Sarah Zaleski: Hello and welcome to the December 3rd edition of the Better Buildings Webinar Series. In this series we profile the best practices of Better Buildings Challenge and Alliance partners and other organizations working to improve energy efficiency in buildings. I'm Sarah Zaleski, a Senior Advisor at the US Department of Energy's Building Technologies Office and I'll be leading our discussion this afternoon. Today we'll discuss the proliferation of zero energy building. By embracing deep energy efficiency these projects prioritize efficiency and then add on-site renewable generation to achieve net zero energy use over the course of a year. So today we'll be hearing from 3 great speakers to explore the financial, technological, and design process innovations that have made zero energy building and projects a reality. So without further ado I'll introduce our 3 presents.

First up we'll have Rachel Bannon-Godfrey of Stantec. Rachel is a Sustainability Discipline Leader for Stantec's Building Group and leads sustainability initiatives and design work, client outreach, and internal operations. She has over 15 years of experience focusing on engineering and design of high-performance net zero energy building. With a passion for multi-disciplinary engagement and expanding the boundaries of sustainability Rachel serves on the Mayor's Sustainability Advisory Council for the City and County of Denver and on the Colorado Resource Council. Through her work with the Global B Corporation community she has gained expertise in spreading diversity and inclusion through design.

After Rachel we'll have Greg Farley. Greg is the first Director of Sustainability for Washington College, 1 of the nation's oldest private liberal arts colleges. His responsibilities include broad sustainability planning, water, storm water, and waste stream management, energy management, efficiency, and campus engagement. Previously Greg was both a sustainability leader and Professor of Biological Science for Chesapeake College where he held the Stuart M. Bounds Distinguished Teaching Chair. He is also the co-editor of a book called *Thinking Like an Island: Navigating a Sustainable Future in Hawaii* that highlights sustainable strategies for islands and other isolated communities. A biologist by training Greg holds degrees from both Duke University and Florida State University.

And then lastly we'll have Jason Fierko. Jason is a Principle Mechanical Engineer at energy modeling at EwingCole, a national leader in architecture, engineering, interior design, planning, and sustainability design – excuse me, sustainable design. With 17 years of experiences he specializes in energy efficient and zero

energy design. He received his undergraduate degree in architectural engineering and a masters of engineering management from Drexel University. He's an instrumental participant in EwingCole's sustainability group and has been involved with several zero energy projects. He speaks regularly and leads certification, energy modeling, zero energy, and building energy use reduction strategies. He was recently presented challenges of net zero design in an urban environment at the 2018 World Energy Congress.

So thank you to all of us for being here today. Before I tell you about our DoE resources and hear more from our speakers, we'd really like to know a little bit more about you who have registered and joined us for today. We have a few polls lined up and we're hoping that you could just take a minute to respond to each of these to kind of give us a level set. Please launch the first poll. So how would you describe your role? If you could just please select 1 of these. I know we hear from quite a few different types of folks in the Better Buildings community and on these webinars. We're curious to know who we have on the phone today.

All right. So it looks like most folks on the phone are government or non-profit like architects, engineers, building managers, and service providers. Thank you. All right, now let's move to our next question. Please move onto the second poll. So which statement best describes your organization's experience with zero energy building? All right, so the results it looks like about 6 percent of you actually own or operate a zero energy building so that's pretty impressive, and then over a quarter have plans to build a retrofitted zero energy building so that's great to hear as well. And then it looks like everybody else is curious or intrigued so more to come but that's really heartening.

And then for the last and final – for the last question if you could please launch that poll this is a question I'm curious to hear folks' opinions on is what do you perceive as the biggest barrier to zero energy buildings? Let's give this a few more seconds. All right, and the results, so it looks like the number 1 by quite a bit is risk aversion to trying something new followed by lack of leadership support and I'm guessing those 2 are related. So I think these are really good data points and I encourage our speakers too to kind of think through these. These are fairly similar to some of the responses I've heard from speaking to others just in terms of trying something new and kind of breaking the mold for how you typically build or renovate buildings and then ultimately convincing your leadership that this can be done in a cost effective

way and can deliver the results that you're hoping for. So thank you all for contributing your thoughts on those.

All right, so moving on I want to remind our audience that we're going to hold our questions until the end of the hour. Please send in questions to the chat box in the webinar screen throughout the session today and we'll try to get to as many of them as we can after the speakers conclude. The session will also be archived and posted to our Better Buildings Solutions Center for your reference afterwards. So to start us off I'm going to turn things over to Rachel Bannon-Godfrey with Stantec to share some of her experiences with a number of zero energy buildings. So Rachel, take it away.

R. Bannon-Godfrey: Great, thank you Sarah. Next slide please. Fantastic and if you wouldn't mind just going on to the next one. So thank you all for joining this webinar and the question I was asked for this presentation is 1 we hear very often: what are the latest innovations and challenges in net zero buildings and how can we scale up? Next slide please. And as much as we all want that silver bullet building technology that will just move aside all those obstacles you know we saw in the polls that there's risk aversion and so on, before Greg and Jason talk specifically about their highly innovative building projects I'm going to start a bit broader because from what I'm seeing globally really the answer comes under these 3 categories instead. Next slide please.

The biggest innovations we're seeing are so much in building systems or technologies themselves, which have been evolving and costs have been coming down, but really they haven't changed that dramatically in the last decade as I'll show later on, but really we're seeing the playbook is where the most dramatic innovation is, the playbook in which we use to design and deliver net zero energy buildings, net zero carbon buildings as well, which I'll talk about or carbon neutral buildings, and specifically how clients are using our energy models during the design and more recently during post-occupancy, which has really been a game changer.

We're also seeing net zero energy is closer to become a baseline rather than a stretch goal. At least in our practice we're seeing the market moving from net zero energy to carbon neutral, which puts a much greater emphasis on the carbon intensity of the grid and the relationship of the building to that grid and also, which is something I'll talk about, it really expand the notion of the project team to include your utility providers or your utility representatives. And lastly but definitely not least we're seeing an

accelerated convergence of the business case for net zero and the business case for investing in the health and well-being of employees and an awareness of the impact of high-performance buildings on a company's personnel costs. Next slide please.

