Paul Torcellini: Hello, and welcome to the 2021 Better Buildings summer webinar series. In this series we are profiling the best practices of Better Buildings Challenge and Alliance Partners and other organizations working to improve energy efficiency in buildings. My name is Paul Torcellini and I'll be your moderator for today. I'm a principal engineer at the National Renewable Energy Lab and work on research and application efforts to move towards zero carbon and zero energy buildings.

I'm also providing technical support for the low carbon pilot. Last fall, Better Buildings rolled out the low carbon pilot. It's an effort to showcase real pathways to low carbon buildings and manufacturing plants. We have over 55 partners that have each selected two buildings for the pilot. Partners are striving to use less energy, achieve operational savings, improve resilience and switch to less carbon-intensive fuels, which has led to today's discussion on electrification.

Every building is important on a pathway to portfolio goals around reducing energy and carbon. The effort is creating what we call action plans for these buildings to be able to show those pathways and identify the barriers. I often ask the question why can't you achieve zero today? What is stopping you? That really becomes the foundation of the effort, how to get you kind of unstuck and how to get you to make progress towards your end goals.

Often in this topic comes up electrification, and most of that electrification discussion focuses around heating. So today's webinar is really to help you think about electrifying. I want you to start thinking of questions for the panel now, right? Go back to where I started. What is stopping you from electrifying today? What is stopping you from moving to all-electric buildings?

I will use a simple example of a hot water heating system to help frame today's discussion. I could use natural gas to directly heat a unit of hot water. That natural gas heater has inefficiency and there are gas system losses to get the natural gas to my building. And so I need about 1.74 units of gas to make that one unit of hot water. I could also use electric resistance, another very common solution, and create that electricity with a natural gas power plant.

Then the amount of natural gas required is slightly more than that direct combustion, but pretty similar the two numbers. If I move to a heat pump hot water heater, the amount of electricity goes down dramatically, cutting the natural gas by two-thirds. Now let's move to a world with more renewables in it. That could either be on the

grid or on your building. I'm not quite sure what to do with the direct natural gas fired unit since that was not renewable to begin with. We could move to electric resistance, but the heat pump still uses one-third of the electricity of the electric resistance or one-third the amount of renewables would be required.

Efficiency is closely tied to that move towards electrification. So as we start to go through this we're excited to announce today that we'll be using Slido, an interactive platform for questions and answers. You can go to Slido.com with your mobile device or opening a new window in a browser. And today's event code is DOE. If you would like to ask our panelists any questions, and again I kind of challenge you with the big question of why don't you electrify everything today, please submit them any time throughout the presentation.

We'll be answering your questions near the end of the session. You can also select a thumbs up icon for questions you like, which will result in the most popular questions being moved to the top of the queue. We're going to start things out with a few polls so we can learn about you, our audience. Please go over to Slido and respond to these polls. So the first poll we want to ask is what sector do you work in?

And so you can select one of those and you'll see in real time those answers coming in. We've got a lot of state and local government folks. Higher ed is right now coming in second. And then we've got some industrial and manufacturing. That's great because a lot of this is dependent on the manufacturing sector to decarbonize. And then we also have some higher ed folks.

As you kind of work through this, we have well over 100 people that have already participated in the poll, so if you'd like to join in please do so now. And when this settles out we'll move to the next poll. Alright, excellent. So the next poll question we have is when do you plan on electrifying your buildings? And so we can go from you're already there or you have no plans at the moment.

And so a lot of you have no plans, so hopefully this webinar will help you think about those plans and some of the possibilities to do that. And again, especially from the half of you that have no plans, you know, what challenges do you face, right? How can the panel today help you think about this and answer some of those questions that you might have? Alright.

And so then we have one third and final poll for this moment, and that is what are the challenges your organization faces when it comes to electrification? So again, why don't you just do it? And this is an open text, so you can respond with a text field, right? So yeah, we've got gas is cheaper, cost, politics. What else is coming through here?

Lack of vision, getting the buy-in, getting the dollars. A lot of dollars in different forms coming up here in those answers. Equity, leadership, low acceptance. So panel, I hope you're watching all these things, and during your presentations you could certainly talk about how you've overcome some of these things and some of the things that you're seeing. Needs to be combined with other upgrades.

How do you negotiate with utility? High electricity rates I've seen several times in different forms. Cost is a priority. Right. So that ever-important business case of how do you make this happen and thinking about it. I've seen lots of different costs. Big letters, little letters, more of an explanation that goes with it. So definitely something people are thinking about here.

Installation barriers from heat pumps, from contractors. Risk aversion, right? Something about not being the way it has been. Redundancy concerns. Not enough renewables on the grid to make sense with that. So excellent, a lot of good thoughts here related to this.

So definitely going to give our panelists something to think about. I think we'll have plenty to talk about here in the next 50 minutes or so. Well, you can continue to put those in for a couple minutes. I'm going to start with our great lineup of presenters, and really ahead of time want to thank our presenters for taking time to share today. First we're going to have Paul Donohoo-Vallett, is a technology and policy analyst at the US Department of Energy's Office of Energy Efficiency and Renewable Energy.

He specializes in electricity sector analysis, renewable energy technology modeling, integration with power systems and markets, and electrification of end uses. And then next we're going to have Christos Chrysiliou who is the Director of Architecture and Engineering Services for the Facilities Services Division of the Los Angeles Unified School District. LAUSD, if you're not familiar, is the second largest school district in the nation with 13,500 educating a population of approximately 640,000 students. He has

over 30 years of experience in architectural planning, development design, project management, sustainability and construction.

