Hannah Debelius: Hello and thanks for joining the webinar today. We are going to give folks just another moment as they're logging in, so thanks so much for joining us and we'll start soon.

[Break in conversation from 0:00:22 to 0:01:04]

Hannah Debelius: Welcome to the 2022-23 Better Building webinar series which is dedicated to bringing you the latest actionable insights from the leading industry experts. This annual series is a chance to explore the topics, technologies, and trends that affect your organization as well as efforts to accelerate decarbonization, energy efficiency, and adoption. Thanks so much for joining us today.

Today's webinar is called "Sustainability and Decarbonization Inside Warehouses and Distribution Centers," but before we dive into that and our wonderful panelists, I do have a couple of housekeeping items for us to go over. The first is that this webinar will be recorded and also archived on our Better Building Solution Center, so you'll be able to see this recording or share it with colleagues after today. Additionally, attendees are all in listen-only mode, which means you're not able to unmute yourself or utilize your microphone, however, if you are experiencing any technical issues or audio issues, you can use the Q&A function which should be at the bottom of your Zoom screen in order to chat with our tech support and we'll hopefully get that solved for you.

Excellent. Well, my name's Hannah Debelius, and I'm with the US Department of Energy, and I have the wonderful privilege of working on our Better Buildings program across the commercial sector and also with the Better Climate Challenge, and I'll be your moderator for today.

So today you're in the right place if you are here to also focus on warehouse and distribution centers. Before I talk about the agenda, I also just want to talk a little bit about the agenda, I also just want to talk a little bit about the context of why we wanted to utilize this theme for our webinar. We know that warehouses and distribution centers are a rapidly growing space type, certainly in response to e-commerce and how that's evolved over the last couple of years and also the demand for shorter delivery times has really spread this space across the entire United States, and the world for that matter. There's also an incredible amount of potential with these spaces with large roof space, the potential for location hubs across the US, and also the integration with fleets. But we also know this comes with a lot of challenges from a variety of different leasing structures in these spaces to how to decarbonize all of these

existing buildings, and also working with a variety of climates across a portfolio of warehouse and distribution centers. I know in speaking with our Better Buildings partners many of them are just entering into this space and have been adding warehouses and distribution centers into their portfolio and really coming to DOE and coming to their peers to talk about this space.

So I am very glad that we have two wonderful panelists today who are going to help to get to the bottom of this and really help us explore this topic. So first we'll have Rois Langner, who's going to give us a little bit of an overview of this space type and talk about some of those potentials and challenges. And then Erica Weeks is a practitioner, and she's going to be diving in deeper on some real examples and some takeaways that you all can utilize in your own portfolios. And of course we'll follow it up with Q&A so you'll have plenty of time to ask questions of our panelists, and we will save at least, I think, 15 minutes for that at the end, so I hope that you all engage in our Q&A throughout the whole time.

Speaking of engaging with us throughout the whole time, we are going to be utilizing a platform called Slido for both Q&A and also for a couple of polls. So right now, if you could please open up another browser or on your mobile device go to slido.com and then enter the event code DOE. So right now again, I'm going to say it again to give you the actual opportunity to open up your cell phone or another browser, go to slido.com, and enter the event code DOE. We've also dropped that into the chat if you'd like to just utilize that link directly.

So we are going to start out with some polls, but as a reminder, you can also use Slido to put in questions throughout the entire time today. Additionally, when those questions are up, you can click the little thumbs up on the corner of a question if it's a question you like, and that will upload the question so it comes up at the top of our screen and we can prioritize that. So with that, we're going to engage you on a couple of polls because we want to learn a little more about you. So I see some people are already jumping in there, which is great. The first question is just what climate zone is your organization located in? And if you've just joined us and are confused about where you enter this, again, you're going to go to slido.com with the event code DOE, and that's listed on the left side of the screen there.

All right, so a lot of people in Climate Zone 4 and 5. Four happens to be where I am, so glad you're on the line today. And this is going to help us and our panelists also just speak a little bit more

about some of the examples you may be able to utilize that are specific to this climate zone. And again, as I mentioned, we also know that it's a challenge when you have a portfolio that is across climate zones and you're working with existing buildings and new buildings.

All right, excellent. Thank you all so much. We are going to move on to our next poll here. This is going to be a word cloud poll, and we are wondering what is the biggest barrier to decarbonization your warehouses and distribution centers are facing? So what is the biggest barrier here? This is going to help DOE as we continue to explore in this space and then also our panelists as we can talk about some of the solutions and options. All right, funding and cost. I'm not surprised to see these as top challenges for sure. We see this across the decarbonization efforts in commercial buildings definitely a thing. But also leases, heating, that makes sense with the space type we're working for. Gas heat to different fuel types for heating. And a lot of leases, triple net leases, reg – or not regular. What is a regular lease? Other types of leases, not being able to control usage or probably I would imagine work with tenants, hosting a tenant relationship. All right, so a lot of leasing. I will then take this time to also say our green lease leaders recognition program actually has just opened our applications today so we can – we'll include something on that.

