Andrew Mitchell: Welcome, ladies and gentlemen. This is Andy Mitchell with the U.S. Department of Energy. I'd like to welcome everyone to today's webinar, *Higher Learning on Interior Lighting*, brought to you by the U.S. Department of Energy's Better Building Program. A little introduction on myself: I'm one of the project managers for the Better Buildings Initiative. I sit here in Washington, D.C. at the Department of Energy working on commercial buildings integration in the energy efficiency and renewable energy office of DOE – that's E-E-R-E-D-O-E. Prior to this I worked in private sector for eleven years, the last five in the energy industry. Also I'll add, since this is a higher education focus, I went to the University – Washington University in St. Louis for undergrad – go Bears – and I got an MBA at the University of Notre Dame – go Irish.

Moving along to our agenda, we're happy to have as our speakers today Michael Myer from the Pacific Northwest National Lab, William Evans from Princeton University, and Vic Clements from the University Financing Foundation. Quick overview of our agenda, we'll start with an overview from me on the DOE Better Buildings Alliance, and the various sort of programs. We'll hand it over to Michael for a brief review of troffers and Interior Lighting Campaign. Princeton University's Icahn Laboratory is a great case study, and we'll hear more about that, and then we'll learn about financing options from TUFF – The University Financing Foundation , and we'll end off with questions and answers. Okay, as I said, I want to start with a quick overview of the Better Buildings Alliance and commercial buildings integration, just to get some context for the Interior Lighting Campaign that we are focused on today. Through the Better Buildings Alliance, and specifically to commercial buildings, the alliance and challenge, members of different market sectors work with DOE's exceptional network of research and technical experts to develop and employ innovative, cost-effective energy-saving solutions that lead to better technologies, more profitable businesses, and better buildings in which we work, shop, eat, stay and learn – no small task to us. A key concept for us is that this is all voluntary. It's voluntary. It's a demonstration of leadership by our partners and our supporters, and it is basically getting out ahead of energy efficiency for the nation, for others to copy.

Why do we do this? As a nation we spend more than $200 billion each year to power our country's commercial buildings, so the goal of the BBA, the Better Buildings Alliance, is to bring that number down without affecting productivity – true productivity is producing the same or more while using less energy, and thus spending less money on it, so that money that would be spent on

energy and sent up a smokestack somewhere, can be freed up and reinvested in the American economy – so, hiring more American workers, purchasing more American-made equipment, and investing in more American companies. So for this reason, energy efficiency efforts like the Interior Lighting Campaign and Better Buildings have support from the business community, as well as sustainability advocates. Energy efficiency efforts in general have broad bipartisan support here in Washington D.C. and we hope to see them continue. On our next slide here, I'm looking at just – we call this our trophy slide. And this is a rich roster of logos for you to enjoy, get a sense for the reach of Better Buildings. It really is all-encompassing; it's all types of floor space, it's all types of facilities, municipalities, manufacturers, hospitals, universities, private sector of all sorts. And today we're focusing on higher ed, and you can certainly see a few of our all-stars listed on there.

Why do partners join Better Buildings? This is kind of our value proposition here. Why would a busy professional take time to join Better Buildings or pursue the Interior Lighting Campaign? The big three are really the reasons: access to experts, tools and resources – so we are that objective source. Peer-to-peer learning – it's really fantastic if participants can learn from their colleagues, take examples from similar facilities that are out there. We maintain a rich library of case studies for just that sort of thing, and we certainly have them available for Interior Lighting applications as well. And finally, public recognition. Certainly many organizations are on the leading edge of energy efficiency and interior lighting in general, and may not be in as deep need for peer-to-peer learning or access to experts. But they do need recognition so that they can continue their leadership position, and that is another key part of what we do. How the Better Buildings is organized, well, when you join, you're grouped according to your sector. And after that, each participant can choose to participate in one of six technology teams listed here. Each team is led by a subject matter expert, and the content is driven by member interest and objective research by DOE. Teams meet by phone on a regular basis, and that meeting is an ideal time for that peer-to-peer learning to happen. Lighting team is one of the most popular of the technology teams because of the high-profile nature of lighting upgrades, and the attractive financial returns that lighting projects often provide. I'm pretty sure we're all aware of that. A quick snapshot of the higher education sector, see our membership list on the right there. Definitely leaders nationally, and we appreciate all those efforts. Just want to emphasize that in terms of the Interior Lighting Campaign, you don't need to be a member of Better Buildings – not a heavy lift to join, but you can join specifically

Interior Lighting Campaign; that's okay. Anyone with questions, I encourage you to reach out to myself.

Want to put a plug in here for the Better Buildings Solution Center, along the lines of access to experts and case studies, our new Better Buildings Solutions Center makes finding resources easier than ever. It's basically a searchable database, pretty user-friendly, and we are adding resources to it every day, so I encourage people to go there. Other ways to stay informed – we have quite a few options and a few regular e-mail blasts that go out. When we send out this deck afterwards, the hyperlinks will be live so you can access them then. Also want to encourage everyone on the call to attend the Better Buildings summit coming up this May. This is the one time a year that we do get together in person. The rest of the Better Buildings effort is all done as remote. It's on the phone; it's intended to be easy to participate in, low cost for our partners. But the summit is that time of year when we all get together, and all those opportunities are there – so access to experts, peer-to-peer learning, and recognition. Again, you don't have to be a member of Better Buildings to attend. That link is easily available on our website.