And then we're going to jump back to some colder climates, and Julie Klump is going to be joining us, is the Vice President for Design and Building Performance and is responsible for design and energy efficiency for development projects and the owned portfolio. She assists POAH in the acquisition process with building investigation, energy budgeting, scope development, and cost estimates. For new construction, she oversees design development and construction, integrating green and sustainable design. And then we're going to round out our panel with Kent Peterson who is Chief Engineer and COO of P2S, Inc., with over 35 years of experience working in the building and infrastructure industries.

Kent is a past ASHRAE Society president and past chair of ASHRAE/USGBC/IES/SSPC 189.1. He is currently a voting member on the ASHRAE Building Decarbonization Taskforce and the General Services Administration Green Building Advisory Committee Federal Building Decarbonization Task Group. And with that, I will hand it off to Paul to kick us off.

Paul D.-Vallett: Thanks, Paul, for that introduction. As mentioned, I'm from the Office of Energy Efficiency and Global Energy, and I have two disclaimers. My first disclaimer is that any of the pay-ins or policy items that I talk about here are strictly my own and my personal Class B and I'm not representing policy positions of the Department of Energy or the Administration. The second disclaimer is that unlike the other panelists, I am an analyst.

I am not a practitioner. So when you pose your question of why aren't you electrifying today, I can say well it's pretty easy. I go to my model and I turn some knobs and, boom, electrification. It's just that easy. But I know it's not that easy, and that's part of why we're here today. So you can jump to the next slide.

So what Paul asked me to do in five short minutes is to sort of set the stage from an analysis perspective, so I'm just going to quickly offer a few key points for thought for the rest of the panelists and for the discussion. One is why we're here. Well, electrification is critical for decarbonization pathways. If you look at any of these fully decarbonization or net zero economy analysis nationwide, any of these big modeling and study efforts, all of them have electrification as a core pillar of the pathway.

Here's one example of many that I am just showing because it's a good example, and this feature highlights that. There's four key parts to any economy-wide decarbonization. One, electricity decarbonization. Clean up the power sector as low as possible. Two, energy efficiency. Take advantage of all those energy efficiency technologies so that's less energy we have to consume.

Three, electrification of all end uses that can be electrified. And then four, for anything that we cannot electrify we have to use carbon capture or some other carbon capture sequestration and use to take care of that. So electrification of buildings is a core piece of this. It's common in almost all of these net zero pathways and analyses. And the reason why it's useful is we know that there are technologies that exist to do building electrification.

The technologies work. Obviously there are challenges that all of you put in that poll, but there are other places where electrification is not possible or not feasible, either the technologies don't exist and we need to reserve our limited amount of emissions budget for those sectors and end uses that cannot be easily electrified or the emissions can go out of them. Next slide please. So at the Department of Energy we have supported a lot of work at the National Labs to do electrification analyses.

Here is just one of these studies called the *Electrification Future Study* that was run out of the National Renewable Energy Lab. I'm not going to go into this in detail, but it focused on the power sector side and what the challenges are from the power sector side. And from a money perspective and from what needs to be done perspective, the power sector basically would need to grow about double in terms of its infrastructure, the generating units and the transmission. We need to build a lot of new stuff.

And while that is challenging, we generally understand it because the way that the power sector is set up. Lots of entities and utilities make money by building stuff. So it's relatively easy to understand and relatively easy to see how we could put the policies in place to allow all of this stuff to get built and have the economics line up to achieve that. It's achievable and the infrastructure is possible. It just needs to get built.

Go to the next slide please. The challenges in the building sector though, as you all are very close to it, is that we're not necessarily building a ton of new stuff. All of the buildings that are going to be around in 2050 in all of these scenarios, the vast majority of them already exist today. So just as a quick analysis on this, this chart

shows the Energy Information Administration's historical look at the growth of commercial buildings in blue and the commercial floor space in green over time. And so today we've got about 100 billion square feet of commercial floor space.

And if we look at the EIA's projections out to 2050, that grows but only by about a quarter to 125 billion square feet of commercial floor space. So the majority of the buildings that we're going to have electrified buildings, that stock exists today and it needs to be retrofitted. And as you know, that's a significantly different challenge than just building a lot of new stuff. Next slide please.

So how fast would this need to happen? Again, a lot of these deep decarbonization and clean electricity scenarios can point the way as what would need to happen. And again, here's another study out of Princeton, a recent one, a *Net Zero America Project* it's called, looking at net zero emissions by 2050. And these two slides just show on the left column the sales of different types of commercial heating appliance, space heating appliances on the top, and of water heating appliances on the bottom, and how that translates into total energy demand on the right-hand column.

As you can see and as you know, the long lifetime of building assets and the slow turnover of stock limits how fast changes can really go into the stock. This isn't telling us what's economic. This is just telling us how fast we would have to adopt these types of electric technologies in order to be on the pathway to deep decarbonization by 2050. So because of this limitation of stock turnovers most of our technologies would need to be at about 100 percent sales well before 2050, and even in the next decade is the time in which we would need to be ramping up adoption of these technologies.

So the early adopters, the leaders, the policymakers, the manufacturers all have to be in alignment sort of in the next decade to really start if you're going to be on this type of adoption curve. Next slide please. So finally, just three critical areas of thought and paths forward to offer from my personal opinion, and I would love to hear the other panelists' take on this and from the rest of the audience. One is finding partners in this. I'm sure you know doing it alone is very challenging, but there are other people out there in the ecosystem who have an interest to electrification and in decarbonization.

I saw many of the things come up, like, well, it's really hard working with utilities. That's not something you can necessarily

change, but if you haven't there are utilities out there that are forward-looking and are thinking about electrification as a business opportunity and as a decarbonization opportunity, and may be looking for partners to demonstrate how value can go to many different players in this area to achieve many different objectives. Two is thinking about moving the whole supply chain. Again, I saw many of the poll responses come through that were like, well, the installers and the contractors don't know how to do this type of thing, and I think that's absolutely right.