All right, this is excellent. I think a lot of these things we're going to be able to tackle today, but I hope to also be able to address some of these in the questions. So if we don't get to your topic today, I hope you added the questions. And with that, we have got one more poll for you all if we could go ahead and launch that. Our final poll is also word cloud, and it's related to building design or occupant experience. What technologies or solutions are you most interested in exploring? This is a little it more of a detailed question. We're looking for the specific technology or solution you're interested in. All right, sub-metering, heat pumps and geothermal. That certainly makes sense since we heard about your barriers in heating and the use of natural gas on that last question. Solar's certainly a big opportunity and also challenge with these building spaces, usually with so much roof space. Cold climate heat pumps of course. I'm seeing controls, air filtration, 3-D digital twins. I like the definitely getting into the tech side on that. Fleet electrification. I'm glad someone brought that up because I think fleet is a big opportunity and challenge here that we'll talk a little bit about today. Occupancy centers, battery storage. All right, so I'm seeing a lot on renewables, a lot on decarbonization of heating, and I think a lot on the potential around using these for both

renewables and probably for an electrified fleet.

All right, excellent. Well, I'm glad to see you all are out there and engaged, and I think we're going to get to a lot of these topics today, so with that we can go ahead and close our polls, and I'm going to thank you. So as I mentioned today, we are very fortunate to be joined by Rois Langner from the National Renewable Energy Laboratory and also Erica Weeks from Hastings Architecture.

So we are going to start out hearing from Rois. Rois Langner is a senior research engineer in the Communities and Urban Sciences Research Group at NREL. Her work at NREL has focused on methods to achieve ultra-high efficiency targets cost effectively in commercial buildings for optimized building design, zero energy performance, carbon reduction, and to enable building load flexibility for demand management in grid coordination. So her bio even touches on a lot of those topics we just heard from you all, so, Rois, if you want to join us on camera and you can go ahead and take it away.

Rois Langner: Thank you so much, Hannah, and thanks for having me here today. As Hannah was saying in my bio, my research at NREL since 2010 has really focused on commercial buildings and how do we really more optimally integrate building end use systems and control them so that we can reach ultra-high performance in our buildings. Historically we've focused more on other commercial buildings. We've done a little bit in the warehouse and distribution center space, but in this past year and a half we've been taking more of a deep dive into the landscape of where warehouses and distribution centers are now and where they're projected to go since we have been seeing a lot of growth in this space, as Hannah noted in the beginning of this call.

And I think my talk today will touch on a few of these topics that you have identified in the polling questions. we are in the process, you know, a lot of what you brought up, we're in the process of realizing, yes, we need to understand a lot of this in more depth and understand the integration piece, so this is a part of the work that we're continuing to do as we move forward in this next year, next couple years probably. So just to take a step back and have everybody on the same page, as a definition, I want to explain that we are defining warehouses and distribution centers as buildings that store goods, manufacture products, merchandise raw material. We are considering refrigerated warehouses, nonrefrigerated warehouse, also conditioned warehouses and nonconditioned warehouses, so there's kind of a wide variety there. We are not

including public rental storage units in this definition, but we are including, of course, distribution and shipping centers in this.

So to illustrate this just a little bit more and to communicate the wide breadth and variety of warehouse buildings in this space, there is this range of is the building conditioned, is it not conditioned, does it have refrigeration or not, and what level of automation is there. I mean, I'm sure people are aware of these videos of looking into the complex level of automation that's in an Amazon distribution center. There's a wide variety here and a lot of different businesses and business models out there that show this range and how complex the building is. And clearly these levels of automation, these levels of conditioning is certainly going to impact the energy consumption of the building and how much renewable energy can help offset some of that building load.

So just a few fun facts about the warehouse sector that we found in our landscaping study that we've done from 2022 EIA Annual Energy Outlook, warehouses represent 15.5 percent of our US commercial building stock. This is about 14.6 billion square feet, and EIA projects that this sector is going to grow by 6 billion square feet in the next 30 years. So we've already seen a significant increase to how many warehouses and distribution center buildings are being built, and we're going to see even more as we move forward in time. Globally they do contribute some significant amounts to our CO_2 emissions, our greenhouse gas emissions, and the bottom one here, just thinking about the highest energy demands of these buildings are going to be those that are fully automated or refrigerated warehouses can consume an enormous amount of energy, in particular if they're located in a very hot climate zone. So on average, they consume about 85.3 KBT per square foot per year. This number, let's just compare it to an energy efficient office building or a net-zero office building that would be in the 20 KBT per square foot per year range.

So sustainability is more of an urgent focus for logistics companies for our supply chain, and really without these commitments to improving supply chain sustainability, it's believed that these companies would struggle in the near future to compete with other companies. And what it brings to the table is cost savings not just on the operation side, not just on the building side or the energy bill side, but also in thinking about that supply chain and materials that are being used, cutting down on waste from shipping, et cetera. It boosts company reputation and certainly builds industry leadership.

