Automated Voice: The broadcast is now starting. All attendees are in listen-only mode.

Ryan Livingston: Hello and good afternoon, everyone. Welcome to the seventh installment of the Better Buildings Summer Webinar Series. So 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 their buildings. We hope you will join us next week for our final summer webinar, and stay tuned for more information on our 2020 to 2021 webinar series launching this fall. Next slide.

So, my name is Ryan Livingston, and I'll be your moderator for today's webinar. I'm a program and project manager supporting the US Department of Energy, the Federal Energy Management Program, and also an account manager for the Better Buildings Data Center Challenge and Accelerator. And we're going to be talking more about that momentarily.

So first, I want to say thank you for all of you for being on with us today. Thank you so much. We have a wonderful session prepared, and some fantastic speakers that we are going to introduce in just a moment. Next slide, please.

So, today we will be using an exciting platform called Slido. It's interactive and we will be utilizing it specifically for Q and A. So if you're unfamiliar, I would ask you to go to www.Slido.com via your mobile-connected device, Internet-connected device, opening a new window in your browser and going there. The event code for today is going to be #DOE. So the information on the slide here. And I'll give everyone just a moment to navigate to Slido.

Okay. So after enter #DOE on Slido, you will then be brought to the Q and A section. You can answer any question there at any time during the presentation, and we will be answering those questions near the end of the session. It already appears that some folks may be entering questions or acknowledging that they are indeed in Slido. So thank you. You can also utilize the thumbs-up icon for questions and that will shoot them up to the top of the queue as the most popular questions that have been asked.

Please note, Slido is the place for any questions to the panelists. Anyone who wants to enter a question, please use Slido, as opposed as the GoToMeeting platform. Again, all questions should be utilized via Slido.

We'll also be using Slido to conduct polls for this afternoon's session. At the top of the website you'll see another tab right next to Q and A labeled Polls. If you select Polls – please do that now – and we'll get to know the poll tab a little bit better. So next slide, please.

So, our first poll; first of four. The first one is this. It's a scale – one to five – how familiar are you with data centers? One being new to the sector and building type; 3, somewhat familiar; five, very familiar. Okay. And this is a live viewing of the Slido poll here. Looks like we've got a nice bell distribution happening. A lot of folks moderately familiar with data centers and that building type. Maybe a few more seconds. See if some more responses come in. That's great. Looks like a great distribution for our discussion this afternoon. Perfect. Thank you for participating, everyone.

So, to continue with our polls, we're going to move to a second poll in Slido. And that will be so we can get a better idea of what data center you're familiar with, and what your organizations have. So, you can write a response in terms of hyperscale, enterprise, HPC, multi-tenant or co-lo data centers, as they're known sometimes, small data center, I don't know but excited to learn more. Got lots of responses coming in here. This is great. A lot of folks excited. It's perfect. Looks like enterprise, small data centers are well-represented, some HPCs and co-los, as well. Okay. Awesome. It looks like folks are logged onto Slido and grasping the poll feature very well. Thanks, everyone.

So thank you for participating in those first two polls. Don't exit out of Slido just yet. We're going to come back to that and take a few more polls here in a moment. But first, let's go to our agenda for this afternoon. So, next slide, please.

Okay. So before going to our main speakers, I want us to, again, go through a brief intro and highlight what we would be discussing on data centers today. So, after that, we will be going through a framework of making the business case for energy efficiency projects and data centers, at step number two. And then finally, we'll be hearing about a data center accelerator partner who has successfully made the business case for energy efficiency projects in their data centers and has some great results to discuss with us. Finally, we will be closing out with about ten minutes or so at the end of today's session for Q and A. Again, please provide your questions for the participants this afternoon via Slido. Okay. Next slide, please.

All right. So the Data Center Accelerator, Better Buildings. So I have the pleasure of announcing some results. We had 21 partners in the Better Buildings Data Center Accelerator. We participated in a five-year effort to reduce their infrastructure or energy intensity in at least one of their data centers. So, our partners cumulatively on average had a 36 percent improvement in their infrastructure energy intensity, surpassing the accelerator's original goal of 25 percent. So that improvement results equates to an energy improvement and a savings of $3.9 million annually. So big, big improvement there.

I'd like to just take a moment and say congratulations and thank you to all our partners who participated in the Data Center Challenge and Accelerator and thank them for their hard work. Although the accelerator itself has come to the conclusion this time, Better Buildings is still providing support for its partners, including their data centers. And to that end, we'll go to the next slide.

So if you are not currently a Better Buildings Challenge partner, we would absolutely encourage you to sign up today. You can receive consultation calls and technical assistance from our subject matter experts and our partners at the national laboratories. So if you're a federal agency, you can also receive assistance from the Federal Energy Management Program on data center-related needs.

And then lastly, if you have any questions about energy efficiency in your data centers, whether you be a Better Buildings Challenge partner, federal agency, or an organization otherwise, please feel free to reach out to betterbuildingschallenge@ee.doe.gov. And a few resources there at the bottom for you as well, if you'd like to learn more.

Okay. So with that, we'll go to our next poll, where we can learn a little bit more about you all before we turn it over to our first presenter this afternoon. So, next slide, please.

So next slide is a poll. Okay. Poll number three. If you haven't already done so, again, please go to Slido.com, and answer the code for this afternoon, #DOE, so you can participate in our poll here. So, this poll is about drivers and your organization and what those drivers might be for helping or hindering or hindering you to implement energy efficiency in your data centers. So there's kind of a wide range of responses there. Let's see what we come up with.

Okay. This is looking good, looking good. We're coming up to about 100 responses here. I think we had about 125 the last poll. So we'll give folks a few more moments. But it seems the two responses, far and away, are reducing energy costs – reducing operating costs, I should say – as a driver. And saving energy in accordance with organizational values. That's great. That's great to hear. Okay. Increasing reliability and resilience, as well, a popular response. That's always an important facet of data centers as critical facilities. Okay.

So we will talk more about these drivers for energy efficiency projects and data centers in a moment. But first, we want to do one last poll with you all. So again, Slido.com, #DOE, if you've yet to join us in the slide. So last poll here. Again, hearing from you, what are the barriers that have you encountered that have prevented you or your organization from implementing energy efficiency in data centers?