Okay, real quick, just want to emphasize that the Interior Lighting Campaign is not a product of whimsy. We do decide what to focus on through a rigorous prioritization process that we call high-impact technology characterization. So what we do is – we're looking for, what technologies out there will realistically make a big difference in the market in terms of energy efficiency, and is there a role for DOE in promoting it? So we look at literally hundreds of options, different technologies, and put them through over 20 different criteria to decide where to focus our efforts. So this is just kind of a look at the screens we put them through – a simplified version, where we go from the broad list to the high-potential technologies, to our final high-impact technologies listed. And depending on what we recognize as the barrier to market transformation – we'll either do a challenge, a demonstration, a specification, or in the case of Interior Lighting Campaign, a campaign. And a little bit of background on that concept for us, this is basically a stand and be counted effort. There's a lot of LED projects going on out there, but there's still a significant amount of hesitancy on the part of all sectors, but certainly higher ed, there's a pretty low risk tolerance there, and it can be hard to push these projects across. So by promoting this campaign and recognizing what we hope to eventually be one million installed LED lights, we can show the nation that this is a technology that's arrived, it's safe, it's been done many times before, and there's a wealth of resources

to draw on. Other campaigns that have done the same thing: Lighting Energy Efficiency in Parking, and the Advanced Rooftop Unit Campaign. Both of those focused on specific technologies related to parking lot lighting and RTUs. Okay, but the Interior Lighting Campaign – the ILC, as we abbreviate it – is focused on high-efficiency troffer lighting with controls. So we are really putting the crosshairs over one specific technology that's out there – one specific type of light, and how we can make it better.

We launched last year at our summit. The goal is to replace a million standard troffers by next May, and that will save the nation about $6 million. So we're going to have a list of resources available for everyone to use, not just those that are participants. Michael will get into that a little bit more in a second here. Why do participants join the ILC? Again, it's the same thing as the Better Buildings in general: access to experts, peer-to-peer learning, and public recognition. I took a look at our registration for today and I noted that we have a lot of reps from lighting companies that are out there promoting this technology – probably their own version of this technology – and also interested parties from higher ed. And we certainly want to welcome all those people, but also emphasize that we intend to be that objective resource. It's one thing to approach a university or college and say, "Look, you're running T12 lights; you should upgrade," and they say, "Well you're a salesperson; of course you would say that." These resources are here for you to draw on and say, "Well look, it's not just me and my company that's saying this; there is objective support from Department of Energy." Same thing goes for those facility managers, the sustainability managers in higher education places, that go to your administrators and say, "Look, I think we should do this project. It's going to save energy, it's going to save money." They say, "Well what do you got? Prove it," basically. That's what we're here to help you do. So please do lean on us for that.

A couple other examples – many universities out there taking a leadership role. Just want to focus on a couple. UC-Davis and the California Lighting Technology Center there has many resources available – there's a link available there. They have a great case study on adaptive corridors, specifically related to troffer lights at UC-San Francisco, and a great short video on the 2012 lighting project that UC-Davis did. Towson University – Stephen Kolb, the energy manager there, spoke at our September lighting team call, and we were thrilled to hear him say that in 2014, TU standardized on LEDs everywhere. That's a shot of their library right there, and troffer application. There's a link at the bottom to Towson's BBC – Better Buildings Challenge – partner profile on our website.

Okay, last plug for recognition. We are going to announce awards for Interior Lighting Campaign projects at the BOMA conference coming up in June. So that is a big conference; touches a lot of people, gets a lot of high-profile attention, and we encourage all participants to submit for an award, or if you have a project that you think is exceptional, please do reach out to us for an award application. For those sales reps out there, if you know of a good project that you're particularly proud of, same thing. Encourage those people to apply for an award.

Okay, at this point I'm going to hand off to Michael Myer, the senior lighting researcher, Pacific Northwest National Laboratory. He's been with the Laboratory since 2007. Michael is involved in several major lighting programs including appliance standards, Lighting Energy Efficiency in Parking campaign – LEEP – the Interior Lighting Campaign, that's market transformation programs. Michael, I actually don't have your undergrad institution and mascot here. Do you remember that?

Michael Myer: I went to Arizona State. I'm a Sun Devil.

Andrew Mitchell: Go Sun Devils. All right. Well thanks, Michael. Take it away.

Michael Myer: Thank you. I'm going to have to push through the slides again real fast. The order got mixed up – my apologies. While doing that, I get the benefit of presenting the big number on troffers. First thing to know for higher education, national grid estimates that it's about $1.10 per square foot on electricity used in higher education, in colleges. Lighting's about 31 percent for higher education facilities of the electricity that you use, and troffers are about 50 percent of all fixtures. Why that's important is that they're probably one of the single biggest users of electricity and energy to focus on. Let's talk about that in pure numbers. There's about 367 million troffers in the U.S.; that's roughly one troffer per every person, or if you think about how many troffers you have, that's about one for every 240 square feet of building space. So they're pretty much everywhere; there's a lot of them. When you look at the fixture itself, they don't use a lot of energy. When you look at them in an aggregate, you're like, "Whoa, that's a lot of energy they do use." So when you look at just one device, you might think it's not enough. But when you look at your whole portfolio, it's a surprising amount. We have what I call the troffer conundrum. There's about eight options of what you can do. Essentially you can do nothing; you can just install fluorescents. You can move up into mixtures of replacement technology, either what we call tubular LEDs or TLEDs, or retrofit

kits, or up to a new fixture. As you go, you get more energy savings into the higher options, because you can pair them with more efficient technology and controls. We have a lot of resources on this, and what you should look at. But it's always just good to know what your options are.