So going even beyond that, what do zero-energy and zero-carbon warehouse buildings bring to the table? And there is this transition to electrification, there's a huge push for electrified transportation. So I think there's opportunities here to bring the supply chain in the embodied carbon of the products that are being manufactured and shipped. There's also the ability or the value of bringing carbon-free shipping to companies as well, and that's through electrified transportation. Lowered operational costs, this can come from energy-efficient building designs and maximizing the potential for onsite renewables and integrating battery storage. There's opportunities when you can reduce your energy consumption and be flexible in when your building consumes energy to participate in wholesale energy markets and utility programs. There's even opportunities to provide grid services such as frequency regulation with these buildings for grid stability and resiliency, and that's just very small fluctuations in the building's energy to help balance out the grid frequency.

As we're seeing the transportation side come into lite with electrification, there's the potential to pull energy from the batteries of these fleet vehicles or even heavy-duty vehicles to help reduce peak load of a building during peak demand times, so that's another opportunity here that we see coming into more light in the future. Of course, all this goes into resiliency efforts too. We can really lower the building's energy design, bring in those flexible building operation, bring in the renewables, bring in storage. This not only helps us reduce our demand but can enable more energy independence so if we have a grid outage for some reason or there's some interruption, can the building float for longer time periods because we've integrated these renewable energy and storage technologies into the building? And in order to do that, you need the efficiency side to come into play as well.

For buildings with less internal loads like a warehouse that doesn't have any automation or maybe is unconditioned, there's a larger potential here that they can become more of an energy hub for surrounding community building. So if they covered the roof with PV, could they help offset some energy needs of surrounding communities? And then the last point on this resiliency side that I wanted to make is the fuel costs have been growing, they've been very expensive, so thinking about how batteries can provide more stability in our transportation as well and how we can charge those batteries more with renewable energy. And lastly, the last point here is just thinking about additional owner benefits as we look toward electrification, decarbonization. There's going to be a lot of upgrades to electrical infrastructure, which I know is a need in

many buildings across the country.

So this is a little bit more focused on the transportation side here, but it's kind of pulling from everything I've just been saying, but if we're really going to realize the full potential value for zero carbon, we do need to think about these key components, and that's the efficiency of the building, efficiency of the operation, efficiency logistics, can we maximize PV generation, can we integrate controls and smart management of not just the loads inside the building but any additional storage that you might have and the integration of EV charging management. And then lastly, let's participate in some of these energy markets to help it be more economical to the building.

So through our landscape work, we have been reaching out to some warehouse and distribution center sector stakeholders, and I've been really pleased to hear about how much they have succeeded in a lot of these areas already, so a number of the stakeholders we've talked to have corporate sustainability plans and plans to reduce emissions. We've seen commitments to 100 percent renewable energy, commitments to reducing their emissions pretty significantly, and even in thinking through waste, how they are reducing their waste through recycling and sorting practices. A number of building technology upgrades, and this includes, as you see here, solar, looking at their building envelope, making sure it's more insulated, using large, more industrial interior fans to help reduce mechanical pooling in these buildings, transitioning to electric heating and cooling equipment. And I will say a low-hanging fruit that I still think can be picked in a lot of buildings across the US is LED lighting. So we've been talking about LED lighting for a long time, but I think there's still a lot of buildings that don't have LED lighting, and it does show significant energy savings.

On the transportation side, of course we're looking at how do we electrify our vehicles, zero-emission delivery trucks or even heavy-duty vehicles? And there are some companies that are putting in place systems to monitor their transportation and help reduce the emissions associated with that. On shipping of food, they – typically companies use what they call reefers, which are refrigerated containers. A lot of companies are starting to switch to plug-in – high-efficiency plug-in refrigerated containers. One company that we talked to said that these were 30 percent more efficient for their shipping of food, frozen food. And even thinking about vehicles in the building itself like electrified forklifts, and then also thinking about the employees and enabling greater access

to public transportation to and from the warehouse facility. So that brings more of an equity side improving employee satisfaction and comfort in getting to and from their employment.

There's been a number of decarbonization programs, and I'd like to highlight a few that we've seen out there. There's just a select few here. So Amazon has their climate pledge to become carbon neutral by 2040. They will do this through regular reporting of their greenhouse gas emissions and reducing emissions through business changes, energy efficiency, renewable energy, reductions in materials, and some additional strategies to really reduce their emissions. Any remaining emissions they plan to neutralize with credible carbon offsets on that. Another example is USPS. So in 2021, USPS announced that they are pursuing a multi-billion-dollar ten-year effort to replace the Postal Service's delivery vehicle fleet, which is one of the largest in the US. So USPS has more than 230,000 vehicles in every class, and the aim is to include fuel-efficient engines and electric battery power trains. And then the last one is this corporate electric vehicle alliance, which has some of the largest corporations in the US as members. So this is, as you see here, Amazon, IKEA, AT&T, DHL as all a part of this alliance, and their aim is to support greater commercial EV adoption. One example of this is Amazon has purported to order 100,000 electric delivery vans.

And on the building side, we're starting to see some zero-energy building warehouse examples, which is great. I have three outlined here just for reference, and there's links at the bottom of this slide to the case studies on this. One is the spice company McCormick & Company. They have a zero-energy warehouse in Maryland. There's another zero-energy warehouse in North Carolina for the National Institute of Environmental Health Science. And then the outdoor recreation company REI has a zero-energy building in Goodyear, Arizona. Erica Weeks, who will be talking right after me, she'll also be talking about REI and a different zero-energy warehouse building, so that'll be a great case study for everyone to hear.

