Timothy Unruh:
Hello, I'm Timothy Unruh, Program Manager for the Department of Energy's (DOE) Federal Energy Management Program (FEMP). Welcome to the 2012 series of First Thursday Seminars. This year FEMP is expanding its training course offerings to help you gain the core competencies necessary to fulfill the Federal Building Personnel Training Act. Furthermore, we recognize the ever-increasing challenge to making our building the best performing they can be. We believe that expanding our training and building performance improvement, especially in energy efficiency can make our workforce best-in-class.

This training will focus on core competencies to meet key job performance goals. We want to provide you with real on-the-job skills that make a difference. First Thursday seminars will help you obtain project funding through a streamlined ESPC process tailored to meet the needs of small sites; place UESC task orders under a GSA area-wide contract; identify, select and deploy new and under-used technologies to drive markets and accelerate change; achieve the great possible energy and cost savings through deep retrofits and identify critical opportunities and implement action plans to achieve energy security in Federal facilities.

The new knowledge and skills in these seminars will help you do your job better, help your agency reach its energy, water and other building performance and sustainability goals and help our government save taxpayer dollars. Through our efforts we want to make the Federal building stock a place of innovation and high performance and efficiency, basing our success on the measured results that we achieve.

Visit the FEMP website for the most up-to-date information, view archive seminars online 24/7 and register for upcoming seminars. We also hope you will take a few moments to provide us with important feedback through the evaluation at the end of this program. Today we can continue to learn, improve our core competencies and meet new energy challenges with confidence. Enjoy the seminar and thanks for joining us.

Kathy Hyland:
Hello. Welcome to the Federal Energy Management Program's First Thursday seminars. I am Kathy Hyland and I will be your moderator today. This is the first course in the 2012 series and it will focus on new lighting technologies. You will note some changes in the First Thursday seminars this year as we align with new requirements to address core competencies for Federal energy and facility managers. If you would like to call in a question do so immediately after the presentation. From time to time on your screen you will see an email address, a fax number and a phone number to ask questions.

We have two instructors today. Jeff McCullough is a senior research engineer at DOE's Pacific Northwest National Laboratory (PNNL). Jeff has led the development of the first ever Energy Star criteria for solid-state lighting and most recently completed the Lumina Maintenance Test Facility, which tests submission for the L Prize competition.

Brian Liebel is a registered professional electrical engineer. His emphasis is in lighting design and energy efficiency with expertise in lighting and vision-related research.

We also have with us live from Washington, DC at the Department of Energy Shawn Herrera. Shawn manages FEMP's Technology Deployment Program. Her main area of focus is to accelerate the deployment of innovative products and technologies.

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Listed on your screen are the core competencies this seminar is designed to address. Our training today will help you to implement lighting projects that increase energy efficiency and reduce greenhouse gas emissions.

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Specifically you will learn how to select optimal lighting replacement projects based on quality baseline data, review a number of potential lighting technologies and select the best solution for a particular application, determine how you will measure project results, and locate DOE and industry resources to support decision-making.

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We will begin with Jeff who will discuss solid-state lighting,

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and then after the break Brian Liebel will discuss spectrally-enhanced lighting.

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Welcome Jeff.

Jeff McCullough:
Thank you Kathy, and I want to extend my welcome to everybody online as well. What I would like to share with you today is exterior solid-state lighting. It is a relatively new technology that we are starting to see work its way into the marketplace.

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I think it is important to start out with what is solid-state lighting. I think many of you out there have heard about the technology, you may have seen it in your local stores, you may start to be using it in some of your facilities, but let us start with a brief introduction as to what the technology is and the areas that we are going to focus on.

So the term "solid-state lighting" is an umbrella term that we use to encompass primarily two different technologies. One is inorganic light-emitting diodes using the semiconductor-based products that you are seeing currently out there in industry. Underneath that we also have organic light-emitting diodes or OLEDs. OLEDs are an up-and-coming technology; you can envision things such as luminous panels; the ceilings in your buildings someday may emit light from all portions of the ceiling. Then a subcategory of OLED is a polymer light-emitting diode or PLED. So for today's discussion and the current state of the industry we will be focusing on light-emitting diodes.

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These are the inorganic products that are currently out there.