The policies that we've seen to date focus a lot on rebates and tax credits for the purchaser, and while that does make a difference on the economics it doesn't make a difference if when your boiler dies and you need to replace it immediately the contractor who comes says, "Well, I don't know how to install it, I don't have that electric heat pump water heater on the truck nor do I have an electrician with me right now, so maybe you have a tax credit for it and that's great but it's going to take some time before I can get around to it." That's a major barrier that needs to be addressed beyond just these end use incentives. And finally, thinking about buildings as a system.

Electrification can't be thought of just as a drop in replacement. The whole value's got to be seen as how electrification works with efficiency with net zero-ready buildings all working together to see how the building can – electrification fits in providing value to building owners and building occupants and achieving any of these objectives. So I will pause there, and I'm excited to hear what our other panelists have to say.

Paul Torcellini: Great. Thanks, Paul. And now we'll hear from Christos in Southern California.

Christos Chrysiliou: Great. Thanks, Paul. Thanks for the introduction. I appreciate it very much. And I want to thank the Department of Energy for always having these very interesting conversations for us, because even all of us here on the panel, I think we get inspired from each other and also we can inspire you as well so you can be able to achieve some of the things that we'll be discussing today, or increase your planning.

So I'm the Director of Architecture and Engineering and overseeing sustainability and energy. It gives me a unique perspective of things, and that's why I'm so interested in electrification myself. And certainly when you manage a portfolio of LA Unified, as Paul was mentioning earlier, we have over

13,500 buildings and we cover over 650,000 of land approximately, spanning all the way from Porter Ranch all the way to San Pedro. So it's a large district with a lot of buildings throughout, and we utilize about 500,000 megawatt of electricity per year. So 500,000 megawatts of electricity per year.

Can we go to the next slide please? So a little bit about our sustainability. We have our focus areas that we have been working for the past actual decade or so through a resolution that was passed by our board, and we continue focusing in those areas. But what's important is that what happened about a year and a half ago when our board of education passed another resolution. Can we go to the next slide please?

So back in 2019, in December, our board passed a resolution, and I very appreciate their forward thinking, for us transitioning LA Unified to 100 percent clean, renewable energy. And the whole concept behind this is actually what it's saying here. That's going to result in healthier students and more sustainable, equitable communities, and that's something that we should be thinking more than anything else because at the end of the day we're here to solve the climate crisis, and these goals will help us get there. So we're focusing in electrification by 2040, but also we're looking at renewables and renewable pathways by 2030.

And I'm showing some of the electricity usage that we have in terms of dollars and also megawatts and natural gas, because all those have to transition to electrify our buildings and we have to come up with possible solutions and scenarios. Let's go to the next slide please. So this is some targets that we've set up working with the Department of Energy and discussing setting up baselines, with 2014 as a baseline with a 2024 target goal for 20 percent reduction. And then in 2019 the resolutions that passed that we're targeting by 2030, 100 percent electrification, and in 2040 targeting pretty much electrification in all sectors. We're going to be focusing on the 2040 target on this presentation more than anything else, but it's important to note that all this targets that we have do help us plan ahead and think how we're going to be able to electrify our buildings by 2040.

And you can see the actual greenhouse gas emissions that we've been having. The EUI, the Energy Usage Index, as I was showing here, being over 35 average for our buildings and trying to kind of minimize that and bring it down to 20 as a target, or to be less than 20. And then our high electricity use that we have, natural gas and

pretty much just being free from gas throughout the entire district. Next slide please. So how do we move forward?

What do we do? And this is where we come into our clean energy plan and thinking through different processes. I think as Paul previously mentioned also there's a lot of thinking that comes into play, and certainly you cannot do this alone. You have to work within the different divisions. LA Unified is a large district. We have to evaluate all of our divisions, understand their needs, issues, identify stakeholders that we have to work specifically, and that's what we did both internal and external.

We looked at the deliverables that we have to put together so we can be able to put a plan together, and certainly collaborate, collaborate with internal and external partnerships, mostly with our utility agencies who can understand their planning as well. And certainly through this engagement we're able to learn, share information, and then we're able to identify pathways that everybody will be comfortable with so we can be able reach our goals of 2030 and 2040. Next slide please. So when we look at pathways there's different ways that you can look at pathways and different ways you can solve always an issue, and certainly for us this is where it's becoming a little bit of a challenge.

And focusing on a specific pathway is the effort that comes into play and what's best also as a business decision for the district as well. Let's go to the next slide please. So after we talk about all our different pathways, the one that always makes sense is the same one as we look for zero net energy. Always do the best that you can by slowing your meter through awareness and conservation it doesn't cost you any money, focusing energy efficiency by applying all the efficiency measures that you can. There's a lot of efficiency measures that are not costing us – actually there's a lot of savings out of it more than anything else.

And then the introduction of renewable energy, to be able to at least achieve the 100 percent clean renewable by a target milestone. Renewable energy today is very different than it was 10 years ago, and there's a plan and pathways you can get there with very minimal – actually with even some cost avoidance if you follow through a process. And then certainly solving for the 2040, looking at renewables and transitioning to clean energy, you can achieve your 2040 milestone. And our actually transitioning to clean energy is not starting after the 2030 milestone.

It started actually a while back and we just have to put more emphasis on it. Next slide please. So here we're going for an analysis to see what is our energy? What are our utility companies and how much energy again are provided per utility, and then what is the plan moving forward and what is the plan that we have to solve in terms of the transition to clean energy? And what you're seeing here is actually that 106 megawatt of power that we have to solve to be able to transition to 100 percent renewable.