So I'm going to go over some examples in our portfolio that illustrate these 3 categories of transformation in the industry and to start with we're going to take a step back, jump back 10 years, almost exactly 10 years, to the very first net zero energy building really that Stantec – it's kind of a signature building for Stantec. This is 10 years ago, the National Renewable Energy Laboratory Research Support Facility, that's a bit of a mouthful, so NREL RSF opened in Golden, Colorado. And at the time that it opened in 2009 it was the first and largest net zero energy office building in the world and was on a campus that is still today operating a net positive energy. And the project was design build with a performance-based contract and we had a financial penalty if we did not meet a very specific EUI, energy use intensity, that NREL the client had set. And that was pretty revolutionary at the time. Next slide please.

The building was designed to an EUI of 35 kBtu per square foot per year, which was about 50 percent better than ASHRAE 90.1, 2007 standards, the standard at the time and there's a number of PV systems located on the roof and the adjacent parking garage. You can see here they're vertically mounted and then also a solar carport. Next slide please.

So now let's fast-forward 10 years to some of our more recent work. So here's the California Military Department Headquarters in Sacramento. Like NREL this project is also design build with a performance-based target and a client who has included very detailed language and requirements in the RFP based on their sophisticated understanding of high-performance buildings. And the thing is the systems are roughly the same as those in NREL, right, with radiant heating and cooling, heat recovery, attention to façade, and glazing performance, and the innovation we're seeing here is that the client is really going into a lot more detail or is going into a lot of detail on how they're using the energy model, the requirements that they're looking at through design of how the energy model is being used to track performance, and also post-occupancy. A lot of post-occupancy work is going into this building. So in this case there were 2 goals and 3 model uses. Next slide please.

The goal number 1 was we were given the site EUI goal not to

exceed. Goal number 2, we had to achieve net zero source energy with a 10-percent safety factor. And if that net zero source energy is not met the design build teams is to come back and install either additional PVs or implement additional EEMs, energy efficient measures to get to net zero. But the PVs can only address a maximum shortfall of about 5 – an EUI of 5 kBtu per square foot per year. After that we have to put in EEMs and we all know how painful that is to come back to a project after it's been built and address additional EEMs so that's a pretty high target. Next slide please.

So – I'm sorry, also to add to that on the California Military Department Headquarters we were asked to model the building in 3 different states. One was cold shell, so it's fully conditioned but unoccupied, the next was occupied, unconditioned, and the next was occupied, conditioned, and adding in PV and I'll go into more detail on that later but it really was – it gives the client the ability to monitor the impact of occupants on the energy use comparing the building unoccupied and occupied and also sets up a level of accountability for the design team to meet those goals and that's what I mean by innovation in the playbook, a level of sensitivity and accountability.

So this project you're seeing here is actually just came – just opened up last month so the building is up and running; we just don't have an updated picture of it. But what we're also seeing I mentioned net zero energy is a baseline goal so it's becoming the foundation on which other goals are added on to raise the bar. So this is the new Denver Water Headquarters, it opened up last month in Denver, and it is a flagship building on a campus of about LEED building and it's on track for LEED Platinum net zero energy, and it was designed to be a One Water Site. Next slide please.

So the signature piece of the One Water concept is in the lobby, see this planter, this building – the site is still under construction as you can see, but that planter is made – known as an eco-machine or living machine where it takes rain water and gray water, cleans it to a level that can be used for toilet flushing and irrigation just using plants and natural processes. So for us net zero energy was the baseline upon which we added further goals around water in this case. Next slide please.

And it's not just office buildings, although office buildings seem to get the most attention, but it's not just office buildings that we're seeing net zero energy goals being set and also being achieved.

We're also – this is UC Davis West Village Student Housing, the largest student housing project in North America under construction right now, and student housing might sound like a simple and fairly repetitive building type to do the net zero math, the equation for that on, but that equation gets very complicated once you factor in the known/unknown shall we say of all the equipment, whether it's beer fridges or TVs or lava lamps, whatever students are putting in their dorm rooms. Those tend to complicate the energy level because those pod loads are often a shot in the dark as I talk about later on – next slide please – in addition to a lot of on-site food services that come with student housing and let's not forget the room dedicated to Amazon deliveries, all the good stuff for today's lifestyle. Next slide please.

And this presentation is called Buildings of All Shapes and Sizes and that's certainly true with our portfolio and what we're seeing in the market as well. This was Montreal's first net zero energy building; it opened up a couple of years. It's a visitor's center at just 5,100 square feet so then it's not just the large, signature office buildings that are getting the attention. Next slide please.

We're also seeing – you know when I go back to where I talked about playbook plays and how to scale these buildings, we're also seeing the portfolios moving from net zero energy to net zero carbon and from the boutique buildings to the speculative template-driven buildings, which is fantastic and that's how we scale. And this leads to the next innovation I'm talking about and that is place. This is evolv1. It's Canada's first building to achieve zero carbon design certification from the Canadian Green Building Council and it's located in a research and technology park, the David Johnson Research and Technology Park in Waterloo, Canada.

This project was led by The Cora Group, who are a fantastic, community-minded, innovative developer in Waterloo and they really decided that they wanted to redefine spec development. They wanted to raise the bar for what an office building could be done – could achieve. And they asked for a carbon neutral office building that prioritized occupant health and well-being, built at market rate, that's critical, and that could be used as a template for the next generation of speculative office buildings. Next slide please.

The building was occupied in last 2018 so it's just about coming up on its 1-year measurement verification period, and for those of you familiar with the Canadian Green Building Council's zero carbon

building standard the building is 105-percent energy positive thanks to a lot of PVs and you see this amazing solar carport here and there's PVs on the roof, but also really attention to the building envelope and internal loads and brought that EUI down as much as possible. And in addition it's on track to achieve carbon neutral status on an annual basis. Interestingly in terms of talking about raising the bar for goals and net zero energy as kind of the baseline, there was also in addition to meeting the EUI goal the team also met the maximum threshold for TEDI, which is not a soft toy that was kept in the office for hard times but TEDI stands for thermal energy demand intensity, which is a metric in the zero carbon building standard that looks at the annual heat loss from the building's envelope and ventilation after solar heat rejections have been accounted for. So I'll cover this later, but that's – again we're not just – EUI and net zero energy is not just the end goal here. Next slide please.