Well let me start by first sharing with you that today FEMP has been working on an exterior solid-state lighting technology initiative, trying to move solid-state lighting into the de facto position for Federal facilities. And to do that there are a number of activities that are underway. One of the things that we are currently working with is various entities. Right now we are working with the Army Corps of Engineers and the U.S. Army Core of Engineers and trying to move policy statements that reinforce solid-state lighting as one of your choices when making decisions. So there is a policy piece that is part of that; we are currently developing implementation plans; to support those implementation plans training is necessary; you are getting a little bit of that today. One of the things that you will see from FEMP in the next couple of months is what we are calling a qualified products list, specifically FEMP-designated performance levels for exterior solid-state lighting products. So that is something for you to keep a watchful eye out for. FEMP will help you in that decision process by setting minimum levels of performance that you can then take and use in your facilities.

In addition to that the solid-state lighting effort through the Department of Energy is actually rather robust; we have a very large solid-state lighting program and there are resources that we can draw upon from that main DOE program that will support you as well.

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So for my talk today I am going to talk a little bit about parking structures. The things that you will learn today include the tools necessary for evaluating other exterior applications as well but the resources that I am providing today I think it is helpful to put them into context from the standpoint of a facility, an entity that you are familiar with and some of the energy potential that you will see from employing some of these technologies. But they do apply to a much broader range of applications.

So let us talk parking structure and let us talk about how large the potential market is. There are approximately 110 million parking stalls in the United States; that is an awful lot of space. The luminaires, the light fixtures that are used in those environments are typically a low to medium wattage fixture. Many of them have very long operation. You can envision some of the subterranean parking garages where they are lit 24/7 so they are on all the time and there is frankly very little use of controls taking advantage of daylighting and occupancy sensing as well. So we will be talking about those here further in the upcoming slides.

Are they a high-energy users? Absolutely: 28.1 terawatt hours, that is a huge number, and is attributed towards luminaires installed in these applications. As I mentioned earlier they are typically infrequently occupied. You can envision a normal business day where there are people coming in in the morning, they might sneak out for lunch but then they start to leave in the late afternoon and evening, and the rest of the time most of the spaces are vacant and yet all the lights are on.

So with occupancy you also have the potential of harvesting daylight, and so depending on the structure of the parking garage you can actually take advantage of that, harvest it, and we will talk about some of the strategies used to take advantage of that.

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So this is a table that shows for all the parking structures that are out there this is the currently installed proportion of the type of lighting technology used in those structures. You can see here that predominantly about 46% is currently using fluorescent technology. About 23% is using high pressure sodium, another 15% using metal halide and down near the bottom you have LED, or solid-state lighting. You can see it's a relatively small portion but I assure you in coming years that percentage is going to increase dramatically. But nonetheless it still has a long way to go. The technology is rapidly moving, it is a technology that is changing almost on a daily basis and so you need to be kept abreast of that and the First Thursday seminar is one way for you to stay abreast of that technology.

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This is an interesting slide that shares with you the question for if I own a parking structure what is the cost on a per space basis to operate that parking structure? And while it might seem trivial, $50 per year, per space, and it attributes to about 9 to 10% of your overall cost of operating that stall, the rest of these, I would point out, are fixed costs; there is not a lot you can do with them, you have to maintain the space, you have maintenance; those types of things are fixed. So you can directly affect that bottom line by improving the lighting by potentially going to solid-state lighting.

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Okay I think we have all been inside parking structures. They have ranged everything from dark caves to well-lit, well-illuminated surfaces. And what I would like to show you here -- and these happen to be two pictures that contrast what you might see out there: the one on the left is a parking garage below ground in Portland, Oregon; you can see a lot of dark concrete that has been stained; it is not well-lit, and that clearly is not doing a very good job of illuminating the spaces. Certainly something like that poses a safety and security risk.

Contrast that with the space on the right, which is not only a concrete space, but the owners have painted the majority of the roof and the columns a lighter color. Now it is important for you to realize that when you design a lighting system we take all these factors into consideration: how much of the light is absorbed? How much is reflected? So what you consider in your design is you have to know the environment that it is installed in. I am not advocating that you paint all your spaces white; it certainly is one technique that you can use. For those that might use concrete as the majority of the structural components some of the concretes out there are actually very light colored as well, so it is a decision you need to make as a designer, part of your A&E firm to consider those reflectants on those surfaces.

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So let us talk about the controls that are available for this technology. What I am going to use by way of an example is a subterranean parking deck. This happens to be the Department of Labor headquarters in Washington, DC. It has a directional flow of traffic. I know most of us have driven through these types of facilities; you enter on one floor and you essentially zigzag throughout the facility and exiting is kind of the opposite; you might go in the opposing direction or you might go down the opposite side of the building. But keep in mind that that directionality plays an important role in the types of controls that you use and how long they stay on.