And through our engagement with our stakeholders, we've really honed in on what are additional needs that this group has, and it was great to see all of your interest, everyone on the call today, in this space as well. What we have pulled away initially is that there is still need for design guidance. I'd say the most important one is integration of systems and controls, which I'll talk a little bit more. Retrofit strategies, what can we do with existing buildings? How do we strategically integrate renewable storage and emergency

generation? There's definitely a need for more case studies, which I think this call is going to fulfill with Erica's talk coming up here. And better dissemination of this information so that we can really have greater engagement with the warehouse distribution center sector.

So current work that NREL is engaged with is we are actively looking to find a warehouse partner right now. We're really interested in analyzing building loads and operation and transportation data to help figure out more of this effective integration of all of these components, the building loads, the renewable energy generation, the energy storage, flexibility, and the vehicle charging. This is just really interesting and complicated space, and some of these outcomes, what we're projecting are going to be, can we maximize the rooftop for PV production? What is the value? Can we really quantify the energy efficiency and the impact of the internal loads of the building? How can these buildings participate in these utility programs and wholesale energy markets? How do we better integrate battery and thermal storage? How do we integrate electric vehicles and the high demand that they will require for charging their batteries? What's the best approach for that? And this last bullet point, is there any additional opportunity to share some resources? I mean, these are large buildings, they have a lot of rooftop space, so can we cover them with PV, and if there's excess, can that go to other community needs?

We're also thinking through some initial design guidance and what that looks like. So I put these slides up in a way just to show you what we're thinking but also as some action items that you might want to take to the table if you're on a design team or you're a building owner or you're even a tenant just to understand where the opportunities really lie. So energy efficiency, of course, if we can improve our building envelope, we can increase the comfort for even nonconditioned buildings but conditioned buildings, and refrigeration will help us lower any additional loads for heating and cooling that are required in the building. And then thinking through if we have a good envelope we can reduce the size of our HVAC system equipment and potentially some refrigeration too if it's really well insulated but integrating the high-efficiency HVAC and refrigeration equipment. Again, LED lighting, I think this – there's a lot of buildings that still don't have LED lights, and I think this should be – it's the low-hanging fruit that could be easily picked. Procuring high-efficiency plug-in devices with controls when possible, so can we have timing of when batteries are being charged in-house or things can just turn off when they're not being

used. And then there's a lot in the automated processes that can be evaluated for efficiency, and I know a lot of logistics companies have probably teams and teams of people who are looking into how do we really increase the efficiency of our automated processes, but that is a really key component.

So on top of all of these systems and how do you really create the most energy-efficient systems in the building, then comes the controls. And really there's two parts of this. One is the integration, so how do we really integrate all of these different components of the building, not just the building loads, but the onsite renewable energy generation, storage, EV charge management, and then how do we continually manage the building for building peak demand and just make sure that we're operating in a more optimal way. this does require sub-meters. I know that was a topic that came up. And it does require diligent facility managers to keep an eye on what's happening. There's a lot of software systems out there that make this easier for facility managers to control and monitor and optimize that process as well.

So lastly, I think Erica will touch on a lot more of these additional actions that you can take. I've mentioned the first two multiple times, but just thinking through what types of utility programs are available for the building, are there wholesale energy markets to participate in? Is there any potential to share some of the renewable energy resources with adjacent communities or buildings? And let's also think about the employees as far as occupant comfort and improving access to public transportation to and from the warehouse. These are just a few examples. I know there's a lot more on this front, but just to spark some ideas from the audience.

And that is it. I think my thank you slide is up, so I really appreciate you hearing my talk, and I look forward to your questions at the end.

Hannah Debelius: Great. Thanks so much, Rois. I think you were able to hit on a lot of those topics we heard in the polls, and I know Erica's going to be able to illustrate some of those ideas and themes that you talked about, so I thank you so much. I will say we already have some questions in our Slido for Q&A, which is great, however you can continue to add to those because we'll take questions at the end. We just dropped that link again in the chat, but if you go to slido.com and enter the event code DOE, that's where you can continue to put in questions or you can also hit the thumbs up to upvote someone else's question. We'll be able to prioritize that at

the end.

So with that, I welcome Erica. Erica Weeks is a licensed architect who has dedicated her career to sustainability. Erica manages the Sustainability Services Sector at Hastings Architecture where she works with owners, architects, engineers, and contractors across the country to facilitate building rating systems. Erica has a keen ability to create synergies between disciplines and execute cross-discipline calculations to forward ideas. All right, we're looking forward to hearing more from you, Erica, so you can go ahead and take it away.

Erica Weeks: Great. Thank you, Hannah, and thank you for inviting us to participate today. It was great to hear from Rois also, all the good things coming out of NREL and looking forward to seeing all those documents. But as Hannah mentioned, we're part of an architecture firm here in Nashville, Tennessee, and I manage our sustainability services sector, and I fortunately get to work all across the country on all kinds of projects, and especially within the past three or five years, many a warehouse distribution center.