And so this is a list of all the systems and based on the time we have for this presentation today I'm not going to go into detail on all these systems, but really hopefully you can see that this is not – there's nothing here that really is not in the marketplace already. However, there is 1 thing that this is the first building to tie into an open exchange field in Waterloo, but other than that the market has all these systems already. What's unique here was first of all we used parametric design modeling to make decisions from day 1 that included a whole range of factors and very quickly turned through a number of different design decisions very quickly. And also with an eye on market rate construction costs and looking at how the carbon intensity of the grid was impacting the design of this building. Next slide please.

We also looked at – I mentioned this was driven by health and well-being, so the University of Waterloo is carrying out extensive post-occupancy research into the impact on health and well-being of the workers in the buildings of working in a high-performance building that prioritized daylight and healthy materials and so on. And this was a speculative office building but it was at full occupancy from day 1 and so the messaging around the high-performance building, it's carbon neutral, this will support your corporate sustainability goals, which was very, very impactful. Next slide please.

Actually you can jump to the next one as well in the interest of time. So when I talk about the playbook it's not just about the energy model but also about other technology that's entering the design process, so for example virtual reality is becoming very

helpful as we're putting more and more sensors and controls in our buildings. Being able to use virtual reality to let occupants and facility managers walk through the building and learn how to use it before day 1, that is also critical in meeting any net zero energy or carbon neutral goals. And it also helps make decision-making much faster based on more detailed information. Next slide please.

And then also on the envelope side I mentioned this new metric, TEDI, which has really been something quite interesting to consider because what it does is it results not only in greater occupant comfort but also it really ensures that designers focus on minimizing the building's energy demand prior to procuring renewable energy and so it's not just business as usual with a massive PV array on top. It's looking at really dialing in this energy use. Next slide please.

Actually go to the next one please. I'm just going to end here because I see the time is ticking along but what I did want to say is as we're looking at energy, energy performance, and as we're looking in more detail at the envelope I do think this is an area that we're seeing significant innovation and not just for comfort. This is not just – looking at envelope is not just about maximizing usable space and perimeter zones, but we're also seeing this become a matter of survival, particularly in the face of our changing climate these days. At Stantec we do a lot of work in communities in remote locations both hot and cold where survival and the impact of the envelope is really significant.

I'm going to end with this slide. This is a study that was done fairly recently where we looked at 4 different house type constructions up in Yukon, northern Canada, the Yukon territory, which is really, really freaking cold. And we looked at what happens to the internal temperature once a winter storm hits. The power goes out; you have no mechanical heating. What happens to the internal temperature in that house as the days go by and you can see the spikes are where – due to global radiation where the sun came out. And the difference between the standard 1908s construction and the passive house type construction, the difference between 19 hours and 216 hours before the temperature fell to a temperature that was harmful to help. That's the difference between first responders having to reach a community and vulnerable population the day of a storm versus having a few days knowing that as long as that person has food and water they're going to be okay. So when we talk about envelope performance it's really – it's not just about comfort but it's also turning into a matter of survival as well. So I think I'm going to end there because I've got an eye on the

time and there is much more in this presentation but maybe I can be able to address it in the questions that come up. So thank you everyone for your time.

Sarah Zaleski: Thank you so much Rachel. That was excellent and I really appreciate how you kind of gave us the landscape across – or kind of covered a landscape of different, very impressive buildings and in a number of them I noticed that you mentioned cost considerations too and cost constraints you know whether it was market rate or to a fixed government budget that you were able to achieve that type of performance on budget and just by using some of those techniques in the playbook and modeling and prioritizing performance specifications so thank you. That was excellent.

So now we're going to dig a little bit deeper into 2 specific projects. So first we'll hear from Greg Farley of Washington College about a smaller building, a zero energy building that they're working on on their campus so I'll turn it over to Greg. Greg? We can't hear you. Greg we still cannot hear you. Sorry folks. We'll figure this out quickly. Why don't we do this? Why don't we skip forward to Jason and then we'll come back to Greg?

So now I'm going to turn it over to Jason Fierko who's going to talk about a very impressive building here in the DC area in Silver Spring, Maryland that was recently completed and I had the privilege to tour. And again this kind of fits the title of the session of being Buildings of All Shapes and Sizes. This is a rather large building with a very unique shape that's quite beautiful as well. So with that Jason I'll turn it over to you to talk about United Therapeutics.

Jason Fierko: Thank you Sarah. Can you hear me?

Sarah Zaleski: Yep, I hear you great.

Jason Fierko: Okay, perfect. Next slide please. And you can move to the next one. So the project we're going to talk about today is the corporate headquarters expansion for United Therapeutics Corporation in Silver Spring, Maryland, which is a suburb of Washington, DC. The project is approximately 210,000 square feet in total. That includes office and lab function, virtual laboratories, parking, a retail component, and a central atrium, which is a real key design feature. And goals that were set for this project at the outset was net zero energy so that was a goal from the start, it wasn't an add-on, and the other requirement was that all of the renewables had to be on the site so we couldn't use remoter rays, we couldn't use

offsets or anything like that. So at the time when we started designing this project, which was 2011, we were targeting a 70 to 75-percent reduction in a benchmark energy to a median building in Silver Spring and the building opened at the end of 2018. Next slide please.

So when we talk about design process for net zero it's a little bit different than our traditional design process. So before we even put pencil to paper on the design we start with a goal-setting and benchmarking exercise where we look at energy use intensity and what we think we can realistically hit for the building. Now the challenge for this building was that in 2011 there wasn't a whole lot of data available for low-energy buildings, certainly nothing of this size or in this location. So we took the information that was available, what little information there was, and we supplemented that with our own energy modeling to begin to set our goals and benchmarks.