Andy did a great job presenting on the high-level stuff, so again, I'd like to reemphasize, it's a million troffers by May of 2016. They can be tubes, kits or new fixtures. We do have it set up so that some fluorescent can comply, but it does have to be pretty super high efficient technology. We do have awards for both new construction and retrofits. Andy mentioned, we have some technical assistance available. We are third-party; we are trying to advance energy efficiency, so if a higher education facility calls up or e-mails and says, "Manufacturer A claims this; it sounds really weird. Is that true?" We can look at it and say, "Yeah, that is true. You can get a 40 percent savings by doing what they're recommending." Or they might claim that their product lasts a million hours, and we say, "Well, there are some technical things you should ask for. A million hours is not a realistic claim unless they can back it up with these five data points," and those type of things. I did use the million hours there as a pretty extreme example, but when you move to some of these newer technology, we're seeing now fluorescent lamps that last for 50,000 to 80,000 hours, and we see LED claims of easily in the 50,000 to 120,000 hours, depending on the right variables. So these long-life claims are true, but when you start hearing some things that are out there, maybe 200,000 hours or a million hours, there's not a lot of data behind that, and they may not have done the right math to verify that.

Participants, you get to learn from others. We do provide technical assistance. We also have a lot of resources available. Supporters, if you join, it's a great way to possibly reach out to others. You can have your efficiency program promoted through us, and it's also a good way to meet other contacts as well.

This slide is just a quick highlight of all the different resources that we have available. We have a performance-based troffer specification available. It does not have to be used to participate, but it is available if you do want it – you will, if you follow, that you would meet and exceed the levels of minimum participation. We also have report fact sheets. The Department of Energy has a program where we actually test equipment, and it provides some fact-based information that's somewhat anonymous, where you go through and read what the manufacturer did and what they claimed

and how it performed. We also have, as I said, technical assistance. Also we provide a pretty mini-database, and when I say mini, that's truncated to just troffer lighting controls related to troffers. So if you're out there looking for your facility and say, "Oh, what are the incentives available?" You can go out to our website and we provide lists of what's available. At this point, we're going to hear more about William Evans' background and what's the great thing they did at Princeton.

Andrew Mitchell: Great, thanks Michael, and thanks for the run-through of those resources that are available. I encourage everyone on the line to check out our website. We will hand it off to William J. Evans, P.E. He's currently working in the facilities engineering department of Princeton University – go Tigers. William is a 1994 graduate of the New Jersey Institute of Technology – go Highlanders. And William has spent over 18 years in electrical engineering. Mr. Evans has been involved in lighting, power, plant automation, building automation and fire alarm design for high-impact polystyrene and antibiotics manufacturing plants. That sounds a little more complicated than a smoke detector. William is interested in finding and promoting functional solutions to electrical and lighting projects that balance the first cost need of a project with the long-term needs of the maintenance department and users. I'm sure this project at the Icahn Laboratory is a good example of that. William, take it away.

William Evans: Thank you, Andy, and thank you, Michael. It's my pleasure to be here this afternoon, or this morning, depending on which time zone you're in. I'd like to talk a little bit about what we did in the Icahn Lab, and what we learned from it. So here's a picture from the field outside. It's overall 98,000 square feet. There are 35,000 square feet of labs on two floors, about a 150-person capacity. It has a beautiful central glass atrium and two-story curving glass wall. Glass wall is shielded by 31 external 40-foot vertical aluminum louvers that rotate with the sun to maximize the shade, and at the same time minimize thermal loading of the building. And this is also the first building-wide interior LED project on our campus here at Princeton. So the annual lighting energy use of the building is about 564,000 kilowatt hours. It's about a $50,000.00 annual cost. The lab and office space lighting is about 815 fixtures, two by two luminaires. Each one was a T8 U-lamp type of bulb, and there were acrylic prismatic lenses which we left in place, and they draw – 59 watts was the existing draw before the retrofit. And it's estimated that the operate about 5,000 hours per year – could be more than that – and about 240,000 kilowatt hours annually, or about 43 percent of the facility's annual lighting energy use is

contained in the lab and office spaces.

So the issues. The removal of the existing fixtures and replacement with new was not seen to be cost-competitive, due to the amount of labor required, and also the fact that it was an occupied facility that needed to stay functional. And based on past experience with the lab users on campus, a simple on/off type occupancy sensor configuration was considered to be a nuisance by the users. They had a habit of becoming deactivated mysteriously. So we looked around at various solutions, and what we came across at length here, and then we took a sample of it to take a look at, was this troffer solution. It was a pan retrofit, available from Maxlite. So the beauty of this was that it basically was just the removal of the existing ballast and fluorescent bulbs, and then four screws that would hold this in the drivers contained behind that aluminum baffle, and the LEDs are pre-mounted on the pan. The output is about 3,300 lumens. It's about a 45-watt power input, and the color temperature was about 4,100 K. Minimum CRI was 82, and it has a 0-0-10 volt control, and what that means is that at zero – the first zero – it's off. And that's actually kind of what put this a nose ahead of some of the other competing technologies at the time of this project's approval. It's also safety certified by ETL, Design Lights Consortium Products List member, and it yields over 57,000 kilowatt hours in annual energy savings before the controls were taken into account.