Okay. We have some responses coming in. Opportunity costs of capital. Only have so much money. Okay. Great. Mission critical. Again, critical facilities. Risk-averse nature of data centers. Makes sense. Okay. Okay. That looks like that's actually, that response is overtaking here as the top barrier slightly. Also, I'd point out lack of awareness as a popular response, okay, in giving out the knowledge around usage and costs and opportunities for energy efficiency and or data solution.

Okay. This is great. Excellent. Well, thank you again, everyone, for participating in this afternoon's poll. This has been really helpful and helped us to identify who all is on the call and how we can best speak to and tailor our message for you this afternoon. We'll be definitely discussing some of these barriers, and opportunities, and approaches to overcome them.

Okay. Next slide, please. Great. So, here are our presenters for this afternoon. First, we will be hearing from Hannah Stratton with Lawrence Berkeley National Lab presenting on a new resource that helps organizations build a business case for energy efficiency in their data centers.

Next, we will be hearing from Jason Morris and Mike Strevell, Los Alamos National Laboratory, who have successfully implemented an energy efficiency project on their campus that has yielded some great results. Lastly, I want to mention Steve Greenberg here. He's our subject matter expert from the Lawrence Berkeley National Laboratory, as well. And he'll be joining our Q and A session to

answer and to help answer your questions. So, whether they be easy or difficult questions, we'd be happy to take a run at them for you. So please feel free to do that and send them in via Slido.com. Again, event code #DOE. Okay. Next slide, please.

So once more, we are going to first be hearing from Hannah. She is a senior research associate for energy efficiency at the standards group at Lawrence Berkeley. She primarily conducts research and provides analytical support for home appliance standards, and has worked on projects related to water conservation and commercial building efficiency. Prior to joining LBNL, she helped to organize net impacts annual sustainability reports. So Hannah, with that I will turn the presentation over to you. Thank you.

Hannah Stratton: Thanks, Ryan. Hi, everyone. My name is Hannah. And as Ryan mentioned, I am with Lawrence Berkeley Lab, lab energy technologies area. And I'm a program manager and one of my projects is the center of expertise for energy efficiency in data centers. So thank you all for joining us today.

I'm going to be talking about the drivers, barriers, and stakeholders that are involved in data center energy efficiency projects; and doing, taking a look at this sort of through the lens of a new resource that we created here at the center of expertise. And that resource is building the business case for energy efficiency in your data centers.

So knowing that we have people with diverse backgrounds on the call, I decided to briefly go over what makes data center energy efficiency unique from other energy efficiency projects. We all know that data centers are mission critical organizations. They help organizations carry out really distinct, their distinct missions. And so because they are so mission critical, there can be a culture of risk adversity for changes, including energy efficiency upgrades.

And also because of this mission critical nature, maintaining continuous up-time is usually the highest priority for data center stuff, followed by providing capacity for future growth. I think we all can think about ways in which our world is increasingly digitized, and really data centers are the backbone of that. So these two priorities are probably going to remain numbers one and two. But we also hope that energy efficiency maybe rank really high up there with those.

And there's a good reason why organizations should look to energy efficiency. Data centers are extremely energy intensive, ten to 100

times more energy intensive than your typical commercial office space. And so, for that reason, there is a really great business case for energy efficiency. They really can deliver substantial savings for an organization.

So as we kind of move through this webinar, I just want to acknowledge that the individual context data center type organizational structure, internal processes that are in place, maybe previous successes or failures with energy efficiency are all going to, of course, play a role in shaping how a project champion may shepherd a project through an organization. But, really, there's a unique set of dynamics at play that makes the barriers, drivers, and stakeholders for energy efficiency projects different from energy efficiency projects generally. Next slide, please.

So with this in mind, we felt that it would be useful to create a resource that would help project champions kind of cut through the organizational inertia and advance their energy efficiency projects and data centers. So this resource helps project champions identify drivers that can effectively demonstrate the benefit of energy efficiency in their data center, help them engage and win over key stakeholders, and also anticipate and hopefully overcome some barriers that might be encountered during the project planning and implementation process. Next slide, please.

So, just to give you a little overview of what this resource is, it's a new interactive web-based resource where we looked at the different drivers that were on the poll earlier, as well as the barriers, and kind of link them to the core stakeholders that we typically see engaged in an energy efficiency project. So, currently, we have a web PDF version available on our site. But very shortly, within the next month, we're going to have this really fun interactive web resource where you can sort of break all these things down as you wish. And next slide, please.

So I just want to just kind of go through each of these different sections of this resource. So, first when we think about drivers, we're just trying to think about why do people pursue energy efficiency in their data centers? What motivating factors are there? And I know that, I think Ryan showed earlier, was reducing operating costs and resiliency ranked pretty highly. And there could be other incentives, too, unique to your organization.

But it's really important that project champion think – not only about what the drivers are from where they stand in their organization, but who the key stakeholders are that they need to

engage and what their drivers are. And include that in their pitch for a project, and even consider those things, also, when selecting energy conservation measures and sort of packaging and marketing that project.

So just to sort of go through briefly the ones that we have covered in this resource is reducing operating costs. Of course, pretty obvious one. Freeing up capacity, whether it be floor space, cooling and power capacity, or computing capacity, increasing data center reliability and resiliency, which is one that everybody ranked pretty highly; aging infrastructure in need of an upgrade. So if your equipment is near the end of its useful life or at the end of its useful life, that can be a great impetus to go ahead and replace and upgrade with more energy efficiency IT equipment. Utility and other financial incentives. Of course, reducing that up-front capital cost.

I think opportunity cost of capital was one of our top barriers. So when there's an opportunity to sort of cost share or reduce the cost of a project, that can also be a great opportunity and something that a project champion can sort of use as leverage for pursuing a project. And aside from incentives, also looking to alternative financing opportunities like energy savings performance contracts. And then another one that I think was ranked pretty highly in the polls here was saving energy in accordance with organizational values. It's probably cliché at this point to say sustainability is a buzz word, because that's been the case for the last 15 years or so. But, organizations are looking to demonstrate their commitments to sustainability, to consumers, to their own employees, and so that's another driver.