So the sustainability efforts for warehouse and distribution centers are unique. You know, not thinking about them as typical office buildings or typical spaces that maybe each of us interacts with on a daily basis. So different ways to think about sustainability, different scales to think about, and the fact that a lot of the projects that we work on are new construction and they're occurring in maybe outlying areas, new greenfield sites. So over the last three or five years, we've seen several themes emerge in this industrial warehouse distribution sector, and we see the industry shift into talking just from operational side issues into holistic carbon-saving issues as well as human factors related to happy workers.

So when we start working on a project, it's key for us to first identify what the project goals are, and some of those goals may come from corporate or portfolio targets. You know, looking at regional opportunities, everybody across the country may have different water stresses, energy stresses, ability to have onsite PV versus other energy systems like geothermal. So we first want to look at these as metric-based goals and those that can be modeled or measured. So looking at what a baseline versus a performance metric would be to help set these targets for how we go into the design process with our design and engineering teams. So these issues based on energy cost, water costs, and the availability of materials as well as how we're potentially even disposing of construction waste materials all has to be customized so that we

can as a team align on these targets so that we can define sort of the process to get to those goals at the end of the project.

And of course we're here today talking a lot about decarbonization, but my teams will tell you that I really like going over some of these definitions just as a level set and alignment. And we spend quite a bit of time reviewing these definitions, and I have more to share with you a couple slides down the deck. But I'm assuming that everybody has kind of seen the general definition of decarbonization, meaning we're trying to reduce the amount of carbon that we are expending into the atmosphere. And in the bill environment cited by Architecture 2030, nearly 50 percent of our annual global CO_2 emissions comes from building operations, building construction materials, and other construction type industry. So when we see this as half of the pie if you will, it's how are we making these impactful decisions and how are we moving forward in these projects so that we can help reduce these wedges?

Again, talk a lot about baselines and benchmarking and how to set these targets. So operational energy savings, of course people talk about that when they talk about their return on investment. We might make different choices or make a choice based on something we're purchasing today for a building that's new construction, and what is it going to save us in the 10, 15, 50 years that we're going to work and operate that building. When we use these baseline and benchmarks also we have a lot of industry standards. So when we're looking at energy particularly, we're going to look at ASHRAE 90.1 baselines, particularly for things like LEED projects, and understand that baseline basic code versus how we're creating a better building performance wise, and doing that analysis early on to see what we can capture from a cost savings standpoint. Now with the newer conversations regarding the operational greenhouse emissions reductions, we layer in some different calculations using our eGrid tables for the US. So the different regions of the country have different grid mixes, and how much is our grid, the actual energy that's coming to our building, being sourced to our building is affecting also what the greenhouse gas emissions we are post when we get into the building.

A lot of talk about electrification, no fossil fuels, none for heating or reheating or generating hot water. So in areas of the country also that have mandates or are changing these regulations regarding the use of fossil fuels, how do we look at these big spaces, hundreds and hundreds of thousands to millions of square feet from a cooling and heating aspect that might be different than what we've typically done with the typical rooftop units that have a gas-fired

reheat? And then extending into water savings, beyond just low flow and low flush fixtures, looking at there's a lot of energy used also to pump and get water to these particular project sites. So by saving water onsite, because again, utilizing roof area, how are we actually helping our carbon metrics so that we can talk about saving energy from water being pumped instead of just using that water we have onsite. And then construction materials, of course, part of the conversation about what we make and manufacture to build those particular buildings, and I'll go through a detailed example on that.

Again, definitions lever here, trying to wrap our heads around these zero-carbon, net-zero carbon, and carbon neutral definitions also that are out in the industry, which ASHRAE is seeking to have an aligned construction industry definition hopefully here in the near future. There are some working groups on that, but right now we sort of rely on some different rating system definitions. So again, working with customers and clients and figuring out when they say we want to decarbonize, we want to be zero carbon, we want to be carbon neutral, how do we look at that from an actual project application standpoint? So LEED has a particular zero carbon certification which is based on operational energy data. So those folks in the existing building realm, we're able to monitor how much energy is delivered to your project site as well as look at your occupant transportation via surveys or other means of transit that's available to you. And that calculation looks particularly at source-based energy. So we're looking all the way back to that point of generation versus international living future zero carbon certification looks at operational energy as well as embodied energy. But it looks at it at the site level. It also looks at it from a no source of combustion, so no fossil fuels, and then how much are we utilizing renewable energy once we get onsite. So again, when folks are coming to us and talking about this decarbonization, there's a lot to unpack here just understanding what are actual targets and goals, which helps us then, again, move into the actual design and collaboration with our engineering teams on the project.

So we do use a lot of different tools and a lot of different methods, and the first thing we typically do is use this tool called Zero Tool, which is part of also if you're in the A&E industry, Architecture 2030. It uses a CBECS 2003 baseline, which is a little bit different than EnergyStar using the newer baselines. But it gives us a rough way to take an order of magnitude snapshot at the location of a building and the type of building it is and gross square footage to sort of start setting your initial EUI, or your energy use intensity, and KBT per square foot per year. And this gives us at least a way

looking historically at projects that we've built and modeled, looking to new projects to say where are we aligned and what types of systems might we have used in the project. it doesn't give us the answers. it gives us this target to say how do we actually get to one of these different goals.