We then moved onto early modeling of modules, so instead of just jumping in and modeling the whole building we looked at a typical module like an office module, a conference room module, et cetera, and we began to optimize each of those on their own looking at things like the envelope, modeling, equipment loads, HVAC system type, et cetera. And once we really optimized that then we could extrude that out to the entire building. We then continued to model all throughout design using the energy model really as a decision-making tool in our process and then we continued that modeling through construction so that we could ensure that the model was an accurate as possible when we went into our post-occupancy measurement and verification period. So at the end of the day it doesn't come down so much to form following function or function following form but it's really about the 2 informing one another. Next slide please.

So early on we wanted to set the expectations for the building. Some people might have a negative connotation of net zero buildings thinking that they're going to be under-lit or hot in the summer, cold in the winter, so we really wanted to set that expectation early so working with United Therapeutics, specifically with their CEO, we talked about expectations for the interior environment, most specifically were we going to ASHRAE 55, which is the thermal comfort standard, or were we going to do something outside of that envelope. And ultimately it was decided that we would design to ASHRAE 55 but we would be at the edges of the envelope, which would result in temperature and humidity swings throughout the course of the year.

The way we corrected for that was by providing a higher level of individual control in each zone. So within each office the occupant has control over their temp so there is a thermostat in every office, it is limited by the DAS to 1 degree in each direction, they have control over their lighting, both at the task and the overhead level, they have control over air movement through a ceiling fan in each room, they have control over daylight penetration into the room through an electrochromic glazing system, and during certain times of the year they can even control the amount of ventilation to their space through operable windows.

But the other piece to this was really to train and educate the employees about their role in the success of this net zero building. And the way that we did that was by using data that we have available through the building automation system and feeding that back into the spaces so people could understand how the building is performing and I'll touch on that a little bit at the end. Next slide please.

So when we started to think about strategies for the building design we wanted to be as low energy as possible so we start by looking at passive strategies, which are strategies that use little to no energy but have a positive impact on energy performance. The most basic of these strategies is building orientation. So if you orient the building in the correct position the building will use less energy. In addition to that we use external shading on the building so the southern façade of the building houses solar panels that are integrated to the curtain wall that not only provide energy generation, which was critical for this net zero building, but also provides solar shading to the southern façade, which can block out the high summer sun and let in the lower winter sun. In addition to that the east façade of the building is sheathed in an external perforated metal screen to knock out the early morning solar gains on that façade.

Daylighting is another passive strategy that we used to a great degree. One hundred percent of our regularly occupied spaces are daylit, which is adequate to light the building about 80 percent of the occupied hours. And yes, even in Silver Spring, Maryland you can naturally ventilate a building. Although the temperatures are extreme about a quarter of the hours of the year the building can be naturally ventilating, which includes overnight purge modes. But again this is Silver Spring, Maryland, it's characterized by hot and humid summers, cold and dry winters, so if we are going to meet our ASHRAE 55 thermal comfort criteria we do need to use active

strategies so the key becomes finding active strategies that use the least amount of energy and the cornerstone of those strategies was the ground coupled geo-exchange system for the building, which is really 1 of the most efficient ways to heat and cool. We then paired that with energy recovery on 100 percent of our airstreams. Next slide please.

The site for the project was I think by far the largest challenge. I think if you ask anyone on the design or construction team they will tell you that. The picture on the top left, the big parking garage in the middle is our site. You will notice that it is surrounded on all 4 sides by high-rise buildings that are built to the vertical zoning limit. That creates a lot of challenges when you're trying to generate renewable energy through solar means because those buildings cast shadows, those shadows change during the course of the day, and through the course of the year so we really needed to get a handle on that very quickly. We knew that energy generation was going to become our limiting factor and that caused us to adjust the program in order to meet the net zero goal, which dictated size of the building, number of occupants, and even the activity levels that we could support in that building. Next slide please.

So the building has 2 primary forms. On the left-hand side of the building there it's a more rectilinear form, which is what we call the core or the nut bolt and that houses a lot of utilities for the floors, toilet rooms, IT rooms, electrical rooms, and a large seminar room. And then we he the elliptical form, which is really the office. You'll see that the major axis of the ellipse is skewed and that's so that the north faces to true north of the building, which is just up to the left in this image, which aligns with the city of Silver Spring.

The elliptical form has an atrium in the center. There was a real benefit to this because it provides a relatively shallow floor print, only about 40 feet at its deepest dimension in the office and that's very good for daylighting and cross-ventilating of air in natural ventilation mode. In addition to that to encourage stair travel we hung a monumental stair in the atrium, which is visible from all areas of the office and we pushed the elevators to the far ends of the floor. Next slide please.

In order to get a handle on the shading and once understood the form of the building we did an early model in Ecotect. This is a solar radiation availability model, which looks at the different surfaces of the building and the amount of solar radiation that they

receive over the course of the year, yellow being the best and blue being the worst. The bottom image shoes an earlier version of the building where it was located closer to the high-rise building on the south and you can see a lot of the shading impacts in blue on the façade of that building. The top is the final configuration of the building where we raised the solar tray and pushed the building away from the adjacent hotel and we tapered the façade to minimize self-shading on the panels. Next slide please.

We talk a lot about climate change and how do you future-proof a design for a climate, which is getting more and more extreme, and there's 2 primary ways to do that. The first is the building envelope, which is your primary barrier between your interior and your exterior environment. Although the building appears to have a lot of glass in reality it really doesn't. In this image the darker striping that you see is a super insulated spandrel panel behind the curtain wall so that's an opaque wall. The clear striping is the actual vision class, which is only about 3-feet tall around the office so it's optimized to capture views and nothing more. And then the white striping that you see is a super insulated daylight panel, which allows us to permit diffuse daylight into the building, which is great for daylighting but gives us the insulating value of a well-insulated wall. The other piece that is affected by climate is the ventilation airstream and we address that by doing total energy recovery through enthalpy wheels on all of our airstreams, including dual wheel technology on the office units, which increased our heat transfer efficiencies above 80 percent. Next slide please.

