple existing and coming down the pike, that help kind of with the verification of zero and really those are things to help the owners with those things.

But ultimately, the design team is accountable to at least the point of turnover of the building to give it that potential, but there is a contractual mechanism to make that work and then it's the owner's responsibility to operate it accordingly. And so there's a little bit of a mix but it's very hard to cross that boundary, and we have some resources that have discussed that over time.

Tony Hans: I'll add in – I made a quick comment in response that I often get this question actually from owners, and I liken it to the same question we got 20 years ago on LEED, and everyone was worried that all these lawsuits were going to happen because projects did or didn't achieve so many points in the LEED point scale, and so I think that it's important for all groups to understand and be transparent about goals, data, what it really takes to achieve those components, to show similar projects and performance and then to track those accordingly, and what you see is that you see the groups that are dedicated to trying to achieve that goal and that stay with the project. They dig into data that shows that a component isn't performing and work to get that component performing the way it was intended.

Paul Torcellini: Yeah. One other one I have noticed is this notion that there's a developer that owns a property for a long period of time, including all of the maintenance and operation costs, and again, that's kind of a sole point of responsibility and the occupant is really leasing the space from that single entity. They have a huge motivation to figure out how to build the building as less expensively and operate it. Often that optimization long term shows that it's better to invest money in the building for a long-term operational savings. That's a different model that achieves the same kind of thing, but it's back to how do you set up the accountability.

Sarah Zaleski: Great. Thanks, Paul. Thanks, Tony. So I think we have a chance for one more question, and maybe I'll ask everyone to maybe give one tip. There was a question about any best practices for retrofitting buildings to these low EUIs or zero energy performance. So I don't know if each of the speakers wants to give one succinct tip as we start to close out for retrofit.

Stet Sanborn: I could jump in on multifamily retrofits because I've been involved in a handful of them, and my first disclaimer is every retrofit is radically different, *[laughs]* at least in multifamily. A lot of them have nuances. But oftentimes like the insulation upgrades are challenging unless the building is being reskinned or new cladding is going on. So a lot of attention on our projects has been from air sealing and looking at some of the new technologies that have come onto the market that are essentially an aerosol-dispersed air sealant that is done during the pressure test, so they – you do a blower door test on your building, pressurize the building, and at that point they sort of release an aerosol sealant that binds to itself and can find cracks.

So that's been one of the most impactful that we've seen, but the big thing for retrofits on multifamily, at least in our market, is that when we're trying to do those in parallel with ZNE energy or electrification a big attention needs to be placed on what your switchgear capacity is and how old it is and sort of the general condition of that is, and that's been the biggest impediment to some of our deep energy retrofits is not being able to switch systems over to heat pumps because the switchgear didn't have enough capacity even after we did efficiency measures throughout the whole building.

Katie Ackerly: I just want to quickly highlight –

Sarah Zaleski: There's one more chance – go ahead, Katie.

Katie Ackerly: Sorry. Oh, just that there are some programs and demonstrations that are happening right now, some industrialized products on the market for kind of rapidly deployable prefabricated envelope and HVAC components that can hopefully solve this question, although it is a big effort to get there.

Sarah Zaleski: That's great. Thank you. Go ahead, Tony.

Tony Hans: We're seeing many states where power purchase agreements are not legal, PPAs aren't an option, and we're seeing a lot of owners that want to achieve zero energy without upfront cost, and so one of the things we've used in retrofits is we've been able to renovate buildings for energy efficiency and then use guaranteed performance contracting to guarantee the energy savings, provide solar throughout a ton of other projects. We just had our first project achieve zero energy through that approach. So we just added a new project to a 15 EUI and then we utilized renovations in other projects owned by the same owner and using solar as an

energy cost saving measure, as an ECM, and took the 15 EUI building and made it zero energy. So there are good options out there for some in terms of being able to do that without upfront cost.

Sarah Zaleski: Great. Thank you.

John Chadwick: And this is John Chadwick. I just wanted to state the obvious, that we have so many more existing buildings than new buildings that it is the next frontier, and next year I would suggest that you have a program specifically on retrofitting buildings because it is so important and there's so much to learn.

Sarah Zaleski: Yeah. Well, thank you all again. I know we have a hard stop here in just a few seconds, so I just wanted to throw up some of these resources that were mentioned today by our speakers as well as some of the organizations that they represent. I want to give a quick plug for the Better Buildings Webinar Series, so we are going to be having many more kind of impactful presentations throughout the summer and then continuing into the fall. I know – so maybe John, that's one of the things that we can queue up for a future webinar, if not next year for the summit. But I just want to thank the presenters one more time today. Here's everyone's contact information. Thank you to the attendees for joining us today. I hope you guys enjoy the rest of the virtual summit. Thank you.

Stet Sanborn: Thanks, everyone.

[End of Audio]