So this is a parking garage that serves an attached office facility, so it is an office space. Originally it was built using T-12 fluorescent technology. Some time back they went and did a lighting retrofit and converted over to high pressure sodium and they are now doing a case study, a demonstration using LEDs. Some of the features

that they are using in this demonstration: they are using individual fixtures, individual luminaires that are using occupancy sensors, so each luminaire, each fixture has an occupancy sensor attached to it.

The luminaires they are using are from one of the other DOE programs that is available and that is called the Next Generation Luminaire Design Competition. That is a competition where the manufacture submits products, they are judged by an illustrious group of lighting designers and winners are selected. And so for this particular facility they chose to use the NGL, the Next Generation Luminaire design winner for parking structures. So this is one of the leading edge products that are out there on the market.

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So what are the results? And one of the things that I will caution you about, and you will hear us talking about it pretty much all afternoon here is that we do not usually recommend just considering one for one savings. But for purposes of illustration I will start with that and then we will build upon that and talk about how the use if controls can further amplify your energy savings.

So the existing luminaire was 137W high pressure sodium. The retrofit product, which is the product there in the center, in the middle is a 62W product. So on a one-for-one basis and with the LED being in the high state where was a direct 55% energy savings by doing that.

Now one of the things that you will probably notice here, in addition to the difference in color, and I think it is pretty clear to everyone that the products that we are talking about on the LED side are actually “white” light, whereas high pressure sodium, for those that drive outside and underneath the tunnels and roadway lighting, the majority of those products are high pressure sodium, they have somewhat of an amber or yellowish color.

So one of the inherent benefits with solid-state lighting is that white light and we will talk more about how that plays into things in future slides. But the things that I wanted to point out here is that the average light output, the illuminants, the light-striking surfaces went down from the high-pressure sodium to the LED. So if I had a light meter I would measure that the light levels actually went down on the averages.

Now what is important to note is that the incumbent technology, high pressure sodium, puts a lot of its light directly below the fixture and then as you move away from that point, the light output drops off quite quickly. One of the benefits with solid-state lighting is that you have all these individual point sources of light that in theory can be aimed individually, and so you can distribute the light in a more uniform pattern. So even though the average light output went down the minimum light levels throughout the space actually went up. So you couple that improvement in uniformity with the white light and you have a winning solution.

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So from a control standpoint we just talked about a one for one retrofit. One of the options that is before you for parking structures is bi-level lighting. It is very easily implemented, clearly when the spaces are not occupied or during off hours you can go to a lower state of illumination. And those can be used for the garage, they can be used for parking lot areas and pedestrian areas as well. I know some of you may have concerns such as, "All right, if I go to that lower light level am I affecting safety in that space?" And the answer is no: we have guidelines through the Illuminating Engineering Society to help us to maintain minimum guidance, minimum light levels for safety and security. But that is not to say that we cannot take advantage of this bi-level capability and go to a lower light level and still meet those requirements. So in addition to that bi-level capability you can envision motion sensors that would sense vehicle traffic, pedestrian traffic and those types of things as well.

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So what I am showing you here -- this is an excerpt from the FEMP technology deployment matrix, and you will be learning about that in future First Thursday Seminars, but I wanted to show you how FEMP scores this particular application. So specifically this is bi-level parking garage, parking lot and pedestrian applications. Solid-state lighting for exterior application is in the top ten of that FEMP technology matrix but if you couple the solid-state lighting with this benefit of bi-level lighting you get a win-win type of scenario.

So from an energy saving standpoint it is pretty good but recognizing that the amount of energy consumed by parking garages in general relative to the rest of the Federal sector is not as large. The potential is there but it is just not as large a savings, so it scores with a 0.9. Cost effectiveness very high so it is a four out of five and it is

weighted to that 30%. Probability of success is a five, which is very high – that is the highest score you can have and so it gets all the points in that area. So it is clearly something you should consider as you move forward.

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One of the things that I talked about at the onset of the presentation is early efforts by the U.S. Army in developing a policy that is moving solid-state lighting into the de facto position. There is a memorandum of understanding between the DOE and the Army to support that effort. That is well underway and the Army is soon to be releasing that policy. If you are a Federal entity and you are interested you can certainly go out and find it; we will provide the resources at the end of this presentation but we expect that other Federal entities will begin to pick this up as it gains momentum, and as those FEMP designated performance levels are established.