Generation of the concept and development, we kind of started in the top left kind of understanding how air and light move the space. We then moved into our DD phase and refined that concept overlaying the engineering systems and really beginning to understand that southern wall and all of the aspects and elements that are on that wall. We then modeled the entire solution in BIM and then actually completed the offices to make sure that they turned out as we intended. Next slide please.

The atrium is a key design feature of the building. One of the interesting features is it is not an actively heated and cooled space. It is passively tempered through an underground early labyrinth, which I'll touch on in a moment. In addition to that we used the form of the building, the height of the atrium, to create an engine for natural ventilation through stack effect so the atrium actually induces airflows through the building in natural ventilation mode. And finally there is a swimming pool in the atrium of the building

and we actually use that swimming pool as a heat rejection source for extra heat that we have in the building. Next slide please.

The atrium is passively heated and cooled through a quarter mile-long underground concrete earth labyrinth. It has 3 chambers and a bypass that we can modulate airflows through. It uses essentially the thermal mass of concrete in contact with the relatively stable temperature of the earth at 4 meters depth to provide some heating effect in the winter and cooling effect in the summer. We have been through both a heating and cooling season with the labyrinth and it has exceeded everyone's expectations. Next slide please.

Speaking of relatively stable ground temperatures the geo-exchange system consists of 52, 500-foot deep wells that are located on the site mostly beneath the building. That actually required getting regulations in the state of Maryland changed to do that but that is 1 of the requirements. When you're on a tight urban site you don't have a large area to put the wells outside of the building footprint. Next slide please. And then the geo-exchange system feeds into a series of water-to-water heat pumps and they feed an active chilled beam system for the office, which we modeled several system options and we found this to the best option for this particular project. Next slide please.

When I said that every surface of the building was a contender for solar I wasn't kidding and this birds eye picture kind of shows that. You can see quite a bit of solar installed on this project. Next slide please. The breakdown of the solar, in total we're just bout 3,000 modules, just over 1 megawatt of connected power projected to produce just under 1,200 megawatt hours per year, which would give us net positive operation. Next slide please.

So 1 of the keys in a smart building is that we have over 11,000 integrated devices, 6 controlled platforms that are integrated into 1 dashboard, so what do you do with this intense amount of data, and the solution here was to provide a custom dashboard, which is a regular green dial system that the facility operator can at a simple glance understand how the building is performing and then click down to the appropriate level of detail to do any troubleshooting that they might need to do. Next slide please.

And then we use that data to actually provide feedback to the building's occupants so they can understand how the building is operating in real-time. This is what I call the giant iPad. It's an interactive screen that takes real-time data and people can go in and understand how the building is operating. There's also a series

of what if scenarios where people can change aspects of their behavior and understand its impact on the building operation. Next slide please. And finally we did a large-scale display in the atrium. This is an LED light display that essentially gives a real-time sign of how the building is operating, whether it's exporting or importing energy, so if the lights of this dial are shining inwards we're importing. If they're shining in this form inward and outward we are actually net positive at that moment in time and that's just a quick way, this is visible from all the office areas, for people to understand how the building is operating. Next slide please. So with that that's my last slide. The building like I said has been running for about 6 months. Our modeled EUI was 26; we're running about 20 percent below that number, which is a good thing. So with that I thank you.

Sarah Zaleski: That's excellent. Thanks so much Jason. It's a really inspiring project. So I'm about to turn it over to Greg and before I do just a quick reminder to send any questions that you. Might have through the webinar chat box on your screen. What we'll do is collect all those questions for a Q&A period at the end of the session. So if we can please tee up Greg's slides from Washington College I'll turn it over to you Greg.

Greg Farley: Can you all hear me now?

Sarah Zaleski: Yes, we can hear you now.

Greg Farley: Excellent, score. So we went back to the old-school technology where I'm yelling at a speakerphone so here we are. Apologies for the interruption you all. So I want to talk today about a very small net zero building built for a very small liberal arts college and I'll tell you a little bit about the college and then sort of our journey to get to the point where we wanted to build a net zero building and then I'll delve into some of the building tech issues. But just real briefly next slide please Sarah.

So Washington College is a small sort of classic liberal arts college. We're 1 of the 10 oldest institutions in the country. When we're fully enrolled we have about 1,400 undergraduates and I'll let you read the rest of the slide but the take-home message here is that we have a really, really strong connection to the environment and that's both by way of a couple of academic programs, we have a really strong academic program in environmental science and a parallel program in environmental studies, and we have a waterfront campus on the Chester River, which is 1 of the major tributaries to the Chesapeake Bay so we're intimately connected to

issues like sea level rise and the ability to study that in situ for some of our properties is really strong. So we're focused on this Center for the Environment and Society and the building I'm about to tell you about is the new home for CES and is the new showpiece for what they do for the campus. Next slide please.

So there's a lot of things that go into planning a building at a college this small, but 1 of them and 1 of the principle drivers on this was we have 2 people who we really wanted to honor by putting up a green building. One of them is Jay Griswold who's a former interim college president, former president of the board, very, very important to the college and also important to the regional environmental community here on the eastern shore of Maryland. And the other 1 is Truman Semans, who again is very important to the environmental community here, 1 of the gentlemen who helped found The Chesapeake Bay Foundation, which is the nation's longest running and by some measures most successful environmental clean-up effort.

So we knew we wanted a new building for the Center for Environment and Society, we knew we wanted it to be on our waterfront campus, and we knew that we wanted to honor some of the very pillars of this community for us. So what you're looking at here is a photograph of the finished thing, the finished building, that looks so much like the architectural rendering it's almost impossible to tell them apart, but the Semans-Griswold Environmental Hall – next slide please – is relatively small, relatively high-impact for us. It has both a high visual impact because of where it's situated and because of the kinds of students and people who pass through it – next slide please – and we also wanted a workable space that was flexible enough to use as a classroom, as a function space, and then as a combined office and set of laboratories for a couple of staff and a couple of faculty. Next slide please.