So next I'd like to talk a little bit about the control solution. We went with a Lutron Quantum Ecosystem with a zero to ten volt ecosystem converter, to drive groups of fixtures. Those converters can handle up to two amps, and that's a picture of one. We also have found through piloting in smaller locations around campus at the Lutron wireless motion and daylight sensors, shown here and here, were quite effective. They have very good battery life, somewhere in the order of ten years, ten-plus years, is expected lifetime for the batteries. And we also went with the Lutron Pico wireless dimmer switches, shown here. Those are also very effective, and in our case because we went with the dimmable drivers, we were able to use dimming controls. We found that to be of great benefit, because that helped us to get around one of the issues that we had had with motion sensors in the past in lab areas around campus, which was, we could have a bi-level dimming philosophy so that if nobody was in a particular area of the lab, we could dim down to a very low level without the chance of annoying the users, and then when somebody would come into that area of the lab, it would boost it back up to the high level, thereby avoiding the off state, which was seen to be uncomfortable by the

users during occupied hours.

So we did some measurements – or actually I should give a shout out to Bob Davis from Pacific Northwest National Labs; he was essential and very helpful in all of this data gathering. But he took readings of the Icahn Lab room 222 before and after the retrofit. And here's a layout of the fixtures that you just saw in the picture. And these are the results they had. In the left column is the fluorescent, was an average of 62 foot candles, and then the LED was on the right, was an average after the retrofit of 103 foot candles. Now you may say, "Well, that's way overlit," and you'd be right; we don't need that might light. The beauty of having the Lutron Ecosystem – and you can do this with many other systems as well – there's other control systems from Philips, Dynalite, Crestron and Fifth Light that I'm aware of, and there's probably more – that is, you can do a high-end trim on this, so you can reap additional savings, not just from the LED retrofit, but also from the high-end trim, which is really invisible to the users. You can just go in and tweak it down to a level that is comfortable for everybody, and you get a double benefit in that you also get the additional lifetime that that provides for the LEDs themselves. And then also there's the columns for illumination at the window top – horizontal illumination at the top shelf. Before was 91; after was 149. And then the vertical illumination at the top shelf before with the fluorescent was 40; after with the LED was 65.

And here's the layout, again, of that same room. And here are the color measurements that Bob Davis came up with. He did color measurements at each fixture for the fluorescent of the left side – the fluorescent CRI – and then the LED, which was much more closely grouped. So that was very nice, as well as the enhanced CRI of 85 without fail on each of those fixtures. So before, we had anywhere from 2,800 color temperature to 3,700. And you could visually see this as you walked through the lab, that some fixtures looked warm and red; others looked cooler and blue. Whereas after the retrofit, it was a very nice, even 4,300. And then he also came out and he did measurements in the corridor for us, and this was his measurement setup, that you'll see on the tripod. And here's a layout of the fixtures in the corridor, 2-3-3. The horizontal illuminances were measured at three foot above finished floor, centered under the fixture row. Vertical illuminances were measured at five foot above the finished floor, along the south wall, aligned with horizontal measurement locations. And here the results with the fluorescent, the horizontal average was 53 foot candles; the LED horizontal was 96. And for the fluorescent vertical, came out with a mean of 30 before the retrofit, and with

the LED vertical, it was 53 1/2 afterwards. And then here's a picture of the open lab area. Horizontal illuminances were measured along the counter at two-foot intervals in the open area, and point zero was at the window at end of the bench; .14 was at the end near the inner wall. And again, across the board, the fluorescent column, which was before the retrofit on the left, the LED on the right, and then the means as well, giving us quite a bit of high-end that we are able to trim with our controls.

Another area was the CFL downlight area, which we retrofit to LED as well. And this was the solution that we came up with the downlights. It was an LED downlight retrofit kit, available from Terralux. We worked very closely with them, and vice versa, which we were very happy to work with the manufacturer directly on developing this solution for buildings around campus. It has a 60,000-plus hour L70 lifetime on this fixture, 80-plus CRI, 92 lumens per watt, and it is Energy Star rated. And this is a picture of one of the areas that we retrofit with the Terralux solution. And again, this is some of the measurements that we did of that Terralux area. The horizontal foot candles, vertical foot candles, are shown here. And in this case, we just had an opportunity for after measurements. And here's the color temperature results. So a little bit warmer than the fixtures in the lab areas, but this is acceptable for this area. 3,500 is a pretty typical color temperature that we look for around campus, and this area in particular where people are gathering, and they're not really concerned so much about the lab functioning itself. It was nice to go a little bit warmer.

And here's a picture of the inside of the atrium. Another picture from the other side. Here's a picture inside the lab showing the work cubicles along the right side, and another shot from outside the lab. So the summary of our experience was, we experienced just top number to top number of the fixture-to-fixture before the controls was 24 percent energy savings off the top. Now we're expecting to see more than that, because like I showed you, the ability that we have to do a high-end trim, and also the bi-level motion sensing allows us to have additional savings in these areas. Light levels and color temperature consistency were improved throughout the space, and it was quite visible and commented on by a number of users, that they appreciated that consistency. And lower maintenance costs are expected, thanks to the increased time between failures of the fixtures.