And then lastly, complying with codes and standards. Federal agencies have to comply with the data center optimization initiative, for example. So, increasingly organizations are looking to efficiency for compliance. Next slide, please.

So this is just a brief kind of look at kind of how this resource is structured. So on the web-based version you can take a look at the different drivers. It will map and show you which stakeholders are most likely to be maybe driven or really interested in that driver. And then just provides kind of a brief summary. Next slide, please.

And so just to give another – so barriers that we looked at pretty similarly. And by barriers, they really just mean impediments to a project. And these barriers can be institutional, technical, or financial. And we have lifted here the ones that we think are most

likely to come up for a project. But, oftentimes these barriers are, of course, driven by valid concerns that may be expressed by a certain stakeholder for reasons that are pretty understandable. I know we touched on earlier that there is some risk aversion given the mission-critical nature of data centers. And that was actually, I think, maybe the top barrier in the poll. So oftentimes these are things that may kind of – a stakeholder may be worried that it sort of goes against their main job objective.

Just to give an example, if an IT manager may be hesitant to remove comatose servers because perhaps there is a project or some business service that runs on those servers very occasionally that they're not completely aware of. Probably an IT manager has never been fired for failing to remove a comatose server. But perhaps they have been fired for removing what they thought was a comatose server, and then they're being – it not working properly. So I think we have to understand that a lot of these barriers people are coming at with real and valid concerns.

So the intention of this barriers section is to give project champions a chance to anticipate and identify these different barriers so that they can maybe design a project that have ECMs that won't be such an issue for these barriers, or pitch the project in a way that helps sort of mitigate some of these concerns. It also can mean thinking about these things in the early stages of a project, engaging stakeholders early so that they have a little bit more of a say and that you can kind of create some more shared understanding of the benefits of the project.

And then we also provide resources for each of these barriers. So basically a project champion can go in and say, "You know, I'm really dealing with issues. There's a lack of awareness of current energy usage costs and opportunities," for example. And then we've coalesced a whole bunch of case studies, tools, reports, and other resources, trainings, things like that; that can help a project champion sort of overcome that barrier. Next slide, please.

So, again, just wanted to give a brief overview of what this looks like. So each barrier describes what the problem is, an opportunity to overcome the problem to stakeholders that are probably going to be most likely to voice this barrier or concern. And then resources for the project champion. So this one here is that no one person is tasked with energy efficiency. Which isn't always the case. But, sometimes in an organization, there is no person who has this in their job description.

So, it basically depends on a project champion of taking this upon themselves, setting aside time and effort that, obviously, could or maybe it should be going to something else. Maybe not should, but that is. They have to find the time in their schedule to facilitate this project. Yeah. So, then we give an example of different ways that people can work around that. In this case, maybe it would be going to management and making sure that it is formally in someone's job description and recognized as an effort that is worth putting in there. Because maybe it won't get done, otherwise. Or creating a cross-functional improvement team to sort of distribute responsibilities and also create a forum for collaboration where people can talk about what the options are. Next slide, please.

So, now we're sort of getting to the crux of the resource, which is the stakeholders. It's often up to the project champion to proactively engage stakeholders in an organization and identify the relevant drivers and frame project benefits in a way that resonates with these stakeholders. And this also could mean identifying and anticipating tension points or conflicts of interest that may come up, and framing them in a way that helps mitigate these barriers.

So stakeholders inherently have different responsibilities. I think we touched on that earlier. Everyone has their own job to do in an organization. And the responsibilities, their concerns, their experiences, and their familiarity or lack thereof with energy efficiency, and energy efficiency specifically in data centers will all affect how they may perceive a proposed project.

So it's really important that stakeholders use terminology that – sorry, that project champions use terminology that – resonates with the target stakeholder, and also realize that not all stakeholders have equal weight for a project. There are people who find is really critical, and there's others who maybe you need to keep them in the loop, or it would be great to have their support, but they're not going to make or break your project. Next slide, please.

So, relevant stakeholders will, of course, vary within each organization. But, we sort of took a look at who we thought was most likely to be involved in a data center project. So the business case resources speaks these six stakeholders. And for each of these, you can understand what drivers resonate with these stakeholders, what barriers might I need to overcome to get their buy-in, and what resources are there to help get their buy-in on a project?

And I just want to kind of point out that we've spoke about drivers and barriers kind of generally. But this resource also sort of tailors

drivers and barriers for each of these stakeholders. So, we have a lot of information on the drivers and barriers specifically for each of these stakeholders.

And then also I just wanted to point out that really any of these people can be a project champion. I think it's most common that we see a facility manager be a project champion. But it could be any one of these people or somebody else in an organization. Next slide, please.

So, I just wanted to give an example stakeholder spotlight. So we're looking here at the facility manager just to give you guys a little bit more information on the type of content that we have and the resources. So, for each of these stakeholders, we take a look at their characteristics. And by characteristics, we really mean what are their objectives and responsibilities relative to data centers. So, looking at the facility manager, they're probably going to be the most likely project champion responsible for maintaining infrastructure, powering cooling needs.

They also work to assure data center up-time and recoverability. And very importantly, they have to accommodate capacity needs coming from an IT manager or a CIO. They're also the most likely to pay or at least see a data center's energy bill, or that their resistor bay. I think about 80 percent or maybe two-thirds of – at least over two-thirds – of organizations, the facility manager is the one who pays the bill.

So just kind of considering this context that they have, what are the drivers for them for energy efficiency? Well, of course reducing operating costs. If they're the ones paying the bill, then they're probably going to be pretty motivated by that driver. Freeing up capacity. You know, freeing up capacity can allow them more space, more floor space, power and cooling capacity, and also allows them to fulfill one of their main job functions, which is being able to accommodate an organization's growth and meet the needs of their IT department.

Additionally, they're often tasked with complying with codes and standards. So that's another important driver for a facility manager, most likely. And then lastly, depending on where the project funds are coming from, if they're coming from a facility fund, then utility and other financial incentives, as well as alternative financing opportunities like ESPCs could be a really important driver for the facility manager.