So it's a small structure. It's a little under 10,000 gross square feet inside, there's another 1,000 square feet of decks outside, which are actually functional spaces. The teaching and research labs from this space all have immediate access to the outdoors so the porch spaces are rigged with extra hose spigots and places for rinsing both people and equipment. There is a flexible classroom space, smart classroom, and there's both a trio of hard offices with real firm walls and then an open office sort of workspace in the center of the building. Research labs in this building are of 2 types. One of them is a drone and robotics and remote sensing laboratory where they build equipment and they just sort of design, conceive,

and test in that space so that has its own energy signature, and the second research lab space is for oyster aquaculture and for that reason the building has a flow-through river water system. We have a set of pumps that bring in water through the Chester River and push it through tanks in that lab and then return it by way of a step-down conveyance back to the environment and hopefully back to the groundwater.

The river is not entirely fresh water. Where we are on the Chester River there is a small amount of salt in there so we had to be very, very specific about how we designed the disposal of that water as it flows out of the building. It was about a $12 million project, about 2/3 donor funded and about 1/3 state funded with a grant by the state of Maryland. The real great part of the story is it's a former brown field site where there used to be a fertilizer and chemical factory so there's a lot of work that's gone on to make this site habitable and useful for educational and recreational use. And as I said before it's the home for the Center for Environment and Society for us. Next slide please.

So we batted around a lot of ideas about how to justify or how to recognize the energy performance and all-around sort of green building-ness in this project. We considered LEED Platinum but it's really not the best fit for us. LEED seems to work really well, the scoresheet, in the urban core, but for example you're looking at buying bicycle racks and that's just not a thing we saw getting a lot of use here in Chestertown. And so we decided to go and seek Living Building certification for this and so Living Building lays out a petal analogy for their energy product and I'd encourage you to go to their website and learn more about it, but there are 7 different sorts of sets of qualifications within the building and buildings must pursue either the energy petal, the water petal, or the materials petal. We decided early in the project to go after the energy petal, at least partially with the justification to the administration at the college that if we did this the building should never have an energy bill and for a science laboratory that's a tall claim.

So the energy petal dictates that the building must push energy back to the grid, it has to be 105-percent positive, and it also must include a battery or some other form of energy back-up so that we could back up 10 percent of the lighting load for a week. In fact, that introduced some really interesting and quirky features of the building's electrical design. Next slide please.

Lots and lots of words on this slide, you certainly don't have to

read them all, but high points here, lots of solar on the roof, 274 panels. Ground source HVAC, groundwater, water-to-water heat pumps work really well here on the eastern shore. The drilling is really easy, we basically live on a giant sandbar, very few rocks, and in this case the building shares an existing ground source HVAC matrix with the boathouse next door so we had that resource in place already and basically needed to expand it a bit to put this building in place. Lots of natural light throughout the building, you'd expect LED and good controls in a building like this, and our EUI falls somewhere in between – I was sort of taking notes as Sarah was talking earlier, but holy cow, I don't believe I've ever seen a building with a 6 kBtu per square foot per year number before; we're certainly not that low. But for again a building with a seawater system and a research lab 32, 33 kBtu per square foot per year is a pretty good number for us. The picture on the right is the manufacture's sales photograph of the battery stack. Next slide please.

So again the decision-making metrics to get here, we really wanted to honor Mr. Semans and Dr. Griswold. The donors for this building who we recruited from supporters of the Center for Environment and Society really drove the decision to make this a green building. I don't even think all of the donors completely understood what that meant but they do understand that green buildings are important to campuses and that green buildings drive things like enrollment and public image as well as the physical sustainability for the college. This was a pretty extensive building on a per square foot basis. If you run the numbers in your head you're looking at about $12 million for about 10,000 square feet and we took a lot of heat from our construction management staff for those numbers, but we certainly are hoping that the building again never has an energy bill and provides us with a lot of resilience going forward in an area where we know there's going to be a lot of stresses on the electricity grid going forward as climate change sort of catches up with this region.

And then finally, next slide please, this is part of an overall sort of planning for resilience for us. And I put this slide in here to illustrate the fact that the Semans-Griswold building is the one on the far left of the photograph, the new-looking roof in the center of the photograph is the new boathouse. There's actually another boathouse that you can't see that's behind those 2 buildings at this angle. We have sort of a natural experiment going on at this site. The Chesapeake Bay is seeing sea level rise at about twice the rate of the global average. We expect something like 3 feet and possibly more by 2100. Whether that comes in at 2030 to 2050 or

it takes longer is a matter of some debate. But the original building on this site, the original boathouse is slab on grade. The boathouse you're looking at there in the center of this photograph is built to modern building code so that's the 1-percent chance flood plus 2 feet, what we used to call the 100-year flood, and when we designed Semans-Griswold we went back to the science literature and back to the climate change literature and made the decision to pull the building up an additional 2 to 3 feet so that one is building code plus another buffer for sea level rise going forward. So we sort of are looking at this site as a long-term experiment in building resilience and how universities and colleges might consider sort of planning for that in their immediate future. Next slide please.

And I just want to leave you with the thought that you know although we're planning for the future this is just a sort of ordinary, good, high tide at that same campus. The sailboats behind us here are for our sailing and racing team and they were visible in the previous photograph also. The gentleman on the right is the director for the Center for Environment and Society and in order to pick a date for this picture we simply picked a day with good, high tide and a south wind. So this property is already needing some resilience planning and I think that's a place where a lot of our buildings are going to find themselves over the next 20 to 50 years. So I'll leave it there and I'll be happy to take questions by way of the chat box. Thank you.

Sarah Zaleski: Thank you so much Greg. Okay, so we have about 10 more minutes so we'll try to get through a few questions but please go ahead and fill in questions in the chat box if you have them. I do want to highlight a few additional resources here so obviously the Better Buildings Solutions Center, we will be adding a fair bit more content on zero energy building in the coming months so check that out. There's a great video on YouTube about the Unisphere building that Jason spoke about, more information about the Semans-Griswold Environmental Hall. One other resource that is not up here is some guides that DoE has funded and partnered with ASHRAE to release called Advanced Energy Design Guides and Zero Energy Building and they provide about 200 pages worth of content of the soft build and the technology combinations to achieve zero energy buildings across the different building types so lots of great resources out there.