And now I'd like to say a little bit of a background, just campus-wide, that it's one thing to reduce the costs because of a more

efficient fixture, but I think it's also important to look at what was done to reduce the cost of the energy going to that building. Because we're on a campus, we have an opportunity to think campus-wide, and I think there's a lot of opportunity for this – many users around the country. But what was once a military jet propulsion technology, was used in such things as the Lockheed F-117 Nighthawk, as well as the McDonnell-Douglas FA-18 Hornet, has now been bolted down in our cogent facility and strapped to a generator that generates up to 15 mega watts of electricity, as well as abundant steam output. And we're able to get up to an 80 percent energy conversion efficiency, so even before retrofitting to LEDs, we're already driving costs of the electricity that we're using and building down as much as possible by generating power when it makes sense. And here's a shot of the cogent facility. On the left is the cooling towers; in the center is a chilled water storage tank, about half that tank is actually below the ground. And you may say, "Well, how do you get chilled water from that?" Well, the steam is used to drive absorption chillers, and that's a good way to make chilled water in the evenings when the thermal efficiency is favorable, as well as the electricity is cheaper when we are on the grid. But we have the ability to go between the grid or the cogent.

And I'd like to think what comes next. There's a lot of technologies out there, and some of the things that we're looking at are, does low-voltage DC distribution make sense? And we believe that it does. One of the companies that has come to our attention is a company called Nextek Power. Here's a little diagram of their understanding of what could come next. And what this does is, it gives you the ability – it gives all of us the ability to drive the LEDs directly with direct current power, rather than having to have additional inefficiencies of having drivers that convert the higher voltage AC to DC. Why not just drive them at 24 volts, is what Nextek is asking. And we're asking the same thing, to be honest with you. And that's really of notice in the upper part of the diagram – their concept of tying in solar and other alternative generation sources, directly to the lighting in the building. So there again, you would reap additional benefits of efficiency without having to do a conversion between AC and DC, because generated DC gets used directly while it's still DC.

What else comes next? Well, there's other technologies that we are starting to look at, and even considering the possibility of replacing troffers with this technology in some cases. So what happens when we think outside of the traditional ceiling troffer? Well, we start to think 24-volt DC LED grid lighting makes sense as one possibility. And there are a couple installations in the local area here, as well

as some of the areas on campus where we're starting to pilot this in place of troffers. And this technology – there's a couple companies that do it, but we've been working with Goldeneye, and this is an installation that they did at the local datacenter called Steel Orca.

And that's about all I have. I'd like to leave you with this thought, that the path to enlightenment begins with a walk around the block. That's by Philip Delves Broughton.

Andrew Mitchell: Well thank you very much, William. That's a very sort of philosophical Princetonian way to finish, and we appreciate your deep dive into some of the technical aspects of an interior lighting retrofit. It's definitely something that oftentimes, it's hard to really dig deep into, and your willingness to share with other peers in the higher ed community, and really anyone, is really appreciated. Next we will look at not technical solutions to Interior Lighting Campaign – interior lighting issues – but market solutions, or financing solutions. Victor R. Clements, CPA is currently with the University Financing Foundation, a national 501(c)(3) private operation foundation whose mission is to assist institutions of education and research in obtaining facilities and equipment at below market cost. TUFF is a blend of real estate, capital markets, investment banking and public finance, with the primary focus to create facilities for institutions which can use those facilities to expand programming at the institution. Vic is a 1987 graduate of Georgia Southern University – go Eagles. He has spent over 25 years in public accounting and senior finance positions, working with organizations ranging from startup companies to larger concerns with international operations. Vic has a particular interest in combining innovative financing strategies with environmentally friendly building solutions to assist the research and education communities. Thanks so much for joining us, Vic, and please take it away.

Vic Clements: All right. Thanks, Andy. I appreciate the opportunity to be with all of you folks today. So a little bit about who TUFF is. We're a 501(c)(3), not-for-profit, founded in 1982. TUFF was actually founded as a result of an issue, a problem, that Georgia Tech had. The president of Georgia Tech at the time, Dr. Pettit, wanted to increase the research enterprise at Georgia Tech, but the state would not provide funds to build facilities for research. And so he went to four alumni and said, "Can you guys figure out a way to help me increase research at Georgia Tech? Can you get me facilities so that I can recruit researchers? There's a place for them to work." So those three individuals went to local attorneys, and discovered that they could start a foundation, and a foundation that

would have the mission of providing and assisting institutions of education and research, by providing facilities and equipment at below market cost. And so what started back in 1982 really as solving a problem for Georgia Tech, has since grown to many of the other institutions that we have worked with and continue to work with, and with a national charter. We're often invited early into the decision-making process when the C-suite at an institution has an issue that they need help resolving. Our objective is that we'll provide turnkey facilities, equipment renovation and energy efficiency projects faster and at a lower level of cost than institutional development methods may provide for. So frequently, institutions – there's a long process and a lot that they have to go through in order to bring a project on board. We tend to be able to push that project through more quickly, working with the markets both from a construction perspective, and from a finance perspective. TUFF's been a participant, supporter and sponsor of the Better Buildings Challenge since its inception in 2011. We were on the steering committee through the Atlanta Better Buildings Challenge. We've participated in over $1 billion in development projects, financings and loans, and for more information after this you can visit our website at www.tuff.org.