So once we get into a little bit more granular and we start to determine the size, shape, structure of our building and how it looks, the next step is to start the energy modeling process as early as possible when we get onboard a project so we can identify the key drivers for those energy end uses: lighting, HVAC, miscellaneous equipment, a lot of what Rois talked about from a process standpoint. And process is typically a big wedge of the energy pie depending on how that warehouse is running from a production and/or distribution side. So this analysis gets into simple box model first where we start to, just at a high level, identify what these energy end uses are, using a lot of baselines from ASHRAE potentially, and then seeing where we can cut or optimize and still meet things like foot candle requirements or comfort requirements. This also helps us start to determine whether or not onsite PV or other renewables would be viable, especially on projects that have large roof areas or large site areas.

Once we start doing this targeted process and we determine how things like lighting are really going to impact the building, we can also start talking about other variables. You know, Rois mentioned the use of LED lighting in existing buildings. Today we're talking a lot about skylighting and sidelighting in different areas of these warehouse distribution centers from a standpoint of knowing that there's shift work and shift work might happen overnight and the lights will have to be on, but can we optimize potentially where some skylighting or sidelighting would be so that we're not even having some of the light son in the building during those daylight hours and also giving people the human factor benefit of daylighting within these large building spaces, which could come – potentially be quite cavernous depending on the type of building it is. From this analysis, then we also start to look at different viable HVAC systems. Part of that electrification conversation, would natural gas be our go-to, our typical if we were building the same box every time? What are the different options? And then also having the conversation about the sweet spot for PV installation. Are we looking to cover the full roof and get a full offset via an annual zero-energy project? Or are we looking for it to optimize the peak? So we're looking at the shift and/or the time of day or when the most energy is being used and trying to balance via not utilizing potentially the whole roof for PV but utilizing a portion of

it to save on first cost as well as then looking at the viability of batter backup to look at other times of day that might use some of that excess versus giving it back to the grid.

So this takes quite a bit of team effort also between your MEP teams and your process engineering teams, and this is just one sort of snipped example of an analysis we did on a recent project where we were looking to have sort of the typical, the good baseline, and then what would be better if we went to an all-electric system, which then gets into our reheat becoming more of a hydronic water-based system, so again that looks at a different cost and installation time and potentially maintenance than folks might be used to, and then what's sort of the best system, which in this case, we were assessing whether geothermal would make sense on this particular project. And this particular analysis with the MEP engineers and the electrical engineers giving some pros and cons to what those requirements for equipment and requirements would be for field work as well as this was a LEED project, so looking at how we're comparing ourselves to that ASHRAE 90.1 2010 baseline from a straight up energy cost savings standpoint and then layering on what – how do we optimize some PV so that we are balancing out that energy use at peak as well as in earning some additional energy cost savings that would contribute to our overall LEED scorecard.

So then we can tie this back to that carbon balance and thinking through, again, our grid energy, back to that source, because some folks understand there are places in the US where your grid is much cleaner and greener than in other places in the US. So when we look also at what electricity is being purchased, how that electricity is being made, the same amount of electricity in two different locations of the country with two different grid mixes might have two different total carbon emissions. And what this does for us is it looks like also if we're looking at offsite renewable energy purchase, are we purchasing some offsite energy in our same eGrid region or are we looking at purchasing it in a different region. So how are we creating that balance?

So this warehouse distribution center is in Ohio, and it is completing construction here in about a month, and the analysis for this project was to look at full and complete over 1 million square feet of solar being put on the rooftop of the project building. And when we did our predictive energy cost savings analysis, just the building itself based on the HVAC systems and lighting and all the energy end using components, we were building a pretty decent building with a 12.7 predicted energy cost savings. But with the

6.5 megawatts of onsite solar, that achieves a generation that gets us up to a 97, 98 percent predicted energy cost savings for the entire project building. So really looking at the investment that the owner of this project was making to apply onsite solar for their offsetting of their full distribution process in this building and also pursuing LEED as a third-party rating system component of that.

So when we talk about also on the embodied carbon side, this gets into sort of the new wave of now we are creating these low-energy using buildings, these net-zero buildings, if you will, from an operational standpoint, what are we doing about the materials that we are selecting to make these buildings out of, which are typically a limited palette of materials. We have pretty typical wall, concrete probably for slabs, roof joists, seal, and roofing materials, and then maybe some different smaller office pods or office materials on an interior, sort of a typical distribution center. So when we make these big buildings, these million-square-foot buildings, we're buying a lot of metal, we're buying a lot of concrete, and how do we look at making those particular choices from an embodied impact standpoint and what options are available to us? Well, we have a couple great tools. You could do a whole building embodied carbon analysis. There's several software tools on the market that do that. But an easier way to look at this is also from carbon leaderships forms materials baselines, and they published a report of these baselines which give you sort of a good, better, best based on some pretty general materials that are in almost every project type where you then can look at environmental product declarations for your particular projects, for your mix designs for your concrete, for where you're getting your steel joists, steel decking, roof materials from, and do a comparison of are you picking a material that's sort of front of the mill industry baseline, or are we picking something that has less impact?