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Okay let us talk about some metering that was done. This is back at that same facility that I was showing you earlier. This happens to be a Thursday. It was not chosen because this is a First Thursday Seminar it is just the data that we happen to have. What this is showing you on the vertical axis is current or amperage for the luminaire. It simply is indicating a high and a low state. So do not make the mistake that this is off and on; it is simply a high and a low state. And if I totaled all of these up -- and intuitively I think you can appreciate that people start trickling in at say 4:30 in the morning. That is too bad for that person, but from say 5:00 to 7:00 there is a pretty high influx of traffic. There is a lull mid-morning, a couple people sneaking out for lunch, and then from about 3:00 to 6:00, 6:30 those people are headed home.

The rest of the time a lower state is warranted. And if I total up the number of on-minutes and the total off-minutes it should not surprise that the ratio is almost 30 on to 70 off. So there is a huge potential there. This varies by location, it varies whether it is a pedestrian walkway, it also varies where the fixture is located, but nonetheless it gives you a sense of the potential by going to a bi-level type configuration.

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Now if I compare that Thursday to a Saturday you can see that some poor soul came in at 5:30 in the morning and left at about 7:00, 8:00 at night; I hope that is not a Federal worker; it could be a maintenance person. But nonetheless the rest of the time the system could either be -- well, it cannot be often; there are security reasons why we do not fully shut the systems off but nonetheless a lower state certainly is warranted.

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So as I shared with you the operating profile at least for this particular demonstrating it was 30% on time versus 70% at the lower -- sorry, 30% at the high state, 70% at the low state. And also factor in that the time of the sensor, meaning the time out; how long does the sensor stay on before going to that lower state has a significant impact upon savings and depending on the technology that you are using for example if that was fluorescent you might have concerns about that frequent on/off cycling shortening lamp life. With solid-state lighting we do not have that issue and so you can actually justify fairly short periods of high/low or on/off.

And as I said earlier on, that the direction of the traffic, if it is one-way versus bi-directional that has a direct impact on what your savings can be as well. So all these things need to be factored in. There has been a lot of studies done that can help you in making those decisions and some of it you have to do yourself; you have to give some thought to what are the traffic flows through my facility.

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What are some of the types of challenges you can expect with employing this technology? I am sure we have seen all kinds of the full gamut of parking garages out there: some are very clean, some of very well-lit. Most of the mechanical systems are well-hidden or unexposed. At the same time you have things such as piping and air handling units and signage that can impede not only the illuminants on the surface but also the controls that you might choose to use for that space. So these are things that you need to take into consideration as you design and work through implementing this type of technology.

A couple of examples that we came across and clearly that some of the HVAC equipment in some spaces actually caused some false triggering with some of the controls. So there is some level of commissioning that you need to do; you cannot walk away from these systems and expect them to work going off into the future; you do

need to come back periodically and tune them, to commission them to make sure that they are operating as intended.

The columns. Clearly these are structures that need to be supported by large, typically cement columns. Those can also block line of sight not only for the light but also for the controls as well and so you need to factor those in in your layouts and in your design. And there can be some false triggering by things that you would not imagine: a piece of litter that is blowing through the garage, a runaway pet, who knows? There are all kinds of things that can cause those triggers. So it is important that you maintain it and you constantly are trying to come back and commission the space and make sure that it is operating to its best potential.

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Okay. Well one of the things I would like to do and I am going to add this as one of your tools to your toolkit. There are some DOE programs out there and the one that I will talk about here for the next few minutes is called the Commercial Building Energy Alliance. Again, we will provide those resources to you at the end of the presentation but the Commercial Building Energy Alliance is groups of large entities; there is one for hospitals, there is an alliance for retailers, there is an alliance for real estate area type applications. So these alliances between DOE and these large entities have worked together in developing a specification.

So this is the Commercial Building Energy Alliance specification for parking structures. And at this point I would like to acknowledge my colleague Michael Meyer. He's led the charge in developing this specification and several of the slides here are from his bag of tricks so to speak. So thank you Michael for allowing me to use them.

So one of the targets is setting an energy efficiency level. We typically do that as we start to talk about energy codes and what is called a lighting power density. So the specification itself sets the lighting power density at 0.8W per foot. The EPAct 40% parking structure lighting power density is matched at that same level. Incidentally the ASHRAE 90.1 2010 specification, which is 0.8W per square foot is actually 10% less than that. So this not only meets current ASHRAE 90.1, but is at least 10% better than ASHRAE 90.1 201.