But something that happened along the way is that it was actually working with the LA100. If you're not familiar with the LA100 it's a study that was conducted by NREL, the National Renewable Energy Lab, and what was quite interesting about this study is that it actually has proven and confirmed that you can have an affordable, reliable, and sustainable power system that is running 100 percent renewable energy, and that is very achievable. So there are different pathways, and I urge you to look at that study because there were thousands of simulations that were done to be able to show how that can be done, and certainly some other things I'm going to talk about on the next slide.

So let's go to the next slide please. So when we're looking at this transition and focusing on how we convert our gas systems to electric, for us it's to identify first of all what uses gas, and certainly there's a lot of things that we have within facilities but also equipment that we use to maintain our schools. Let's go to the next slide. So looking at our buildings, we have different types of buildings. Our building portfolio has gymnasiums, classrooms, administrative facilities, two-, three-story buildings, we have auditoriums, we have our food services, and certainly all these different types of buildings use different types of equipment, that we have to focus on those equipment to be able to transition to a electrify our buildings.

And certainly we do that by updating our specifications and we look at the service life of those equipment with the idea and understanding that at a certain time we have to transition, and why not transition by looking at what's more efficient and healthier for out students and the environment? So we're looking at grant opportunities and we're looking at modernization to modernize our buildings to take advantage of these opportunities, because we have time and we can do it within the timeframe. Next slide please. So we've continuing – I've also kind of given an overview of our roadmap.

And I think's going to be similar throughout, is that we're continuing through our own green efficiency planning, looking at low hanging fruit by our lighting systems, operating those through LEDs certainly throughout the facilities. We're looking at the building envelope. We're looking at glazing. We're looking at optimizing pretty much the configuring to modernize our buildings to see how we can create more efficiency, and looking at our mechanical systems.

We're working through pretty much all the different areas of the divisions that are within LA Unified engage and discuss with transportation, looking at health and safety, we're looking at structure and also food services. Because of the size of the district we have to work together, but also these are independent divisions that we have to make sure we share information to meet this pathway. So the energy taskforce that is looking at this and working closely with this, it's putting together a plan, and the plan is to be presented through the taskforce and then to our board of education for approval. So a lot of this planning, it's in discussions, and part of the planning it is to test new systems, it is to test proposals for solar or new equipment and how we can be able to find more efficient systems that are electric through the industry.

So working with the industry but also we're looking at our design standards and specifications and how we can be able to alter those as we move forward. It says here for new construction, but modernizing buildings perhaps a little bit more challenging, and that's why we're upgrading our specifications to reflect that. Next slide please.

Paul Torcellini: Hey, so Christos we need to kind of wrap it up there.

Christos Chrysiliou: Yeah, so I'll wrap it up. So there's some of the challenges that we're sharing, and we heard about them in funding and maintenance costs, lifecycle costs, just electrifying in general some of the underground infrastructure, cost of electricity, scheduling of the infrastructure, and some of the solutions that we're sharing here is to replace some of the equipment that we have and some of the things that I've talked about earlier. We're looking at hybrid solutions, we're looking at induction cooking, we're looking at piloting all these new technologies for mechanical systems and operating our specifications. So these are things that are right now in the planning and we're incorporating as we move forward. Next slide please.

And I'm going to close with that. That again, you know, is quite important for us to continue electrifying our buildings so we can provide a cleaner, healthier, sustainable and equitable learning environment for our students. With that, thank you, and Paul I'll turn it back to you. Thanks.

Paul Torcellini: Alright. Thanks, Christos. We'll now move to the Northeast and Julie.

Julie Klump: Hey, everybody. Thanks so much for having me on this panel. It's certainly a great topic and look forward to the conversation about it. So POAH has made a few good strides in electrification towards our goal of decarbonization. We all know that the grid isn't perfect, but we feel like the best we can do is to get our enclosures as robust as possible. Switch to electric heating, cooling, domestic hot water where we can.

Where we can't, to at least design whatever system is still fossil fuel to be ready to make that electrical jump whenever the technology catches up. So the slide that's on the screen right now is what we do in new construction. Mostly, if not all, of our new construction is committed to passive house. So we have several in design, one under construction, and we feel like passive house plus renewables can easily equal net zero. The density that we build, a lot of times we're going to need offsite electrical, and you can sort of see there's some notes on each of the projects that are some are all electric and some require gas, domestic hot water.

That one challenge we have in New England and in Illinois that gas is so much cheaper than electricity, so that's a big hurdle for us. In the building up in the right corner with the yellow sort of opaque glazing, that's the other hurdle that we're facing there is we have a design for a solar storage system there, but when we submitted for our building permit the phone sort of rang off the wall with effectively telling us try again. So we plan to work with the fire department and the building department in Boston. What they've told is that there's a lot of batteries in service but they've locked them all out because they just have real concerns about safety. So next slide.

So I just want to walk you through one project that I'm pretty excited about. It's a two-tower, 10-story building with 281 units. It was built in 1973 when code allowed the brick to be supported from the ground up with very few brick ties holding it back to the structure. When we approached our rehab for this we kind of expected to do some repointing and maybe reattachment of some

brick, and what turned out when we started opening the brick walls and doing some more investigation was that the brick would have to come down. And it's unfortunate in terms of the cost of the project, but it's very fortunate for me and my team because we get to really tackle energy efficiency here.

So next slide. So you can see on the far right the existing brick cladding is sitting over a metal stud wall with some bad insulation. The graphic in the middle shows that we are coming back with a new product that we're pretty excited about. It's called Amorwall. It's a structural, insulated sheathing, and it can be used on high rise. It passes some of the fire tests that some cities are concerned about on this sized building.