And then similarly, looking at the barriers that they have. Because they are maybe the most likely project champion, they might be the ones who have to work to try to align stakeholder interests and cut through that organizational inertia and really develop a pitch and a business case for each of these stakeholders. And then similarly, if nobody is tasked with energy efficiency, but they are kind of the ones that take it on, project is more likely to fall through the cracks. So that's an important barrier that they'll have to overcome, which is finding the resources to devote to the project.

And then lastly, lack of awareness of energy usage, costs, and opportunities. You know, a facility manager is probably paying the energy bill, and maybe seeing it, and some of them may be well-informed on what the opportunities really are with energy efficiency in data centers. But, others may not. So, they'll have to take it upon themselves to maybe take a training, or something like that. And even if they are familiar with the opportunities, they're probably going to be trying to engage a lot of people, especially at the management level that simply are not very well-informed. So they have to kind of expect to do a certain level of information exchange in education. Next slide, please.

So, just wanted to give you a view of what it looks like, the resource looks like. So for each stakeholder we have information on their roles and responsibilities relative to data centers, drivers, barriers, and then resources targeted towards that stakeholder. So, we have some good resources on why the CFO really should be engaged with an IT department. Sometimes there are things that the project champion themselves can use to kind of win over that stakeholder. But sometimes there are tools or documents that are really geared towards that specific stakeholder that kind of shows them why they should care about data center energy efficiency. Next slide, please.

So, some key takeaways is that data center energy efficiency projects can require a really concerted and coordinated effort. Of course, this is going to change – people are going to have different experiences in their organization based on a whole host of variables. But sometimes it takes a lot. It can take establishment of a cross-functional improvement team, or like writing this into someone's job description to make sure that it really gets done.

So project champions should look at really who in their organization they need to engage, and try to think about how the project that they're proposing kind of advances certain drivers and anticipate what barriers they may encounter. And they also should

take the initiative to share information and educate others, and definitely should not assume familiarity with a topic, especially as they're moving up to the C-suite or management level. Those people are concerned with a lot of other things. And not to say that they shouldn't care, but you're going to have to clearly articulate to them why they care, and speak to them on their terms.

Also, early engagement of the stakeholders and establishment of a cross-functional team can really help facilitate mutual understanding, and achieve buy-in, and provide the forum and also distribution of responsibilities. And developing and presenting the project in a way that leverages key stakeholder interests and addresses or mitigates their concern is important. You can't expect to make maybe the same pitch to the IT manager as you do the CFO or the CEO.

And then also just wanted to point out that measuring project outcomes can pave the way for future projects. It's important to maybe document your process, and also measure before you implement your project. Of course, you can actually track your improvements so that hopefully one is a success that can help kind of grease the wheels to maybe the next project that you undertake.

And so I was only sort of able to cover our resource here at a high level. But we've aggregated a lot of good information for everyone in our business case resource, and we hope that it can help project champions on their path towards data center energy efficiency. And again, that's available for download on our website, and we have our interactive resource coming soon. Thank you.

Ryan Livingston: Okay. All right. Thank you, Hannah. That was excellent information, I think a very valuable resource for the folks with us this afternoon. So, as a quick reminder, please go to Slido.com and enter any questions you might have there, again, using the event code #DOE, and we will get to as many of those as possible during the Q and A session at the end of today's presentation. So thanks again, Hannah.

Moving forward, we're going to transition to Jason and Mike at Los Alamos National Laboratory. So real quickly about those guys. Jason currently works as the information technology program manager for Los Alamos National Laboratory as member of the network infrastructure and engineering division and team. He accomplishes strategic management of many laboratory information technology systems to include the data center. So his primary background is from the United States Air Force, where he

spent over 20 years working with airborne networks, radar systems, information systems, and virtual warfare simulation. Very cool.

We'll also hear from Mike, as well, who is a project manager in the high-performance computing, the HPC at Los Alamos National Laboratory. He's been managing the advanced technology projects there for decades. His recent projects have included designs for a highly efficient supercomputer data center, as well as the consolidation of several old data centers and closets. Quickly, Mike has a BS in electrical engineering from the United States Air Force Academy, and a master's in industrial engineering and management from North Dakota State University, and then a master's and PhD in electrical engineering and high-performance computing from the University of Texas at Austin. So, Jason and Mike, over to you guys.

Jason Lee Morris: All right. Great. Thanks a lot, Ryan. Appreciate you inviting us in, having the great introduction there. We really appreciate that. Again, my name is Jason Morris. If I'm looking back and forth here, it's because I'm sharing two screens and I'm trying to kind of juggle what I'm looking at with my slides. So apologies in advance if I'm not making direct eye contact with the camera.

So, as Ryan mentioned, my background is with the US Air Force, kind of at a high level. I've got some experience with data centers in multiple different environments out there; from desert to higher altitudes and things of that nature. And kind of the one thing that I really took away from that experience is how much the outside environment can affect the inside efficiency of the data center. And we'll kind of talk about that here today.

And again, to reiterate what Ryan said, I've been with Los Alamos National Laboratory since 2017, with network and infrastructure engineering, kind of doing the business side of management for some of our business type of data centers. And Mike works the high-performance side, and I'll tun it over to Mike fore a few seconds to talk about his background.

Mike Strevell: That's right. Well, we're excited to present some energy efficiency conceptual designs that we developed to provide our senior management some alternatives between making upgrades to existing facilities versus building a new data center. Jason.

Jason Lee Morris: All right. Great. Thanks, Mike. Next slide. Okay. Here's what we're going to talk about during our time here today. We're going

to look at data center strategic management, PUE monitoring, some infrastructure upgrades, and environmental advantages. And just to kind of expound on those real quick, the data center strategic management. When I came to the lab in 2017, this was my first task was to kind of get our data center centralized in a management functional format that we could use to effectively make things more energy efficiency. And I've got a kind of a funny story with that that I'll talk about during that portion of the briefing.