So with that let's go ahead and we'll take some questions. Thank you for those who have contributed some. I'm going to send the first on over to Rachel and if we can just keep our responses to 30 seconds or so we'll have a chance to get to a few of them. So

Rachel – sorry, we're getting an echo. For 1F projects that don't have grants or other external kind of supplemental funding sometimes building to cost is certainly an issue and even to market rate can be challenging. How are these buildings doing done at cost or how are those costs coming in and who's taking the hit if anyone in some of the projects you've seen?

R. Bannon-Godfrey: Yeah, thank you Sarah. That's a really good question and you know I hate to give the answer it depends, but really what we've seen is the very first meeting, even when you're in that pursuit phase of that project, if you don't have your utility reps or somebody from your local utility company in the room in the meeting then stop and invite them in because a lot of times we've seen – talked to utility companies to leverage any incentives that they have around renewable energy. The actual construction costs for the base building are not – the premium is not that high. Where the costs come in is when you're adding in on-site renewable energy systems. So for some of the projects that we've done recently at least here in Colorado working with Xcel Energy it's also being creative with timing. So it might be that you wait until the next funding cycle to get the PVs on your site.

We had a class B office building that just waited a funding cycle and then was able to add PV and suddenly went from just a class B office building to an elite gold office building because they were able to just be creative about what bucket of funds do we fund certain parts of the building in. And then also there's pace financing. It's increasingly popular in the states that have pace financing and also you know by using things like parametric modeling you're able to see where it's not always additive. Better glass results in savings elsewhere. Better zoning results in savings elsewhere. So it's really looking at the relationship between if you are adding costs in the project where are you saving elsewhere and being really detailed in your cost model.

Sarah Zaleski: That's great. Thank you so much Rachel. So I had a question for Jason now about the Unisphere building. So the geothermal system, it looks like it was under the building. What was done with the mechanical design to make sure those could be maintained if there were issues with the geothermal wells?

Jason Fierko: Yeah, so there was a lot of concern – I mentioned that we actually had to petition the state to change the regulations and that was 1 of their concerns. The result was A, the geosystem is actually designed with some redundant wells in it and that's pretty standard actually for geosystems that you do design for some level of

redundancy. In addition to that all of the wells that are located beneath the building have well-head vaults on them so that you can actually access the well if there was a need to kind of get into it, do inspection, or some kind of testing on it so that's the way it was addressed.

Sarah Zaleski: That's great. Thank you. So somebody asked about the speakers' perceptions and this is a question for all 3 of you about what you perceive as the biggest barriers to more widespread pursuit of zero energy buildings. So across your respective disciplines as architects and engineers and owners what's been your perception? Maybe I'll turn it over to Greg first to answer that.

Greg Farley: Sorry, I was muted against. I'm not sure I understand the crux of the question. Can you rephrase?

Sarah Zaleski: Sure. So just from your experience what was the biggest barrier or hurdle to building a zero energy building?

Greg Farley: Oh yeah, and I think this is 1 of the questions that came in from the Q&A too. The biggest barrier for us was really the additional cost of building this. Our operating culture as an institution is to try and do things as cheaply as possible so the idea of building a building that was almost $1,200 a square foot was met with stiff resistance in predictable quarters. And I think the way we overcame that was really to sort of keep pushing on the fact that this is – I think for now it looks like it's experimental and now it looks like this is really cutting edge, but I think this is where buildings need to go if we're going to talk about decarbonization and this is a chance for the college to position itself as a place where one might go to learn about that and also to exercise a little bit of leadership about how that sort of project gets done. And so for us we really I think ended up – and I don't want to make it sound like it was a cage match, but we ended up sort of pitting the MBAs against the faculty and the donors on this project and just slowly and surely discussing it enough to bring the MBAs around to our point of view to try and do the green building. Did I answer your question?

Sarah Zaleski: Thank you. Yeah, no, that's great. What about you Rachel? Anything from your birds eye view of working on a number of these projects?

R. Bannon-Godfrey: Yeah, thanks Sarah. I think the biggest obstacle is perceived cost, not actual cost, but just perceived cost and also not thinking long-term, not thinking lifecycle. We are seeing a number of clients asking us to do lifecycle cost analysis but so we're doing the

exercise but then not either taking the recommendation seriously or even just kind of paying as much credence as possible because when you look at the long-term lifecycle, when you bear in mind you know carbon tech is coming and it is precedent is some jurisdictions and just thinking long-term and getting over that perceived versus cost.

Sarah Zaleski: Thank you. And Jason, any other thoughts on that question?

Jason Fierko: I would say advocacy is probably one of the big ones. I think the reason why the Unisphere project was successful was because the CEO of the organization was the biggest advocate of net zero and put that goal up front and essentially said, "If you can't do it we're not doing the project." And so what we find in other experiences where projects might start on a net zero path and then not end up there is that you don't really have that buy-in on the advocacy side. You don't have a champion on the owner's side who's really, really committed to it. So I think that's been my experience with the challenge.

Sarah Zaleski: That's great. Thank you. So we have – thank you all for sending some wonderful questions our way. We unfortunately have many more questions than we have time to answer. So I am going to ask – we will try to address some of these questions kind of offline in written form and post this on the Solutions Center as well if our speakers are willing to commit a bit more time to this. So I apologize if we were not able to get to your question today because we are running out of time but we'll try to do our best to address some of those and then post those to follow up.

So as we wrap up with 1 more minute I just want to share a couple of announcements. I hope you'll plan to attend our next Better Buildings webinar, which will be held Tuesday, January 7th from 3:00 to 4:00 and the title is Best of the Betters: The 2019 Better Project and Better Practice Presentations. So these were created to recognize outstanding accomplishments in implementing and promoting industrial energy efficiency programs. So that will be in January and then I am also pleased to announce that we do have a date for the 2020 Better Building Summit on the books. That will be held in Arlington, Virginia June 8th through 10th next summer and so if anybody hasn't been to the summit in the past we have wonderful sessions, we have ask the expert kind of office hours, building tours, and obviously lots of opportunities to network with your peers, so stay tuned for registration on that.