And what it allows us to do is attach that sheathing product to our structure and then attach our cladding to the sheathing that's part of that structural panel, which means that we've avoided all thermal breaks and given ourselves an air/water barrier because that's integral to the structural panel. And then the cladding we've chosen for this one is aluminum. The graphic on the far left just shows that we are adding six inches of insulation to the roof. So we're going from probably an R5 wall to an R30 wall, which is pretty exciting, as well as really good windows.

So we're excited about this enclosure upgrade and feel like that's the place to start on any project. Next slide. So you might've noticed in the photograph that there were through-wall sleeves for air conditioning which is not good for the enclosure and not necessarily an efficient way to cool the units themselves. So we knew we wanted to add fresh air to the units, we knew we wanted cooing with a through-wall sleeve.

So due to some structural constraints in the building, big I-beams that we couldn't pass through from ductwork run through the hallway, we ended up using the Minotair. We installed it in a management office that was a former unit and only heard good things from the staff that used that unit in terms of the fresh air. So basically it's heating/cooling/ventilation in a box. We're building a closet on the exterior intake, exhaust, going through this acting as an ERV as well as a cooling system. There is a fossil fuel boiler and domestic hot water system.

That heating system will be supplemental to this. So effectively we have an all-electric heating, cooling, and ventilation system. Next slide. And then finally, probably the most exciting piece of this for me is that we're installing a vertical solar PV array. So in

combination with the rooftop array in this south wall – this building sits really high up on a hill and has no obstructions to the sun – so we're excited that with the combination of these two arrays we should offset at least 50 percent of our electricity. Next slide.

So just to wrap up, I mean how close are we? What we consider the most important thing is to get the energy efficiency in the building and spend the money there. So when we do a rehab and we have to replace cladding we're going to get continuous insulation, we're going to get a robust enclosure, we're going to buy the best windows we can. It's not always a triple pane. Sometimes we have hurricane-resistant parameters we have to meet, but we do the best we can.

It has been a challenge to convince our lenders that doing an enclosure upgrade can't be done on terms, and so doing kitchens and baths sometimes has to be – that priority has to sort of be brought down a little bit in order to conceded to making the enclosure. And then without a robust enclosure I don't think it's fair to do all electric heating. I think sometimes those systems can't keep up. We are trying a new technology that has a heat booster that's an all-electric hydronic electric heating and cooling system that we hope is going to be a real solution for us on our historic buildings where we can't do as much to the enclosure as we'd like.

And then, of course, the renewable system to the extent you can cover your roof, use offsite, and then we'll let you know how it goes with the wall-mounted array. So I appreciate everybody's time and look forward to some questions.

Paul Torcellini: Alright. Thanks, Julie. And finally, let's move to Kent.

Kent Peterson: Thank you, Paul. I'm going to be able to provide you a consulting engineer's perspective on at least building electrification and some of the challenges that we've been running into and where we're at right now on this. Go to the next slide please. First of all, just a perspective on that first bullet of the size of firm we're coming with. Most of our designs are in the Western United States, kind of taking a different approach than what Julie's doing on the East Coast in the cold climates.

And we find different things that I'm going to share with you. The vast majority of our current new construction projects are all electric buildings. So at a firm like ours that's very important because when we start seeing vast demand for all-electric buildings,

whether they happen to be the local codes or the state codes for these things, we might have 20 or 30 buildings in design at any given point in time, and so we need to be able to react quickly and be able to do it right. I can tell you that we also provide a lot of solutions for reducing carbon in existing facilities.

So part of my slides are going to focus more on existing facilities because my next bullet kind of hits on the point that I am going to make the generalization that all-electric buildings that are new are relatively easy when compared to retrofitting existing large buildings and they're even easier when we get under 20,000 square feet. So that's a lot of the building stock that's out there. It's when we get into the more complicated institutional-type facilities that things get more complex. And like other speakers have said, building efficiency by far is number one priority order when we're talking about electrifying buildings.

Next slide please. So what are some of the challenges? Definitely I would say that the engineering community is not well trained in all-electric heating options, costs, and obstacles, and whether we're talking about heating or we're talking even about going domestic hot water, there's so many options out there. And how we responded to that as an engineering firm is we created a 20-person building decarbonization task group internally that included representatives from all of our offices in various disciplines to basically set the course of what our firm needed to do for all of our clients to make sure that we were doing the same thing through all our offices and coming up with the right solutions for the right clients and the right types of things.

So that's important because I think we need a lot more education in our industry. Space requirements are going to be vastly different when we look at all-electric technologies for many things. When we compare it to being used to using condensing boilers, whether we're talking a gas water heater or we're talking about a gas boiler, there's a lot more space requirements, and those discussions really need to occur in the conceptual design phase. Next slide please. We also found that when it comes to modeling challenges on the engineering side that one of the predominantly used load calculation platforms in our industry grossly overestimates the actual peak heating loads and buildings, sometimes by 200 percent and greater.

And this is backed up by us actually getting trended data over years of analysis on the buildings that we designed and operated, and then running our EnergyPlus and IESVE simulations. And

what we found is EnergyPlus and IESVE more accounted for the sizing we were seeing in the trend data. And our load calculation software that we were using, while not a big deal when you're doing gas boilers because it's not a big expense, it's a huge deal when you're doing all-electric solutions or the cost is much greater. So we've basically decided we're not using that platform.