Next, we're going to talk about PUE monitoring. For most folks who know, PUE is the big metric for managing data center efficiency and effectiveness, and it's definitely something we want to keep an eye on. So we'll speak to that a little bit. We'll also discuss some infrastructure upgrades that we're looking at doing and that we have done in some of our data centers. Some of our buildings are quite high-tech, and some of our buildings are quite low-tech and older. And we'll kind of touch on the mix and match that we deal with here at Los Alamos, in particular.

And then finally, we'll discuss environmental advantages. Again, hitting on what I just talked about, which is the outside environment very much affects the inside efficiency of a data center, no matter where you're at. So if you're in a desert, your data center may not be very efficient or effective, whereas up here in Los Alamos, we have a nice semi-arid environment that gets us kind of some help with efficiency. Next slide.

Okay. So talking about strategic management. So, to kind of kick things off with a story, when I arrived here in 2017, again, I was told, "Jason, we need to centralize the management of our data centers. We have a lot of data centers here in Los Alamos. We have closets that are made for storage that are being used to hold servers. We have trailers. We have high-tech buildings. We have lots of stuff out here. So try to get this stuff under control."

So what I immediately did was I took the list that we did have, I worked with a lot of different stakeholders out there, primarily with folks who run networks and servers, and we started just kind of tracing out where are our data centers located at, where are all these little rooms? If someone has a scientific project, they want a nice little closet that they can put their server in so they don't have to deal with a lot of the overhead that comes with trying to get data center space.

Well, things have kind of changed over the years. And I'll speak to that a little bit more. But we now have the infrastructure on demand capability that helps us pull in a lot of those little desperate servers and data centers out there. But the most interesting thing I've found was there was one data center on my list that nobody could find. Turns out this data center was in a trailer, and had been for a number of years, and the trailer had since been dispositioned, was no longer with the lab, and we had been reporting on for, I think, two or three years as an active data center, when in fact it was no longer in existence. So always good to take a look at the books and dust off, kind of check things out, make sure things haven't gotten too neglected. At least once a year, annually, kind of take a look at your inventory. Make sure it's as accurate as possible.

Another thing we look at was the – and, of course, with the list of data centers, there's our procurements. FITARA requirements, for folks who aren't familiar with FITARA, it's the federal IT acquisition regulation. Basically, wanting us to make all of our procurements more efficient. A specific aspect of FITARA is that we can't expand our data centers without a darn good reason to expand them. And if we do an expansion, it needs to be well thought-out and made as energy efficient as possible.

For instance, we've found out some folks the other day were going to take a closet attached to a data center, put some heating and cooling in there, throw in some servers, and expand out their data center. And we had to take a second to look at that and make sure we weren't going to violate FITARA as a result. It turns out we were not. So, everybody was happy at the end of the day. But, in line with that, we have a system setup here at the lab where we can do a data center expansion notification through our permits and projects regulation system, where if anybody's going to do anything to a data center, it kicks off a flag, and we get the review process and make sure that we're meeting the intent of FITARA.

We also do consolidation planning. So like I said, we traced out our infrastructure, found a lot of closets and other areas out there. We started building a plan to consolidate these closets into infrastructure on demand. And we found out there are scientific stakeholders who are the customers building these small, little rooms; really enjoy infrastructure on demand. What basically is, it's a portion of our data center that we've carved out and we've loaded it up with storage and networking capability – or I should say processing capability.

What this means is that someone who needs a data center now doesn't have to go out and buy servers, see if they're cyber secure, get them put on the network, and then load them into our data center. Everything in the infrastructure is already there. They just have to come in and request the processing time and the storage space. And our stakeholders who are scientists really love that because now they don't have to spend money on an admin, or somebody like that to come in and actually manage their hardware. So, it's really been a very effective tool for consolidation planning, giving a venue for folks to close down their little data centers, shut those, and bring it into a formally-managed cyber secure facility.

And then we have our new data center planning, where we plan our our new data centers and hopefully make these as energy efficient as possible. And at this point, I'm going to turn it over to Mike to discuss our new data center planning. Mike?

Mike Strevell: As we were evaluating our requirements for new data centers, specifically for power and cooling – we can go to the next slide – we wanted to give our management a choice between upgrading existing data centers or building a new data center. So we developed a fairly detailed conceptual design of a new, highly-efficient data center. And you can see a picture of that on the right, a sketch. The gray building that looks kind of shiny is the actual data center that houses the supercomputer. The tan building in the front provides some small drop-in office space and mechanical cooling and pumps.

Up in the upper left-hand corner, we see an array of adiabatic dried coolers. That's about the size of a football field. And we'll go into more detail on that. In between the data center and the adiabatic dried coolers, we can see some what are fan walls for outside air cooling. And then on the right side of the picture, you can see some outside transformers that reduce the power from 13,000 volts down to the 600 volts that we'll be using on future supercomputers.

So this data center has both a low power usage effectiveness – low number, high effectiveness – and it's very efficient at water usage efficiency. It uses very little water. The supercomputer that goes into this building uses warm water cooling, and it uses hybrid-drive coolers to reduce the temperature to reject the heat to the outside. It does not have any chillers. So everything's done with the hybrid drive coolers. There is most of the heat is rejected with the hybrid drive coolers and the warm water cooling.

But there's still a small amount of heat that comes out of the cabinets when you're looking at a 40-megawatt data center that adds up. So you still have to have some air flow through your data center. And we use outside air cooling for that. The rectangular shape provides a longer wall to provide enough air going into the facility, as well as shortening the distance to the outside transformers on the right side, there.

One of the benefits – so, frequently, we'll hear about the advantages of locating the transformers close to the computer racks; perhaps underneath, on the other side of a wall in the building. But there's also benefits to locating the transformers outside. Again, transformers have waste heat associated with them. So if we can use free air cooling for that waste heat from the transformers, then we don't have to pay to reject that heat to the outside.

And the other thing is this whole building is immediately adjacent to a high-power substation. And that reduces our costs, as well. And we'll talk a little more about that. Next slide.