For those of you that are in municipal type organizations or for-profit there is a tax incentive for parking structures, and I want to be very clear here that this tax deduction -- and it is a deduction -- is not for exterior applications except that the IRS has made the determination that because parking structures have walls, because they have ceilings parking structures do indeed apply. So what I am providing for you in this slide is the direct reference to the IRS. I would encourage you to go out there and look at it. For those that are in some Federal entities there is a pass-through mechanism that you can take advantage of the deduction and pass that on to your lighting design team. You as a Federal entity cannot benefit but you can pass that along. So I have provided here as information for you.

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Okay so let us talk about the specification itself. The table that is in front of you shows minimal illuminance requirements both horizontal and vertical. Now illuminance is the amount of light striking a surface and the unit of measurement here is the foot-candle. If I had a light meter and I placed that on the ground before you I would be measuring the illuminance striking that meter, or that sensor.

It should be no surprise to you that based on the location within that parking structure the illuminance level, the needs change, not only from the location but also the time of day. I will not go through the numbers but suffice it to say that range is anywhere from 0.75 foot-candles all the way up to 50 for the vehicle entrance during the day.

Likewise there is a vertical illuminance requirement and keep in mind if you close your eyes that vertical illuminance of course is on the wall and that point is measured approximately 5ft. up from the finished floor and so those are the requirements for vertical illuminants on those side walls.

Here is where solid-state lighting in particular does quite well and that is with uniformity. For those that have been involved in the design of exterior lighting applications we typically can see “max” to mean, and that is the “max” light output measured in a grid to the minimum amount, being as high as 20 to one. The lower that ratio the more uniform that distribution is. So you can see here that in certain applications IES might allow 20 to one but for this specification we are encouraging ten to one, in one case seven to one or lower, or better. The uniformity coefficient of variance -- one of the things that is important to note here is that that max to min measurement is

one value so that the highest value compared to the lowest value. It says nothing about the distribution of light or illuminance from that max to the min. So this uniformity coefficient of variance accounts for that as well.

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Okay, I should share with you that even though our discussion today is solid-state lighting, in particular LEDs, the specification itself is technology neutral. So you could consider fluorescent, you could consider induction, but given the implementation and integration of controls LEDs frankly are probably going to be on the top of your list for consideration.

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So let us talk more about some of the specification and in particular some of the daylighting controls that are required. So luminaires that are within 20ft. of a perimeter wall, and that wall is greater than 40% open must be controlled with daylight harvesting. So you can envision having a sensor and then all luminaires that are within 20ft. of that curtain wall or of that side-wall those can be controlled separately and taking advantage of the daylighting capability that is adjacent to them.

Some of the requirements for photocells -- and as I said earlier if you are talking solid-state lighting there really is not a problem turning a fixture on or off frequently or going from a high state to a low state. So it lends itself to doing this type of narrow control but the recommendation is from 15 to 30 seconds of a delay from an on cycle to an off, or from a high to a low. The recommended illuminance set point for the sensor is 10ft. candles. And again we talked about obstructions in parking spaces, parking garages. You need to make sure that it is an unobstructed view of what it is it is trying to see.

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So here is some additional information on the occupancy sensing controls that you would consider. We do recommend one occupant sensor per luminaire and set for the maximum coverage possible. There is a NEMA specification out there called WD7-2000 that a lot of the new controls that are coming on to the market will meet that requirement. We would encourage you to take a look at that. The technology used for these applications; it is recommended that we use infrared or microwave and using sensors that are not affected by ambient temperature. Clearly these are open spaces, they are not conditioned, and they can see wide ranges in temperatures. We do not want false triggers because of it getting too cold or too hot.

One of the important considerations with implementing any control scheme, especially for when life, health and safety is involved is making sure that if there is a failure that it fails in the on mode. We do not want to have dark spaces and then have something happen. So there is a liability, there is a risk associated with that. So make sure that any control scheme does set itself into the one mode if there is a failure.

And one of the decisions you will make as a site owner is do I go on or off; do I go high or low? I think primarily for parking garages, because of the need to maintain safety and security high and low would be your preferable choice.