That platform is soon I think to be replaced next year with a different platform by the manufacturer that provides it. Also on energy modeling software, many people are looking at heat pump technology when there's simultaneous heating and cooling that occur. It might be domestic hot water and space heating when they can actually use the chill water that's coming off of that. And there's currently not any platform out there on the energy modeling side that can actually model heat recovery chillers in a heat follow mode. They model them in a cooling follow mode, and that's not the way you would operate it to provide your primary heating and get the cooling as a secondary effect.

Next slide please. You know, this is talking more about existing facilities, but there's a lot of existing large institutions out there and I'm sure people on this webinar, where you have existing systems that are providing 180-degree water, whether it was supplied by steam or provided by boilers, and those are all connected to one row of coils, whether those are heating coils or reheat coils and VAV systems. Going to all electric can be much more complicated in those type of facilities. And my advice is don't be afraid to do partial conversions in existing facilities.

I'll give you that example on the next slide. So the second bullet here is about reliability data and that reliability data is not available on a lot of these electric technologies. So we've got to push our industry, the manufacturers to start to get some of this reliability data so we know what kind of redundancy we need to be put in when we're doing compressor technology versus doing gas boiler technology. This slide is an example of a retrofit of a 10-year-old LEED platinum building that was converted to all electric.

We designed the original building that was LEED platinum, but this is very typical of what we're seeing, at least in the Western United States when we look at heating load profiles. One point on the bottom being the size capacity that was installed in the building. This one happened to be 22 BTUs per square foot. And what you see over here on the left-hand side on the green bars is what the distribution of the actual load is for the percentage of operating hours of that system. And so you'll see just those two left bars

making up over 60 percent of the operating hours were less than 2.2 BTUs per square foot.

That's extremely low. I mean, we're talking about less than 10 percent. And so you have the ability in these types of systems to put in if you want to go for existing retrofits and you don't want to put in the cost of a full all-electric system. What we're seeing at least in the Western United States is we can put in 20 percent of the peak on an all-electric technology, supplement it with a gas boiler technology that's running at 180 for those peak conditions, and still offset 80 percent of the carbon emissions that are coming from the gas boilers by being able to do that, and that from a lifecycle cost standpoint is a good solution when you're looking at retrofit solutions. Next slide please.

The last one I wanted to do is at least talk about challenges in refrigerants, and refrigerants are an important aspect in all-electric buildings. We're talking primarily about compressor technology with refrigerants. On the first bullet there I show you the different refrigerants we're currently using today with what their ambient restrictions are normally around. So if you're below 35 degrees, R-134a is not going to be a good solution for you. You're going to have to go to R-410a.

But these are HFC refrigerants, at least the two on the left. The CO2 is not. And HFC replacements in many places like California, we're starting to see things being phased out. So we're going to have to move into – the replacements are A2L, lower flammability category. We were all dealing with no flammability on the HFCs. And so that changes to more stringent requirements in new ASHRAE Standard 15. So keep those things in mind when we're doing that.

Right now R32 in my opinion appears to be the strong choice for a non-HFC heat pumps, but the manufacturers ultimately will make which choice they want to go. Last slide. I think that great building envelopes provide the best all-electric buildings in my opinion. We're talking about new construction. The most we can do – I mean, it changes the whole paradigm shift and cost-effectiveness. So what was cost-effective when we were looking at gas technologies to do heating and building changes when we go to all-electric technologies.

And so we're finding that things that we couldn't justify we can justify with the electric technologies but then downsize the electric technologies and get a better overall project and not increasing the

construction costs of the overall project. So there's a lot of tradeoffs on these things, and that even includes heat recovery technologies that might be used in doing that. We need to seize the opportunity to make the largest operational carbon reductions I believe as an industry in our existing building stock. We certainly – as I said, it's an easy thing to start doing all-electric new building construction, and we really need to look at what we can do.

And we don't have to go all-electric in some of these reductions. As I said before, if we went electric for 20 percent of the load we found it actually reduced 80 percent of the carbon emissions from the heating site. Keep these things in mind when you start looking at life cycle costs. And then we also need to have a very good understanding of the heating load distribution profiles, both for new construction and on existing buildings you want to retrofit. Get that trend data before you actually start sizing any of your replacement systems that are going to be out there.

And the final thing is ample training is necessary to transform the market in the entire architect/engineering/construction markets. Thank you.

Paul Torcellini: Alright. Thanks, Kent. Let's bring back the panel. And we have gotten a huge number of questions here. I'm going to characterize some of those. The first characterization is there's been a lot of questions around how to move from gas to electric. And that could be one person is talking about their building is currently heated with gas boilers – how do I electrify that?

Somebody else is talking about a limitation on heat pumps to 20 tons, especially when you talk about things like rooftops – how do we electrify that? Then there were other related questions to that. So maybe Kent, we'll start with you and you can give us some things on how we're going to this equipment.

Kent Peterson: I'll build a little bit on what Julie indicated earlier. When it comes to actually electrifying, the first thing we want to do is even if we're designing buildings today and you're not electrifying them, let's set a criteria on what the requirements should be if we're going to today use natural gas boilers, for instance, and their condensing systems. We should be using low-temperature heating hot water systems if that happens to be heating up water for reheat or anything like that, that can easily drop in any of the new technologies that we're going to do.

The second thing is that when it comes to what you can do to be cost-effective definitely, as I said earlier in my presentation, we can be cost-effective by trying to right size the electric technologies that are going to be there like we do with energy efficiency retrofits. What's going to give me the most bang for my buck in terms of reducing carbon emissions in the building and understanding what needs to happen out there?

Paul Torcellini: Anybody else on the panel want to chime in on the kind of direct replacements and how to electrify the gas boiler?