So what is TUFF? We're not a speculative developer, so we're not an Ambling, an American Campus Communities or Place Properties. We're not an energy services company, so we're not a Siemens, Energy Systems Group, Johnson Controls, et cetera. And we're not a vendor. What we do is, we come in and we sit on the same side of the table, if you will, as a partner with the institution. We help them evaluate who is the best developer for a project. Who is the best energy services company for a particular project. We'll help them with the RFP process. We'll actually go and purchase land on behalf of the institution. We'll develop what other project it is that they have the requirement for, so that could be classroom facilities, it could be research facilities, it could be student housing, it could be renovation of an existing facility, and I'll get to some examples of that a little bit later. We'll bring independent, realistic views of the market – again, an objective view, because it's – we're agnostic as to who the energy services company that would come in and do an energy retrofit, or who would come in to design a new facility, whether that be from an architectural perspective or from an engineering perspective. We're an accelerator, so we will forward fund projects for institutions, whether that just be the up-front cost of having design drawings or preliminary evaluations of what energy savings are possible, having new investment rate audits performed – on behalf of the institution prior to a project beginning. And we also consider

ourselves an innovator, and a little bit off-subject for today's discussion, but really in activating projects and creating community in the projects that we're involved in and develop. This is probably more relevant in this next slide for the CFO types, who may not be on the phone today, but I think it's good for you to know that often, when you're trying to get approval for a project through the chief business officer of an institution, they have other issues that they have to consider. And frequently, one thing they consider is, how does this impact us from a financial perspective, and particularly from a ratings perspective? And how does it impact our balance sheet? TUFF is somewhat uniquely able to structure things that will remain off the balance sheet of the institution, if it happens to be something that's important to the institution.

So one example of a project that we've been involved in is the GTRI Cobb Research Campus. So this is Georgia Tech Research Institution; it's a 160,000 square foot cluster of six buildings. It's on 52 acres near Dobbins Air Force Base, just outside of Atlanta in Cobb County. We've actually leased this project to them since the mid-'80s, and the original construction of this project was in the mid-'60s by Lockheed-Martin. One interesting thing is that when you walked into even the building that's on the screen – when you walked in the front door and turned on the light switch, that turned on every light on that floor in the building. So needless to say, there was a lot of low-hanging fruit available to us there. We did a deep energy retrofit and renovation, reduced annual energy costs in excess of 40 percent. The renovation was $14 million; probably over half of that was mechanical systems. The remainder of that was just upgrades – more aesthetic upgrades, if you will. Energy, capital repairs and annual maintenance were reduced by over $800,000.00. And if you've got research facilities on campus, and you've got an independent third party, grants through whether it be – it could be through DOE or DOD – but the lease payments for projects like that, as long as they're independently owned by third parties, are fully reimbursable under those research grants. So all of the renovations and the lease costs associated with those in this particular project, which the majority of this is used for Department of Defense research, are reimbursable under those DOD grants – the research that's done there.

The Clark/Spelman Central Utility Plant – so back in late 2006, Clark – Atlanta University and Spelman College had been sharing a central utility plant that was originally built, I believe, in the '30s, and has last been renovated either in the late '60s or early '70s. And an unfortunately story that the CFO of Spelman tells is that he was

at a convention of some sort, and one of his comrades said, "Did you know that you were on *Good Morning America*?" And unfortunately this plant had completely failed, and Spelman was actually on the national news with the students complaining that they had no heat or hot water in the dorms. So anyway, they called us. They wanted a new independent owner for the plant. We did a complete renovation – a $12 million renovation originally – back in 2009, and hired – you know, went through an RFP process to hire an energy services company that ended up being Energy Systems Group, to not only renovate the plant, but also to operate it. And then last year, we did an expansion of that. So that central utility plant, I think, serves 39-plus buildings and growing, because there's some additional capacity. You can see the reduction in kilowatts – 15 million kilowatt – 27 percent reduction equivalent of 1,555 homes of electricity use per year.

Centergy One – this is a complex in midtown Atlanta; it's where Georgia Tech expanded across the interstate, I-75 and I-85, and it also is the home of Georgia Tech's incubator, Advanced Technology Development. This is an example of a small project that we'll just fund out of the checkbook, if you will, as opposed to doing over large financings for either new development or the energy retrofit like the central utility plant and the one at Cobb GTRI Research Campus that I mentioned earlier. So the cost was $150,000.00; we did re-lamp the entire building. There were some lighting controls. We instituted day cleaning, so that in theory, all of the lights go off earlier during the day as well. And it decreased utility consumption by over 26 percent, which has netted an annual savings in excess of $350,000.00 for that project.

Technology Square Research Building – performed numerous projects. They're laid out there; I don't need to read through all of those for you. The total capital cost was $265,000.00. Decreased utility usage by almost 32 percent, netting annual savings of $177,000.00. This is a facility that we leased to Georgia Tech. We financed the in-house over a three-year period, so the annual savings were $177,000.00, the lease payment was maybe $95,000.00. So Georgia Tech saw an immediate cash savings on an annual basis of $80,000.00 for the first few years of the project, and now they're realizing the entire savings of $177,000.00 on an annual basis. So when we come in and try to do these projects, we're trying to make the institution whole, or have them ahead on a cash flow basis, really from day one on those projects.