And then in closing I'd just like to thank our panelists very much

for again taking the time to share your expertise and your really exciting projects with us. Feel free to contact our presenters directly if you have additional questions or if we couldn't get back to you during our Q&A period. I encourage you to follow Better Buildings on Twitter with all of our latest news and thank you again for all of your partnerships. Thanks everybody. With that we'll sign off.

[End of Audio]

Additional Speaker Q&A

General Questions:

Audience Member: Does anyone have the experience of using perforated metal panel as the solar hot air collector? Is it an efficient way to get energy?

Jason Fierko: Yes, we did this at a project in New Hampshire. We found it as an effective way to provide some preheating of the ventilation air.

Audience Member: What do the speakers view as the biggest barriers to more widespread pursuit of net zero buildings?

Greg Farley: For us, it was definitely established practice to bring the building project back under budget through, "value engineering," which is one way of saying, "cutting elements of the engineering documents out of the project to save money." We had to keep emphasizing that the up-front investments in cost would pay off in future power and water bills. Working with existing finance and construction-management practices, which place heavy emphasis on controlling a "dollars-per-square-foot" metric, was difficult to overcome.

Questions for Jason Fierko:

Audience Member: If people could open windows, how was noise dealt with?

Jason Fierko: Noise was discussed during the initial meetings, which focused around expectations of the interior environment. Street noise is audible when the building is naturally ventilating, which changes the character of the interior environment. A sound masking system was installed to mitigate some of the noise. Occupants can also choose to work in other common areas of the building that are not naturally ventilated if they are performing tasks that require low ambient noise (conference calls, heavy concentration, etc.). A series of sound isolated conference rooms and huddle rooms were provided in the design.

Audience Member: What is the R-value and Visible Light Transmission % of Okalux daylighting panel?

Jason Fierko: Overall U-value is 0.11, 25% VLT

Audience Member: Great presentation; could you please share the vendor's info for the super insulated daylight panel that are placed about the 3' vision glazing?

Jason Fierko: Okalux: https://www.okalux.com/

Audience Member: The solar roof and wall on the garage looks to have significant shading. Was the image an accurate rendering? Was a cost-effectiveness assessment done for that portion of the solar array?

Jason Fierko: The image is an actual photo of the building. That portion of the solar array does exhibit considerable shading during certain times of the day. This shading was analyzed and the reductions in output were presented to the Owner during design. The decision was made to move ahead with the installation of these panels since the output provided, even though it was reduced due to the shading, was critical to meeting the zero net energy goal.

Audience Member: Jason, does united thera have retail tenants yet?

Jason Fierko: The retail space is not yet leased. We believe this is partially the reason why the building is trending considerably lower on the consumption side.

Audience Member: What was the energy dashboard that the EwingCole project used to integrate meters and energy management systems?

Jason Fierko: Schneider EcoStruxure, custom built.

Audience Member: What types of R-values were used in the "increased insulating values" referenced?

Jason Fierko: Various values were modeled to determine where to best focus our efforts for the envelope. We found it was better to focus on glazing, which we did by going to a triple-paned glazing system, improving from U=0.45 baseline to 0.24. Opaque surface insulating values were improved for the walls from U=0.64 baseline to 0.60. Roof insulation was increased from R20 baseline to R30.

Audience Member: With the geothermal system placed underneath the structure, how did the mechanical design account for operational maintenance and potential failure of those wells?

Jason Fierko: Redundancy was built into the well field in case of extreme failure. Each well has a well head vault for accessibility and inspection. Installation of the well field was overseen by a full-time expert who then facilitated all of the pressure, flow and leak testing for the wells prior to completion.

Audience Member: Who uses the pool?

Jason Fierko: Open swim times are scheduled throughout the week. The pool is open to all employees.

Questions for Greg Farley:

Audience Member: In the photos your buildings all have lots of glass. What are you doing to mitigate for bird collisions?

Greg Farley: Nothing, unfortunately. Despite the fact that the Center for Environmental Science is home to the Foreman's Branch Bird Observatory - one of the busiest and longest-standing bird-banding stations on the East Coast - bird-friendly glazing was deemed too expensive for the project.

Audience Member: At $1,170 per square foot, that seems quite high. What was the primary driver for such high cost on such a small building knowing that one of the major hurdles of net zero buildings is the incremental increase in costs above that of a baseline code building?

Greg Farley: The primary drivers for this decision were the donors and CES staff. We went into the design process knowing that a large proportion of the donations for the building were contingent upon green-building construction. The building is also a partial answer to Washington College's efforts to reduce our carbon footprint. New buildings have a carbon impact, but that impact is minimized by choosing to minimize energy use, reuse materials, and be selective about new materials involved in a construction project. We also recognize that green-building construction is almost de rigueur for colleges & universities now: as students compare campuses and choose colleges, green buildings send a message to potential students (and parents!) about environmental stewardship and forward thinking by the administration.

Audience Member: Tell us more about the back-up week of lighting- can you describe how that system is designed?

Greg Farley: We have a small battery system (46kWh) that allows us to back up critical lighting. There is so much natural light in the building that the battery is actually pretty small - smaller than the battery capacity in my car!

Audience Member: Could you say more about why LEED Platinum wasn't a good fit? You said something about bike racks? Also, is LEED Platinum considered more or less progressive/green than Living Buildings?

Greg Farley: We looked at the LEED check sheet, and for this site and this

project, it wasn't the best fit. Items like "surrounding density" (we're in a very rural area) and "access to quality transit," for example, were points we'd never be able to capture. We'd have been able to capture most of the building-science points, and the IEQ points, but the site made LEED difficult for us. You're also correct to note that there's more enthusiasm for Living Buildings in the architecture community; because the stated goal is "to reconcile the built environment with the natural environment, into a civilization that creates greater biodiversity, resilience and opportunities for life…," the goals seem more sweeping - and more in line with the kinds of changes that societies need to make to avoid overshooting the resource limits of the planet.