Paul D.-Vallett: I'll say a number of the things that I've seen have echoed what Kent is saying. The hybrid solutions are pretty cost-effective at avoiding having to build out for electric just for those really cold heating design days and rely on the gas for those days. But you could meet a significant amount of the rest of the days with an electric system.

Kent Peterson: There's also an opportunity, Paul, to couple your domestic hot water with your heating hot water. This is more for new construction, but we found a lot of savings by us being able to take our heat recovery chillers and preheat our incoming cold water going to the domestic hot water system and then downsize those by half for those type of systems. So there's a lot of ways we connect these systems together and use the synergies when we have simultaneous heating and cooling.

Paul Torcellini: And Julie, you approached some of that with the ventilation and trying to capture some of that energy leaving the ventilation air to help with the heat pump, correct?

Julie Klump: I don't think so in this project. I know we're looking at a new system that's coming out that does have some capability. We're not using it for the domestic hot water capability, but there is a way to install this system, the HEX system or the hybrid VR system. And the reason we like that system is because it becomes a hydronic system. We really minimize the refrigerant in the building, and it has a booster which allows our enclosure to not be as good, and it also has the capability of creating some hot water with the rejected heat.

Paul Torcellini: Yeah, I was thinking on the ventilation air system where you've got the ventilation air leaving and the energy associated with that and you're putting that energy into the inlet with a heat pump between those two streams.

Julie Klump: Yeah, and that's just the way that that Minotair – you know, the Pentacare System, that's the way that system works. I mean, it's basically an ERV that also provides heating and cooling. But don't ask me how it works.

Paul Torcellini: Okay. The magic box, right?

Julie Klump: Yeah, the magic box. That's what I call it.

Paul Torcellini: Yeah. So there was another kind of flavor of question here related to kind of the reliability on the electric grid. Somebody mentioned Texas this past winter and extreme weather events. Isn't electrification putting all the eggs in one basket? There was one kind of line of questioning there.

How does the future security and stability of the power grid factor into electrification? Would somebody on the pane like to address that and your thinking about that?

Paul D.-Vallett: Yeah. I can take a stab at that from the system perspective. I see some of the commentors on that one already addressed it, but the gas system and the electric system are already intertwined and they're unextractable. As many pointed out, the Texas event, you'd need electricity to start your gas furnace or your boiler in many cases, and from the system perspective there were electric pumps that run the gas pipeline system. And if those aren't receiving electricity you can't pump the gas either. So these systems are already intertwined very well.

Similar, people talk about electrification and gas or gasoline for cars. You need electricity to run the pumps to move the gas out of the underground tanks into your car. So keeping the electric system secure and reliable is always critical, and I don't think that there's a significant change in that as we approach electrification.

Christos Chrysiliou: Yeah. And I can touch on that, Paul. In terms of even my experience with the LA100 study that was conducted the last four or five years for the Department of Water and Power here in Los Angeles. What we've learned is that when we started we were very actually concerned about this and this question specifically, and then what we were able to find out is that you can reach 100 percent renewable with the systems that we have and you can have the reliability that you need.

And certainly if there's any concerns about that you can always have a backup solution, a backup scenario for that. But in terms of

our buildings and our systems, as Paul was just mentioning earlier right now, I think it's unfair to say that if you have gas your buildings will be shut down. They will shut down if you don't have electricity. It works both ways, right? If you don't have electricity it's going to shut down, if you don't have gas it's still going to shut down, right?

So it's not going to function just with the gas only. So the bottom lien is we have to find solutions. There are hybrid solutions. And we can have again alternate solutions like battery backup storage or other solutions to be able to maintain electricity in our building so it can continue their operations.

Paul Torcellini: Alright. Thanks, Christos. So this question is probably – the two Pauls on the panel are directly involved with this, but the other three of you deal with cost every day, right, as owners or as on the engineering consulting side. We've got several questions around cost. How do you address the cost discussion?

And then there's kind of a followup on this. Are there things that we can do to reduce the cost of electrification, and maybe some ideas around that. Some of that may be futuristic or things that you can implement today.

Julie Klump: I'll just throw out there that it's interesting that in New England or Massachusetts specifically the incentives for us to doing passive house allow us to do it, because what those incentives are doing is they're covering the premium and construction costs until the market is sort of aligned and we have some cost parity. When we moved to Illinois where we're starting to do some passive house buildings, there's a lot of training that has to happen because immediately people hear passive house and there's like this mystical escalation that pops in just because people don't understand that we're doing the same thing, and then similarly when we go to D.C. and do a building there. So I think it's going to take – what we try to do is a lot of training with subs and GCs and estimators and architects and engineers in order to bring them along on this.

And I think the training helped us go from an 8 percent premium down to 2 percent on our project in Boston. So I think to the extent utilities can incentivize it or there are special grant programs, once we can get the market moving in the right direction the whole notion of building a nice robust enclosure that allows for electric systems is going to happen.

Paul Torcellini: Anybody else want to comment on the solution to cost?

Kent Peterson: Absolutely. I would agree with Julie on this, because when we talk about costs we could talk about first costs, we could talk about lifecycle costs, so we should probably talk about both. But I think Julie was talking primarily about first costs and trying to get those first costs to be more equal to each other. But as we said in some of our presentations, it makes a huge difference on what we do on the building envelope and downsizing and looking at the overall solution than just taking a given load and saying now I'm going to compare this to my condensing gas boiler and compare what my electric heating option is.

If I can downsize that by doing other things, and even as I said before being able to take some of that and connect my domestic hot water requirements if I'm doing all electric with my space heating requirements, now I can actually reduce the first cost substantially. We've figured out ways to reduce the first cost, but we've also figured out on many of these buildings that we can actually get the lifecycle costs from looking over the 20-year operation, that it's going to be cheaper with the electric solutions if we're taking building efficiency into account.