There are my contact details, and I will turn it over back to Andy. Thank you.

Andrew Mitchell: Great. Thanks a lot, Vic. Great to know that there's options out there, and that TUFF is available. So again, we'll send these slides out afterwards for contact information, and we're certainly easy to find here at DOE. We did get a number of questions that came in over the course. One of them, directed at myself, was, are the campaigns separate from sectors when participants join? Short answer to that is yes. We launch these campaigns in an effort to kind of bust the doors wide open for anyone in the country who's doing great work, wants to be recognized as a leader, or would benefit from learning from their peers or access to experts. So you can join Interior Lighting Campaign if you change out on troffer from an old-school fluorescent to one new energy efficient technology – probably an LED, but not necessarily. If you include censures and controls, all the better. And that number goes all the way up to – Target, I think, committed to over 70,000 LED troffer lights from their stores, so that the range is big.

Okay, Michael, can you provide a rule of thumb on calculations for how the dimming extends the LED lifespan? Talk about that in general; I don't mean to put you on the spot. And also can you review what bi-level dimming means, again, and when that approach is used?

Michael Myer: Yeah. The idea is that LEDs don't like heat. They're rated at – when they test them in a laboratory, they're tested at 25 degrees Centigrade, and then we do some math extrapolations, and based on those math extrapolations, we test them out for about 6,000 hours and we say, based on this hot/warm environment, they will keep producing light for a period of time. If you are running them at a lower output, you are not running them at the full current, so you're getting slightly less heat. And therefore if you're getting slightly less heat, you should have an extended – somewhat of an extended – time that which they will continue producing light. And I wish there was a rule of thumb, but there's too many variables there. It depends on the LEDs themselves. It also depends on the fixture that you're using, and a couple of other things. So the easiest thing to do is, it helps it, but I can't just say a two times multiplier or a three times multiplier. But the easiest thing to do is just look at your data sheet. In terms of bi-level, that's just typically what we mean by bi-level is, full output, and you have somewhere between full output and no output, usually a low output. And the idea there is that – stairwells is a great example. Not everybody feels comfortable with the stairwells going dark, so what they often do is a bi-level, so they say, "Okay, we'd like our LEDs to go out

to, let's say, 30 percent – or not even LEDs – any light fixture to go out to a 30 percent output at a low output setting."

Andrew Mitchell: I see. So whereas in my dining room I might have one of those slide switches to create just such a mood; for a university stairwell it's either 100 percent or 30 percent or – well, probably never off unless there's windows – but it's a more simplified approach to dimming. Okay, that makes sense. William, a question for you – actually a number of questions came in along the same lines of what you can tell us about the feedback or experience that the students and staff had. Did you get complaints or compliments? Also were you able to determine if there was any change in productivity after the installation?

William Evans: We had many positive comments back from the users about the way that it looked. It looked brighter because of the cooler color temperature, and also because of the more even color temperature between fixtures. It was a definite plus. It didn't draw people's attention to the lights. So when you walked in, you could just pay more attention to what you were doing, really, rather than looking at which light looked warm and which one looked cool. As far as actual productivity, I don't have any data on that. But I do think that in general, what I've heard and seen across organizations such as the university, is when people feel like you're trying to do something to help them, there's always a benefit to that. It's a benefit even greater than adding money to their paycheck, from what I've heard anecdotally, is that they feel like they are being cared about, basically, and being treated as human.

Andrew Mitchell: Got it. Yeah, that's a really interesting point to make. There's that appreciation level. Okay, we're coming up on the hour. Michael, I'll send one more question over to you. I feel kind of like a radio host saying, just in one minute, can you talk a little bit about power over Ethernet – POE – it seems like it's going to be a game-changer. What is your opinion of POE?

Michael Myer: So power over Ethernet means that instead of running a separate wire for data and power, it's all coming through in a cat 5 cable – or maybe it's not cat 5 exactly, but it's a cat cable. And this is like, if you plug in your router, that's the same type of cable that you're getting. But instead of having to have a separate power cord, it's all coming through there. The advantage is, you have now one set of cabling, you have both data and power coming. You can do a lot more – we talked Internet of things and all the data analytics that you can use, and so now you're just getting your data through there. So it's a great idea. I do like it in concept. Where I would

have some reservations about it would be in a retrofit scenario. If you're doing new construction, William showed a great example where they're using DC power. POE might be another whole idea in a new construction. The reason why is that your labor to – in a space where you already have a fixture and you're just replacing it, that's a minimal amount of labor; you don't have to run any new wiring and those types of things. In a major wholesale retrofit where maybe you're just leaving the shell and ripping everything out, which is essentially new construction, POE might make also sense there. It's been around for about two to three years, and we're seeing some major players, not in only the lighting world, but in the IT world, a partner with the major players in the lighting world, come out with some new products and new technology. So it's a great start. I'd love to see where it is in two or three years. I would definitely promote it and say it's a good idea, but make sure it's the right application.