So let's look in a little more detail at the concept of outside air cooling. So starting in the lower left-hand corner of that figure, the green arrow represents outside air that's coming into the data center. It's pumped into the – flooded into the – data center. And then we have hot aisle containment, represented by the red arrows that takes the heat out to the hot air exhaust as you follow that red arrow to the left. And that's exhausted outside.

Now, in really cold temperatures, we can warm the air going into the data center in the wintertime, for example, by mixing some of the hot air exhaust in with the outside air. Or, if it's really hot, for a small percentage of our days, we can use warm water from the idiomatic drive coolers to slightly cool the air coming into the data center. It turns out we can use the outside air economizer for 85 percent of the annual hours. Now, one of the things to recognize with outside air cooling is that it's difficult to retrofit that into an existing building due to the high air flows that are required. All right. Next slide.

Let's talk a little bit about the environment. So the important thing is to be sustainable for your environment, we're all located in different environments. Some people are in hot, humid temperatures. Other people are in deserts. We happen to be in the mountains. We have a ski area just outside of town. And you can see in this aerial photo of Los Alamos National Laboratory some

mountains in the background. And the ski area is up there. So it's certainly cool in the wintertime, and it's also relatively cool in the summer. We have slightly warm afternoons, but it cools down again in the evenings. So it's mainly those summer afternoons that we have to devise clever strategies for cooling our warm water.

It's also very low humidity here. So while evaporative cooling towers work very well, water is also a valuable resource here in the southwest where we're located in New Mexico. So we try to be sensitive to the community and conserve those water resources, even though the lab itself does have ample water rights. So, it turns out that we can use the dry coolers and outside air for 85 percent of the hours in the year without needing to use water at all. Next slide.

Jason also mentioned consolidation. So one of the other projects that we worked on recently is developing this conceptual design for converting a 1960s-era data center to offices. This building was originally built to house the IBM stretch computer in the early '60s. And it's about 32,000 square feet total. And what we were finding is that there was not enough power or cooling in this building for today's high performance computing systems. But there was lots of space.

So we consolidated in this design all the computing into that upper right-hand corner. And that became the remaining space for computing. And then we designed office space for the other three-quarters of the building, the 24,000 square feet. The office space doesn't require very much power cooling. But we have a shortage of office space, and this is right in the center of our main area at the lab. So it's high-value real estate that can be used more effectively for offices now. Next slide. Jason.

Jason Lee Morris: All right. Thanks, Mike. So to talk real quick about DOE monitoring with regards so some of our stakeholders. So, as Mike mentioned some of our buildings are older, 1960s-type buildings. As a result some their infrastructure was constructed with low accessibility piping. HVAC systems were built in a way that weren't very accessible. So right now we're trying to find ways of sensoring some of these systems, kind of retrofitting them, if you will, using sonic sensors to look at some water flow, and things of that nature.

All of this is to go for PUE monitoring. We want to monitor how much energy is coming in versus how much energy is getting used and put back out into the environment there, as well. I list on here a

couple of obstacles to implementation. These aren't obstacles in the negative light. They're obstacles in the sense that they're challenges. So like I said, we have some dated infrastructure here.

But the other thing, also, is cyber security. We want to make sure that any time we're doing sensoring for putting any kind of PUE monitoring at a rack level data, any kind of data feeds or networking that we're doing is definitely passing the cyber security test. Those do offer a threat vector that we want to be aware of whenever we're doing any kind of PUE monitoring. So just something to be aware of kind of as you press ahead into the world of PUE monitoring out there. And to discuss PUE monitoring in detail, I'll turn it back over to Mike.

Mike Strevell: So, the next slide is an example of the PUE dashboard that we are developing right now for one of our big supercomputer centers. This is called a Sankey diagram, and the different streams represent the flow of energy. So we're bringing 15 megawatts in from the grid. The top three streams represent our IT load, about 12 megawatts. And then the green stream and the first red stream represent the non-IT load. So the IT load is our trinity, our big supercomputer, our commodity technology system one, and also network and storage. And then chillers, and pumps and fans, lights, and plugs are the non-IT load. So in this example, our PUE works out to about 1.23, which is not bad for an older data center, but it doesn't keep up with the most modern data centers without chillers. Jason? Next slide.

Jason Lee Morris: All right. Thanks, Mike. Yeah. Next slide, there. Got it. Infrastructure upgrades. So, as I mentioned earlier, we're doing some electrical updates in order to make things a little more energy efficient. We're also looking at more energy efficient IT gear, such as servers, and increasing our processing density out there, as well. We already discussed infrastructure on demand earlier. That does help us keep things very efficient in that we're using very uniform equipment, and the people trained to use it, we only have to train one person, versus training one person on two or three different systems, which takes time and effort, and uses up cycles in the work day. So trying to work on not only energy efficiency, but also worker and workload efficiency, as well.

But, like I said, the infrastructure on demand has been a pretty huge winner for us as far as our business owners and our scientific customers, as well as our platform owners out there, as well, folks who are maintaining a flat form of software and need to provide a service out to a customer. Next slide.

Mike Strevell: The next slide is a picture of Adiabatic dry coolers, which can be used to maximize water savings. They, in the picture on the left, you can see what an actual adiabatic dry cooler looks like. On the right is a diagram showing how it works. The big advantage of this is it uses very little water in our climate – about one-eighth of the water required for an evaporative cooling tower. The disadvantage is it's about twice as expensive as an evaporative cooling tower and takes up about six times more square footage. So, as I mentioned before, for a 40-megawatt data center, it takes a football field full of adiabatic dry coolers to accomplish the water savings. Next slide.

So some of the key energy efficiency takeaways for you are, first of all, take advantage of your own weather condition to achieve compressor-less cooling. Anticipate your future cooling system transitions. I saw there was a question about liquid cooling. A lot of data centers have started out with air cooling, then moved to chilled water cooling, and will probably be moving to warm water and hot water cooling in the future. So think about what systems you're going to need in your future data centers as you just design them.

As I mentioned, it's valuable if you can bring your computers to the power, rather than having to run megawatts worth of power to the computers, you can save a lot of capital costs and reduce the power losses from those cables. The adiabatic dry coolers significantly reduce water consumption and it's important to integrate your data center with your long-term site plan. That concludes the energy efficiency concepts. Next slide.