We create a baseline calculation based on the amount of the material that we are anticipating, and then we look at the actual. So what are we specifying or what are we getting or do we know where our steel is coming from, and is it coming from an EAF mill? So when we look at this calculation, then we're trying to look at what materials are sort of the industry baseline versus what are we getting that is better, that we can specify, that we can ensure is coming from a more friendly resourced with less global warming emissions. And we put together this calculation to come up with a total project embodied carbon reduction. And this is the methodology that's used in the LEED pilot credit for the procurement of low-carbon construction materials, so it's pretty straightforward and pretty easy when you look at the amount of

materials that you have, and you can even do it in sort of a highlighted way where you might take a bay or a portion of your building to do a quick analysis so that you can understand where your specifications may have to adjust or change. We're fortunate in middle Tennessee to have some great concrete-related resources that our mix designs can employ to have a lower amount of cement so that we can get a lower amount of embodied carbon within our concrete here from a variety of different sources.

One of the important things that I mentioned at the top is we're getting a lot more focus on water and rainwater collection for toilet flushing also. Again, these distribution centers are sometimes put in out-of-the-way places and a lot of infrastructure comes to the site, and we're really looking at what energy are we causing by – or expending by extending that infrastructure? So more and more often, also with customers and clients that have higher sustainability goals and we're building in these greenfield off-the-beaten-path locations, there's not a lot of LEED points that we can get for site and location, so how do we then make up that balance? And we're finding very strong appetites for folks to do rainwater collection for toilet flushing for their main locker room or main office areas where three shifts a day of 100 or so people are coming in, they're flushing toilets, and we're getting a great return on investment with these systems because we aren't having to purchase that water coming to the site or using what we can collect because we have such a large roof area. There is a cost to the cisterns and the pumping and a little bit of annual maintenance that has to go on, but otherwise a really great system for folks to consider and to consider that layer of that pump energy of how you're getting that water to site. You're using it right onsite, so you're already doing a big reduction by not having to just continually pump that water.

Sort of the last little bit here when we talk about human factors and the quality of spaces and places, we're actually spending quite a bit of time talking with folks about daylight and views, how they're creating different pockets of spaces within their distribution areas where people can see out so they can see the passage of time, so they can see clouds, sky, things like that. Also leading to the discussion of if skylights are available and we can coordinate those around PV and other rooftop equipment, how is that saving us some energy by having the daylight sensors or daylight harvesting because we're getting some skylight daylight through to the distribution center floor? But I feel like design is a great topic where we're looking at how we're infusing visual cues to nature to give people moments of respite. The universal design features of

being able to utilize everything in the project building regardless of your abilities. And then indoor air quality especially hot topic post last couple of years for how we're looking at air filtration, where air is coming from, even from the outdoor air distribution, where it's recirculating, and how are we metering or monitoring air quality throughout different areas of facilities. And then tying back again into those materials, ingredient transparency is a strong component. What are we applying as material finishes? Are those finishes some third-party certifications so that we know that the ingredient transparency has gone through a vetting of things called red list materials? And how are we applying that for, again, the benefit of occupants that might be interacting with those materials on a daily basis?

This leads us into sort of a secondary discussion on sustainability goals, putting the metrics and the measurements aside. And I know this is probably small on your screens across, but when we start to get into these employee engagement statements, these human factor statements, we start to again layer on those qualitative aspects and then how would we measure those. Something like indoor air quality, for example, how would we select that as a qualitative measure? It doesn't necessarily support our carbon neutral goal because we might be thinking about different components of indoor air quality like filtration or other things, but how do you then have communication to why you particularly do something in your facility versus another facility?

I'll just end on we're working on – as Rois mentioned, we're working on a fourth distribution center for REI here in Tennessee, and this will be an all-electric facility. It will also be a zero-waste facility and to operations, and it will us renewable energy to optimize its peak load when it's completed. It's under construction and will open in the fall here. A lot of emphasis on the amount of skylights and daylights and sidelights, so again the employee occupant engagement as well as the selection of materials for the project for a lower embodied carbon footprint.

Hannah Debelius: Thank you so much, Erica. That was a lot of wonderful information. I know we've got some questions about the recording or the slides here, and all of the slides and the recording and transcript as well as an additional resources PDF will be e-mailed to all of you who've registered and also available in our Better Buildings Solution Center. So with that, we have time for just a couple of questions. So again, it's not too late to put in one or upvote, and we can bring up Slido.com, the hashtag DOE, and be able to jump in on these.

So a very popular question is at the top. Ten people have voted for this, so the question is, is it realistic to expect electrification of direct gas-fired heaters without reliance on electric resistance in colder climates? So to me, it's not – I'm not sure if Erica or Rois wants to tackle that, so I'm going to give it a beat, and if one of you wants to jump in, that would be great. Rois, looks like you unmuted, so go for it.