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So based on what I have shared with you thus far it is pretty clear that parking structures have great potential. They are what we like to call low-hanging fruit; there is lots of opportunity. There are a lot of them out there: 110 million spaces out there that are prime. There is a potential for a tax credit. So I hope I have convinced you that they are something that you should consider in your lighting bag of tricks for exterior applications.

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What I want to do now is talk about a few of the locations where the specification actually has been used. So thus far I have given you some examples, I have given you the specification itself; now I am going to shift gears and share with you how it has been applied and the savings that those building owners, those facility owners have seen by using the specification.

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So the Cleveland Clinic in Cleveland, Ohio has used this specification. The space is actually about a million square feet; that is a very large parking structure, about 1,500 spaces. They converted from high-pressure sodium to LED and in the picture you can see in the background there the high-pressure sodium fixtures still

there; in the foreground is the LED product. A total of 840 fixtures were retrofit; 620 had occupancy sensors; 212 had those daylight sensors that we talked about, those luminaires that are within 20ft. of a perimeter wall where there is 40% or more opening. And based on not only the 0.18W per sq. ft., but the use of controls, the bi-level controls 82% savings are predicted for this particular project. That is huge. And for this particular project a 4.2 year simple payback has been calculated.

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Here is another application that is currently in the works and this is actually from the Washington, D.C. metro area. They have put a solicitation out on the street that is using the commercial building energy alliance specification for parking structures. There are some 13,000 high-pressure sodium luminaires that are out there; a lot of them are 24-hour operations. Remember those loading profiles that we talked about earlier. There are a total of 24 parking structures, ranging from about 300,000 to 1.1 million ft^2. and they have been constructed from about 1980 to as new as 2011.

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So we will provide you an update on those particular projects as they move forward; I just wanted to make you aware that that specification is being used and have hit the street already.

A very exciting new application is a project that is currently underway with the National Renewable Energy Laboratory located at Golden, Colorado. And this is the first of its kind from the standpoint that it is not only net zero but it also provides additional power to the adjacent buildings. So it is 1,800 parking stalls; there are 1.13MW of photovoltaic arrays on this structure. And if you look at the image, clearly most of those are on the roof portions. This is a rendering, but the actual final version, the short curtain walls that are typically used in these types of applications, those also will be arrayed with PVs as well. So not only did the roof but also the surface walls will also have PV arrays.

As you can imagine they have full daylighting and occupancy/motion controls. They are using 77W LED luminaires and the table that I am providing you gives you a sense as to what the energy savings potential is. They claim to have less than 0.05W per sq.ft. of lighting power density, an average illuminance of less than one foot-candle. The Commercial Building Energy Alliance spec that we have been talking about range from 0.05 to 0.18 and that yielded about one to five foot-candles of illuminance, and this is average illuminance, mind you. And then ASHRAE 90.1 is set at 0.18 to 0.3 and that yields typically greater than five foot-candles. So you can see how exciting this is as we move forward and this project actually goes through the metering phase – we will come back to you and share what the results are but it is very exciting to implement not only LED not only to implement bi-level and controls but also a renewable energy source and photovoltaics.

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So you are a facility owner, facility manager, and you are considering solid-state lighting; what are the types of applications that it makes sense? Clearly parking lots and parking areas are one area where it is a good choice and should be high on the list of considerations. Parking structures we have talked about at length today. Roadway lighting -- if you have some approach roads and those types of things you are starting to see more and more roadways and a lot of municipalities are actually moving towards solid-state lighting in their street lighting applications. Wall pack -- those are the luminaires that are fixed to your building that provide some perimeter illumination. Canopies -- these can range from storage areas, fuel canopies those types of applications and bollards; those are the things that you walk into when you are looking up going into a mall. But those are applications where the inherent directionality that solid stage lighting brings, as well as the white light.

So what are some of the benefits? We have talked about the improvement in uniformity. If you can get that max to min ratio as low as possible that uniformity level, if I couple that with white lighting versus say a high-pressure sodium and amber light source that makes a dramatic improvement. Certainly solid-state lighting is a long-lived technology. I would also offer a little bit of caution here as the state of the industry is still unfolding; we are still developing standards and test procedures that can be used to predict what is the life. And for LEDS we do not use a catastrophic failure; we use lumen maintenance threshold. And that is the point at which 70% of an initial light output is maintained. So you need to factor that into your design -- do you come back and replace the light engine? How many hours is that? Those all need to be factored in. Clearly they are durable; there are no filaments or elements that can be damaged per se, and because they are a low voltage source and they do not have the complexity of a fluorescent ballast they are inherently more controllable.