Feel free to call Jason or I, or send us an e-mail if you have any questions. And I've also put in a link to the energy efficient HBC working group, which is free for anyone to join.

Jason Lee Morris: All right. Thanks, everybody.

Ryan Livingston: Okay. Yeah. Thank you, Jason. Thank you, Mike. I know we're quickly approaching the top of the hour here, but wanted to maybe get in a question or two before quickly reviewing some of the recap slides and additional resources for you all. So thanks for hanging in there with us here at the end.

I want to also introduce Steve Greenberg. He's on the call with us. He's from Lawrence Berkeley, as well, and a senior energy management engineer from the lab. He's researched applied energy

efficiency for buildings and industrial systems for a variety of clients over the past 37 years. So his data center experience and engineering with data centers spans over 20 years. And includes data centers ranging from server closets to supercomputers in excess of 15 megawatts, as they're looking at for Los Alamos. So, we're glad to have Steve with us.

So thank you, everyone, and all our presenters for speaking today. I'll quickly, I guess, ask one question of Steve here to that point that I just made in his bio. What, Steve, is typically considered a data center? Does it include smaller servers in IT rooms? Is it a facility that don't have dedicated servers, as well? What's the range?

Steve Greenberg: Yeah. So, absolutely it includes all those. A big issue with small data centers is they're embedded in other buildings, and that poses challenges of sorting out how much energy is going to what part of the facility. And there's an ASHRAE definition of data centers, which is ten kilowatts of infrastructure technology load, of server load. And 20 watts per square foot of floor area. So you could have a single rack of servers that meets that definition of data center. So the short answer is yes and yes.

Ryan Livingston: Perfect. Thank you. I wanted to also just route a quick question to Hannah, as well. Someone was curious about what was the tool that you were discussing? What is that called and where can they find it?

Hannah Stratton: Yeah. So the tool is called Building the Business Case for Energy Efficiency in Data Centers, and you can find that at the Center of Expertise for Energy in Data Centers at datacenters.lbl.gov. And it's actually going to be on the resources slide, as well, so you can find it there from this slide deck that will be posted at a later date I believe.

Ryan Livingston: Perfect. Thank you, Hannah. Thank you, Hannah and Steve. Thanks, everyone for staying on again. I know we have an abridged Q and A version today. But we really appreciate it. I'll quickly, with that great segue way, go to some additional resources slides.

So we have some additional resources here put together by today's presenters, specifically the COE at LBL for energy efficiency and data centers. There's some great links and information there for you to follow. I also want to give a shout out, as Mike mentioned, the Energy Efficiency HPC working group. Again, that's open to

anyone to join. You don't have to be a national lab or a federal entity to do so. So please feel free to check out their resources, as well. Next slide.

We have the E-Learning Center, also, with Better Buildings. It's an on-demand library of webinars and other programs that Better Buildings has put on. It has resources, and a range of relevant solutions for the Better Buildings partners there. So please go check that out, including the Solution Center. Next slide.

Last thing I want to mention, our summer webinar series. Again, this is the seventh of eight, so the penultimate webinar for us here today. All previous webinars are recorded and are available on demand, as this one will be, as well. So please go and check those out.

And this is the *[Laughs]* last webinar in the series, Succeeding with Submetering. Again, it's free to register, and we hope that you do so.

Lastly, this our Better Buildings Solution Center here. A little bit of a quick tutorial on how it works. But again, all Better Buildings partners put together solutions that are then put onto the Solution Center for the benefit of everyone hoping to learn about energy efficiency and ways to maximize their facilities.

Lastly, I'll go to the close. If anyone has any questions, feel free to reach out in any way at the e-mails there, or at the links provided on the left. We'd be more than happy to get to some of the questions that we were unfortunately unable to get to today. Thank you for joining, and thanks again to all of our fantastic panelists for the information and resources they share with us this afternoon. We hope to see you again at another Better Buildings Summer Webinar series and feel free to be interacting with us on things like Twitter in the future. Thanks, everyone. Have a great afternoon.

Additional Speaker Q&A:

General Questions:

Audience member: For warmer, more humid climates, what are some suggestions for energy efficiency?

Response: With temperature and dewpoint working against you, raise the temperature setpoint, as in hot water cooling. The ability to do this depends on the computer system.

Audience member: Maybe I heard it wrong but did I hear servers are going towards using 600V?

Response: Yes, voltage to racks in some new supercomputers is increasing from 480V to 600V.

Questions for Jason Lee Morris:

Audience member: Will you please disclose your design server inlet conditions (both temperature and humidity)? Also, it appears that this is a non-mission critical application (no UPS, no generator). Is that correct?

Jason Lee Morris: For the Trinity Cray XC40, the warm water supply temperature is about 70F, and somewhat cooler in the winter. You are correct that the energy efficient conceptual design did not have chillers, UPS, or generators. The simulations that run on the supercomputer in that building can run for many days. For these applications on power intensive supercomputers (tens of megawatts), the applications are checkpointed at regular intervals. So if there is a power failure, the application resumes from the last checkpoint. These are mission critical applications, with UPS etc. providing communications and other networking services across the laboratory, some life critical communications are supported as well.

Audience member: With more and more users migrating to colocation, how is it that a better metric (other than PUE) hasn't been developed, since PUE typically doesn't meet the needs to measure true efficiency for colos as they scale and have unsold space?

Jason Lee Morris: That's a great question, we only use PUE as a "baseline metric" in order to watch for changes in efficiency (good or bad). We do look at processing density and storage density as a means of a metric of increased efficiency.
Both National Lab supercomputer centers and colos will have better PUE and true efficiency when they are full. Datacenters are less efficient when run partially full. This is because as a

datacenter fills up, the IT load goes up faster than the Non-IT load. When full, the Non-IT load (fans, pumps, lights, plugs) is spread across a larger IT Load.

Audience member: Are data centers good candidates for SEM (Strategic Energy Management)?