Christos Chrysiliou: I'll put in please. We have to start thinking about in terms of the life expectancy of our existing systems, when they have their service life, and then start transitioning to the new systems. After you test them you make sure that again they are fine. Are you going to find that they're not more costly than what you're paying to replace the system with a gas system?

Paul Torcellini: Alright. Thanks. Now that we've got my unmute working here. That is going to be all the time we have today. Thank you very much. A lot of great discussion related to this. As mentioned, this is part of the 2021 summer series. We have a great line of presentations through August.

Visit the Better Buildings Solution Center to register. And we hope that you will join us on the 15th for our next webinar titled *Becoming ESPC Ready*. Join this webinar to better understand the basics of energy savings performance contracting and how it can help you. And then if you want to watch any of the recordings from any of the series you can go to the on-demand webinar library where all the previously recorded presentations are archived. Thank you so much for joining, and we look forward to seeing you on a future webinar.

Christos Chrysiliou: Thank you, Paul.

[End of Audio]

Additional Speaker Q&A:

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Additional Questions

Audience Member:

With the event in Texas this past winter and extreme weather events becoming more common, isn't electrification putting all your eggs in one basket?

Response:

Keep in mind that most home gas heating and cooking systems in Texas failed when the power went out too- they need electricity to operate. It was also the failure of the gas system to deliver fuel to power plants that caused the outage.

Gas systems require electricity to operate. Thus, a gas + electric system has two independent critical failure conditions. An electric-only system has only one critical failure mode. Thus, electric-only is lower risk than gas + electric.

Audience Member:

What are some short-term ways we can reduce the costs of electrification?

Response:

Reduce energy by applying best practices and energy efficiency measures such as occupant behavior and optimizing system efficiency. Work with the utility company and enroll in demand response, apply for rebates and incentives etc.

Audience Member:

How does the future security and stability of the power grid factor into electrification?

Response

Take a look at Rewiring America's analysis. They show we could significantly reduce the total amount of energy used in the US by electrifying.

Grid costs are driven by peak demand. Thus, technologies which are more efficient during peak should be preferred. Air-source heat pumps are much less efficient at peak than are geothermal systems. Thus, geothermal should be preferred.

Audience Member:

Are there grid capacity restrictions especially in large cities like New York?

Response:

Columbia U researchers looked at this and for the immediate future (while the peak is still summer evening), no. Eventually, the peak may flip to heating season, however.

Audience Member:

Our town has noise concerns about heat pumps. Is there a definitive study on Heat Pump noise ratings? Are there standards for noise on Energy Star rated heat pumps?

Response:

Air-source heat pumps are often noisy. However, geothermal heat pumps are not. So,

if noise is an issue, use geothermal, not air-source.

Audience Member:

How to best address the cost and technical complexity of large campus settings with central power plants?

Response:

Continuous system monitoring, retro-commissioning and staff training.

Audience Member:

Has a study been done to assess building readiness for electrification (e.g. capacity)

Response:

Yes as each new project undergoes an assessment to meet ZNE which also includes a feasibility to electrify our systems.

Audience Member:

How do you fold resilience into the process of electrification and pathways to zero carbon?

Response:

By incorporating microgrid systems at sites with greater vulnerability, subject to fires, floods, high winds etc.

Audience Member:

If my utility is on a path to net zero carbon, why would I need to consider electric to efficient electric conversions to support my zero carbon goals?

Response:

Ex: In New York State, only 18% of energy-related carbon emissions come from electricity generation or use. Heating and transportation each produce about 35% of emissions. In NY and the northeast, electric utilities aren't the problem.
I think the answer is that reducing load on the grid will be important to grid reliability as buildings and vehicles electrify and it will help to keep grid expansion costs lower as well. But if the grid is zero carbon, your building is too

Audience Member:

Is there enough incentive to go electric if EnergyStar uses a higher electricity multiplier to calculate Source EUI than nat gas? Or to say it simply. What's the incentive for building managers to electrify now if the grid is not ready?

Response:

The devices being electrified have long life spans. The choice is to emit a constant (or likely slowly increasing with age) stream of GHGs for ~15 years, or electrify now and see emissions decrease each year as the grid gets cleaner.
Same Q for new construction, where energy codes / LEED require compliance by energy cost. Need those to stop de-incentivizing all-electric.

Audience Member:

How can we enhance building envelopes in a cost-effective manner?

Response:

By performing a life cycle cost analysis on the proposed building envelope/glazing

feature to prove the energy efficiency savings by modeling the building.

Audience Member:

How do you reconcile modeled energy data from real world performance? Are there building commissioning practices in place?

Response:

Yes they are. We are commissioning the systems either through an internal team review or a an independent 3rd party verification.

Audience Member:

We are aware of water to air and air to air heat pumps, but what about air to water heat pumps that could effectively support electrification of current thermally heated buildings?

Response:

Enertech is one of several who do air-to-water https://enertechusa.com/advantage-air-to-water-heat-pump

Questions for Christos at LAUSD:

Audience Member:

It looks like you all just added solar over the top of existing historic use. Does your modeling anticipate an increase in electric demand with the switch? Or a decrease with efficiency? Or that is it is a wash?

Response:

Just to clarify we did not add solar on top of an existing historic building. This action will require several conservancy reviews and approvals and it is not advisable.

Audience Member:

Is the LAUSD also looking at ground source / geothermal heat pumps?

Response:

Yes, as we have a few installations of geothermal heat pumps. Obviously they are easier on new construction or major modernizations due to the site impact and logistics. Our focus remains on other energy efficiency measures.