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So how would I go about evaluating this technology if I was going to go forward? You do need to exercise your due diligence. I am not saying to you that every project using solid-state lighting makes sense -- and you can see here that the range or paybacks three years to 20 years -- it depends on what your level of risk is, your tolerance, maybe your organization limits you on what the either simple payback or life cycle cost needs to be to consider doing a solid-state lighting project. So you do need to exercise due diligence. I strongly encourage you to do life cycle costing. I know there is a natural tendency to do simple payback but clearly the durability and the long-lived operation of this technology lends itself to factoring in maintenance into your equation as well.

I have talked about some of the non-energy benefits, the white light, the durability, the safety, those types of things. So if I were pursuing a solid-state lighting project I would look for a product that has at least a five-year warranty -- now keep in mind we are talking exterior now so at least a five-year warranty. There are some products that are approaching ten years.

The IES reports -- and I alluded to this a little bit ago -- with the onset of the technology there has been a lot of effort to begin standardizing measuring light, measuring lumen maintenance so I would caution you to use and ask for the manufacture's 4M790, that is the light output measurements and directionality measurements. LM80 is the lumen maintenance at the package level for the device module or array and the newest one to come out is TM21 and that is where you can take the LM80 data and make projections forward as to what the lumen maintenance will be in your application at various drive currents and at various temperature.

Color appropriate for the application and then of course consider distribution and glare because you have all these point light sources you need to be careful that you do not have high angle glare in certain applications. You need to know what you are doing; I strongly encourage involving a lighting designer so that they can guide you through some of those questions.

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On the M and V side of things if you are doing a simple one-for-one retrofit you can certainly just to do a spot measurement of the pre-condition and the post condition for most projects 12 hours per day for exterior operation is reasonable however when you go to occupant and daylight type controls clearly you need to do some level of metering, multiple luminaires or sections of luminaires to fully capture what is the savings by virtue of those additional controls.

One other thing that I would encourage you to do and as I think you are all aware at this point LEDs do not usually fail catastrophically, they become dimmer and dimmer over time; we need to monitor that light output and we can actually reach a point where we need to act, where we need to replace the light engine. And so I would encourage you to do some illuminance readings over time and track that. Do not just rely on what the manufacturer tells you; track it yourself and then you can make those decisions on when you act to do a new lamp or a new light engine.

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So FEMP has developed a number of resources to again add to your toolkit. We have a number of FAQ sheets. There is a street and roadway lighting FAQ sheet, and a parking structure sheet. There are some general resources not only through FEMP but also through DOE's main solid-state lighting website. One shout out I will give is the Design Lights Consortium and the reason I bring it up is that will be the mechanism that FEMP uses for those FEMP-designated levels of performance. The Design Light Consortium is a group of Northeast utilities that maintain a database of solid-state lighting products and FEMP intends to use that database but for exterior applications set to criteria higher as appropriate. For those that are interested it is DesignLight.org; you will be learning more about that in the future.

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So with that I thank you very much.

Kathy Hyland:
Now let's hear from Shawn Herrera.

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Shawn Herrera:
At FEMP lighting is an important part of our technology deployment program. Our goal is to accelerate the use of lighting technologies that are proven but not yet widely used. FEMP's technology deployment team is supported by a broad range of expertise at DOE labs across the country. We also coordinate activities of the interagency technology deployment working group. This group meets quarterly to review guidance, evaluate tools and resources, support new agency programs and share best practices.

FEMP's new technology deployment matrix can help you select the best technologies for your facility. The matrix ranks 49 emerging and underused technologies in six categories. To expedite implementation efforts it includes factors for cost effectiveness, case studies, technical assessments, vendor information and listings to contact experts. To learn more, register for the First Thursday Seminar on April 15th on the topic of new and underused technologies.

FEMP's training keeps you up-to-date on lighting technology deployment strategies, build testing results, performance metrics and project funding opportunities. Current webinars focus on the latest L Prize winner in exterior solid-state lighting to help you select and install safe, secure and efficient lighting in Federal parking areas. We collaborate with the DOE building technology program to leverage Federal and industry partnerships. Check the FEMP technologies website for ways you can get involved. We also encourage you to participate in the FEMP exteriors solid-state lighting pilot program, signature case studies and data sets so we can document exterior solid-state lighting performance and best practices.

Contact Jeff McCullough for more information on this pilot program. We are excited about the potential to advance the use of promising new and underused lighting technologies in the Federal sector. I look forward to answering your questions at the end of this program.