Andrew Mitchell: Okay, good to know. That's definitely a look forward for folks getting off the call now. That's something to take away, the future is coming. Lights operated by a fire wire and controlled from your computer – the possibilities are endless. We are at the top of the hour. We have a lot of great questions here, so I want to invite folks to stay on the line if you're interested in hearing more questions. If you asked some questions and are looking for answers, we'll probably stay on for five or eight more minutes, if William and Vic can give us that time. But for those that have to leave us, I want to thank you for joining. I encourage you to seek more information from our website and reach out with any questions. With that, I'll take a question to myself here. Is there a program in the Better Buildings Initiative or Interior Lighting Campaign program for LED exit sign retrofits and LED under-cabinets? That's a great question. What I was referring to back at the beginning of the presentation was how we approach what to focus on. And we decided for the opening year of the Interior Lighting Campaign, to focus specifically on troffers. This is this ubiquitous fixture; it's in almost every commercial building; certainly all over college campuses in the U.S., and by focusing just on that, we felt we could have the most impact. But as we move forward, we will expand the Interior Lighting Campaign to other applications like the downlights that William discussed, and certainly the LED exit signs, or exit signs in general – those that are on, burning 24/7, have great potential for energy savings. So look forward to that in the future. We haven't made any determination on what we'll focus on next, but we will use that rigorous prioritization process we have to decide where to go.

William, I'll send another question over to you, and I'm not sure if you have numbers handy, or to what extent you can share them, but a lot of questions came across regarding some of the financial savings that came from the project. What is your maintenance savings on fluorescents versus the retrofit LEDs? What was the cost of the installation, and do you have an ROI yet? And when will you get numbers from the savings from controls? William, don't feel obligated to answer all three of those, but if you could speak to the finance in general, that would be great.

William Evans: To be honest, I don't have the numbers in front of me, but I do know that it was less than a five-year payback for the project. And as far as the controls payback, part of what went into that was the 0-0-10 volt control allowed us to kind of have the advantage of the Lutron Ecosystem, along with getting a standard fixture retrofit kit from the manufacturer. So it enabled us to kind of almost have our cake and eat it, too, as far as the costs to us. It was also a little bit less expensive, as I understand it, than buying and installing a brand-new fixture in this instance. If it had been a new installation – obviously if I had my druthers, I would go ahead with a brand-new fixture, no question, with the Lutron Ecosystem or comparable control system built into the fixture, such as a Dolly system, which the driver – it simplifies it a good bit when you can do that. In this case it was kind of a special case with an existing building, so that option was not available to us.

Andrew Mitchell: Got it. How about the savings from the control functions? Is that the type of thing you'd measure over the course of a year, or an academic year?

William Evans: It's something that I'm thinking that we should be able to get off of the system, but at this point, I don't have any of that information on hand. But I hope to get a hold of that information.

Andrew Mitchell: Got it. Yeah, it sounded like, from the numbers you quoted around 50,000 kWh savings a year or just approaching ten percent – that was before controls in general. So some impressive returns there. Some questions came across also, William, regarding the systems that were in place before the retrofit – the fluorescent lighting system. How old was it when it was replaced? And what type of troffers and lamps were in place?

William Evans: The existing fixtures were – actually the bodies were reused – but the existing bulbs were 32 watt U-Bend bulbs. I think they were running at 31 watts, based on our measurement. We were getting about 59 watts total for the fixture. I don't know what the

manufacturer of it was, but I do know it was two U-Bend fluorescent type bulbs in each fixture.

Andrew Mitchell: Do you know a ballpark of how old they were?

William Evans: They were original to the building. And I want to say the building is probably about ten years old. Again, I don't have that information right in front of me. But they were the original fixtures to the building.

Andrew Mitchell: Got it, okay. Vic, maybe I'll send that same question over to you, or one of those same questions that came in earlier on any reports you got from users, either students, staff, researchers – complaints, praise on any of the projects you mentioned, either Centergy One, the GTRI Cobb Research Campus. What was the reaction of the people working in those labs?

Vic Clements: So particularly at Cobb, just because there was complete renovation that included aesthetics, everyone was absolutely elated. There was a significant challenge with that project, because we did the renovation on a building-by-building basis. So we literally moved researchers amongst the buildings, and only closed on building down at a time, and were able to complete that in a three-month shorter schedule than what was originally envisioned. All the researchers were elated. They thought that the lighting improvements were significant. The comfort level in the building was significantly improved. Everything was just incredibly well-received. At both Centergy One and Technology Square Research Building, we get the tenants very involved, the occupants very involved in what we're doing, including – we put in some, we call them green screens, that showed what improvements were occurring, the savings that were generated from the various improvements that we did install and put in place. So there was both the buy-in from a green perspective, as well as obviously the savings that everyone enjoyed. Therefore they were able to use the dollars that would have gone, as someone mentioned earlier, up in smoke or up a smokestack, for additional equipment, lab equipment, et cetera, that they can use in their research.

Andrew Mitchell: That's great. I take that as kind of a pro tip, and I wrote here in my notes, "occupants were elated." I think that's a really good point, that there's more to these projects than just the technical savings that go into it, and getting that buy-in from your occupants, from your tenants, from your students staff, researchers, can be a big win. So thank you for that, Vic. On that note, I think we can wrap it up. We've covered most of the questions. For those that we were

not able to cover, please do reach out to us. This is one of our favorite topics, and we look forward to discussing it more. Again, I encourage all those attending to either join if you are doing an interior lighting upgrade on troffers and controls, or if you're a manufacturer or contractor, please encourage the projects you're working on to join us – stand and be counted and be recognized for leadership. So on that note, we'll wrap up. Thank you again for everyone. Talk to you soon.

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