Rois Langner: It's like hitting the game button, but I don't mean to jump in too soon. I think there is this question about cold climate heat pumps, and there's a lot of research that's happening right now on cold climate heat pumps and how big they can be and how much space they can actually provide adequate heating for in a commercial building. So there is a lot of research there. I don't have a clear concrete answer of saying like, oh yes, we are doing this. I think there are options for ground source heat pumps to come into play for larger buildings. We have seen some examples there with like IKEA is a great example. They've done a lot of ground source heat pump systems. And I do think in the real cold climates, like we spoke to a stakeholder that was based out of Alaska, where gas is still really cheap. So I think this transition to electrification is not quite there for all of the climate zones and for really achieving electrification in the colder climates. But there's a lot of research in that space, so hopefully we are getting there. Erica, maybe you have some real-world experience that can help answer this question too.

Erica Weeks: Yeah, I think looking at any water-based, so hydronic systems also so that your distribution of that to your particular mechanical system. So I think there's lots of options, and especially with many parts of the country starting to eliminate natural gas usage for their different permitting purposes. I think there's more and more things also coming to market and being realistic and coming in at a good cost.

Hannah Debelius: Great. Thank you both. The next question we have here, and I know you touched on some of these, but are there any design or planning resources regarding the retrofit of existing warehouses to decarbonize buildings? Rois, you want to take that one first again?

Rois Langner: Yeah, I'm happy to dive into this. So there is a bit of a dearth of resources I think on what are the design options for warehouses, at least from what we've produced from the national labs and Department of Energy. We've really focused – we have a series of advanced energy design guides. We did do one on small

warehouse buildings, but that was completed many years ago, so it's a bit outdated and it was only for 30 percent energy savings compared to ASHRAE baseline. And I think it was 1999 baseline.

So what we are trying to do right now is pull general guidance from some of the other more recent advanced energy design guides that we've done that may apply to a warehouse as far as – an example would be looking at our big box retail advanced energy design guide because we see that there's a lot of overlap in what the design recommendations could be. As far as refrigeration, there is a lot of work out there through ASHRAE and IRR, the International – I'm blanking on the – I had it up here a second ago and I don't have it now. It's the international refrigeration organization, industry organization. So I think we have enough guidance to provide direction and point to some of these other industry organization guidance documents that are out there. Again, Erica, I don't – where do you go for resources on designing buildings? I'd love to hear from you on that too.

Erica Weeks: Yeah, there's many places, again sort of tying to what the goal is but a lot of industry standard from ASHRAE, the design guides that you mentioned for the 30 percent to 50 percent, so there's – again, depending on the ask of what we need. Also there's a lot of things related to just having a retro commissioning activity. So if you don't know where to start in your existing warehouse, figuring out how you can utilize a commissioning agent to come back in and just making sure everything is first operating exactly as it should be. You'll probably find there's something left open or there's something that maybe can be tuned up or different, and that'll give you a way to also have sort of a capital improvement plan to a lighting retrofit or some other HVAC expenditure that might give you a good return on investment.

Hannah Debelius: Great. Thank you both. Unfortunately, we are at time here, so I've got just a couple of conclusion slides before we let you go. This webinar is part of a whole series, so as you can see, you could be booked from now to March with wonderful information from Better Buildings. In fact, our next webinar is coming up on October 13, and it's going to be "Hydrogen 101: The Basics of Hydrogen and Fuel Cells for Buildings and Plants." So you can join that to hear examples of how hydrogen and fuel cells can be used in building some plants.

And with that, I would like to thank our panelists once more. You offered an incredible amount of information. I know we didn't get to a lot of the questions today, but you all have the contact

information for everyone on this call, so you're welcome to reach out with additional questions. Thank you so much to our audience for joining, and yeah – and again, I'm going to give one more thank you to our panelists. It was wonderful to hear about this. I know this is a growing space type that is relevant to a lot of our partners, so we really appreciate it. And again, everything today will be available on the Better Building Solution Center. So with that, have a wonderful rest of your day.

[End of Audio]

Sustainability and Decarbonization Inside Warehouses and Distribution Centers

Additional Resources

Learn more about the topics discussed on the webinar by visiting the resources below.

Better Buildings Resources

- REI Net Zero Energy Distribution Center webpage
- Case Study: Link Logistics Industrial Solar PV

Explore more resources on the Better Buildings Solution Center

Other Resources

- 2022 EIA Annual Energy Outlook
- EPA SmartWay Transport Partnership Report
- The Food Cold-Chain and Climate Change | Article
- Logistics Commitment to Sustainability Grows | Article
- Decarbonization Program Examples
  - Amazon Climate Pledge
  - U.S. Postal Service
  - Clean Transport
- McCormick Warehouse Cuts Energy Bill to Zero | Article
- Grand Opening Celebrates NIEHS Net-Zero Energy Warehouse | Article
- Architecture 2030: Why the Building Sector?
- U.S. Green Building Council: LEED Zero
- International Living Future Institute: Zero Carbon Certification
- Zero Tool and User Guide
- Carbon Leadership Forum Policy Resource: Guidance on Embodied Carbon Disclosure

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