Jason Lee Morris: Strategic energy management allows for continuous energy performance improvement by providing the processes and systems needed to incorporate energy considerations and energy management into daily operations. The National Laboratory Supercomputer centers are continuously looking for ways to increase efficiency. Existing datacenters will be more limited in the ways they can improve efficiency as opposed to a new datacenter.

Questions for Mike Strevell:

Audience member: How do we think about purifying the air of airborne microbial droplets, particles, coronavirus, etc. - while we are also managing energy and temperature?

Mike Strevell: Yes, outside air cooling does raise the issue of bringing in contaminants in the outside air. One example would be nearby forest fires. Most fan walls will have a "filter wall" to filter out some of the particles. The air handling units are capable of closing the outside air inlet and recirculating air. But that may require reducing the load during warm weather. Some new warm water cooled supercomputers are claiming the ability to reject 99% of heat via the warm water, which reduces the amount of heat that needs to be rejected via air.

Audience member: Couldn't see the denominator on the PUE calc on the screen - what was it?

Mike Strevell: $$PUE = \frac{\text{IT Load + Non-IT Load}}{\text{IT Load}}$$

PUE = (IT Load + Non-IT Load)/(IT Load)

Questions for Hannah Stratton:

Audience member: Do you have resources on select data center types? (ie, on site data center vs off site)

Hannah Stratton: We have some resources specific to data center markets (e.g. Small Data centers and Federal data centers), which you can find here and here. However, the Better Buildings Solutions center will have some resource sheets by data center type (e.g. colo, enterprise, small, etc.). I don't believe that these are available yet, but they will be available on the Toolkits page

(https://betterbuildingssolutioncenter.energy.gov/better-buildings-toolkits) when the Data Center Accelerator Toolkit is finalized , or posted in the "All Resources" section of the Center of Expertise site at https://datacenters.lbl.gov/resources.

Audience member: One of the noted issues was that no one in the facility was focused on energy efficiency for the data center. Without someone dedicated how does a "champion" begin discussions?

Hannah Stratton: Some good first steps could be to identify what energy efficiency opportunities exist in your data center. The Center of Expertise's data center profiling tool can serve as a helpful starting point for exploring opportunities, and results can serve as a starting point to kick off discussions with relevant stakeholders. The Energy Assessment Process Manual (particularly Phase 1) has information on steps that should be taken when initiating an assessment process in your data center. Your organization may already have an energy management plan, policy, or individuals who are tasked with these responsibilities. If so, ask around to find out how your project can fit into the existing framework and processes. If no formal energy management plan or policy exists, I would look to the ISO 50001 Ready Navigator tool for more information on how to initiate an energy management plan in your organization. While it is not specific to data centers, the resources and information could be applied to any energy project (even if you do not decide to move forward with a formal plan). The Ready Navigator has helpful information on establishing a cross-functional improvement team. This could be an early step to help kick start discussions in your organization, though depending on your relationship with certain stakeholders - particularly the Facility Manager and IT Manager, it might make sense to have more informal discussions first.

Questions for Steve Greenberg:

Audience member: What are the typical energy conservation measures in systems, air management, HVAC etc? Is there any estimates of the potential energy savings for each conservation measure?

Steve Greenberg: Eliminating chillers is by far the largest energy savings. Switching to warm water cooling eliminates the chillers and a lot of fan energy. Heat can be moved much more efficiently with water pumps rather than fans. Please reference *Figure 1* below.

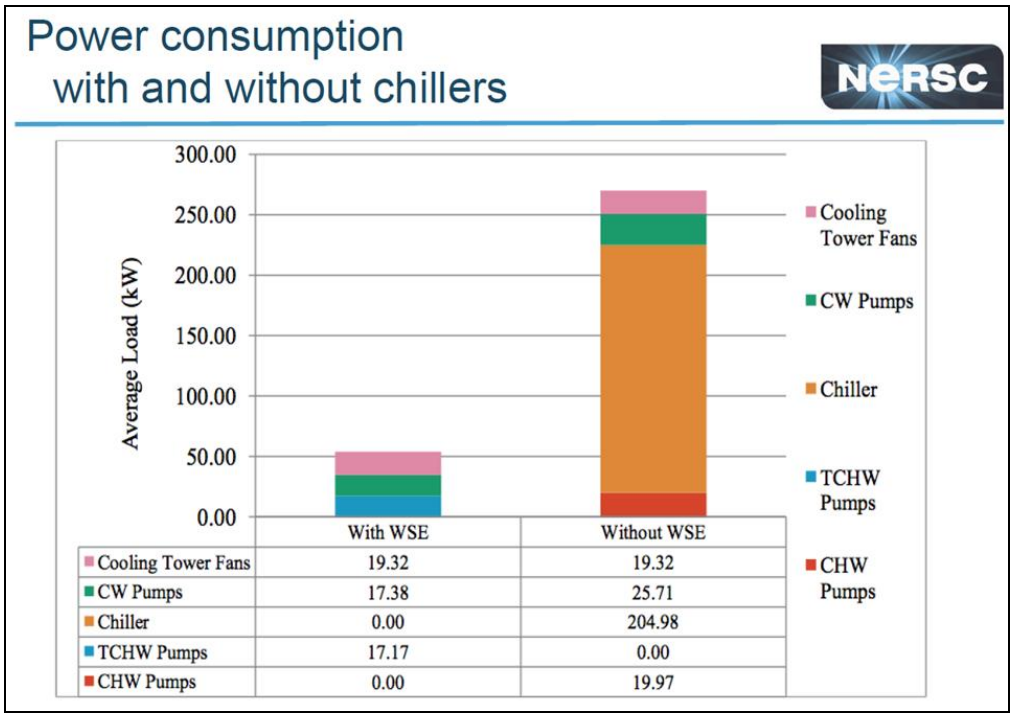
Power consumption
with and without chillers
NERSC
Average Load (kW)
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Cooling Tower Fans
CW Pumps
Chiller
TCHW Pumps
CHW Pumps
With WSE
Without WSE
Cooling Tower Fans 19.32 19.32
CW Pumps 17.38 25.71
Chiller 0.00 204.98
TCHW Pumps 17.17 0.00
CHW Pumps 0.00 19.97

Figure 1