Kathy Hyland:
Now to discuss spectrally-enhanced lighting is Brian Liebel.

Brian Liebel:
Thank you Kathy and thank you for having us here to talk about this. I am going to be talking about spectrally-enhanced and the first thing we would like to do is give you an idea of what it is that we are specifically talking about with spectrally-enhanced lighting.

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Spectrally-enhanced lighting is not a technology per se. In fact, spectrally-enhanced lighting is a design method and we use it in interior lighting applications where visual acuity is important such as offices and medical facilities where reading is a primary function. And in this case we are not talking about outdoor lighting. I would like to just start off by going over some of the ideas, giving you some images of that it is

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and why it is that FEMP believes that this is a very important technology to use. In a deployment technology, the technology deployment matrix spectrally-enhanced lighting has the distinction of being ranked number one with a score of 91 and we are very happy about that. The reason for that is it uses standard products, standard lamps, standard ballasts that are easily obtainable and very cost effective. And in most interior lighting applications we can expect results of 20 to 30% energy savings. It does not require any special controls or equipment and for typical paybacks from using fluorescent technologies as our baseline you can expect payback to be three to four years on a T8 to T8 retrofit and a one year payback when you go from T12 to T8 electronic ballast retrofits using spectrally-enhanced lighting.

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As you might imagine here when we talk about spectral we are talking about really the color of lighting. And here we have some before and after pictures of some installations that have installed spectrally-enhanced lighting. As you can see, the before images have a light that is a warmer color or a yellower color, whereas with spectrally-enhanced lighting we are really talking about adding a little bit more blue which results in whiter light, light that is more representative of daylight.

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Another picture of the Washington, D.C. Navy office building, which was done using spectrally-enhanced lighting. These were retrofit projects.

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At new installations we use it and really advocate it for using in buildings that are day-lit. This is a project that received LEED Gold certification and spectrally-enhanced lighting technology was used for the energy savings that it attained and also for the matching of the daylight spaces that helped also attain that gold status.

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I want to start a little bit as we get into this just as a little bit of background for how we talk about lighting color. And the lamp nomenclature that is used in the industry and is typically a three-digit number, and here I am using 835. Now the eight in the beginning is in reference to something called the color rendering index. The color-rendering index is a scale from zero to 100, with 100 being the best and zero meaning the worst of how well a lamp renders color. And so the eight means it is around 80 -- 78 to 85 CRI. That is a pretty good number and most fluorescent lighting technologies are going to give you that kind of color rendering.

The 35, the second two digits of this three-digit number are a shorthand way of talking about the color temperature of the light. And here we are looking at 35 which is a shorthand way of describing 3500˚ Kelvin correlated color temperature, and the image on the right of the screen gives you an idea of what that scale represents in more normal lighting situations. The 2700˚Kelvin is an incandescent light and 2700 to 3500˚ Kelvins is considered warm colored lighting temperature. At 6500K to an 8000K is considered a cooler color temperature _____ higher color CCT. And so that's a CCT scale, the correlate color-temperature ranging from 2700˚ to 8000˚. Just as a reference: daylight is usually about 8000˚ in the middle of the day for your reference; 2700˚ is incandescent.

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Let us talk about the background of this now. When you use higher CCT lamps, lamps that have a little bit more blue that give you a white color rendition, they are more like daylight. When you use that relative to a warmer colored light source this results in the pupil of the eye becoming smaller and when that happens you increase the visual acuity; you are actually able to see things more clearly. Most recent research has also shown that more higher color temperature lighting can also affect circadian rhythm. We will not talk about that much but it is something that is of interest and follows some of the research that we will be talking about.

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The illustration that you are seeing now is an animation that describes how this works. And what this diagram is if you can imagine the circle here being a cross sectional view of the eye and the eye opening, the pupil of the eye being where I am pointing to here where the ray of lights come in, that warm color lighting does not excite the peripheral photo receptors, that is the amount -- the light receptors that are around the periphery of the eye as much as a cooler color light or a higher color temperature light would do.

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So when we change the color from a warmer color temperature light to a higher color temperature lighting then the pupil of the eye gets smaller and when the eye gets smaller then you get increased visual acuity.

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So that is a phenomenon that is physiologically happening as you increase the CCT and use higher CCT lighting and this effect is what drive spectrally-enhanced lighting.

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Now here is an analogy that we like to use which helps describe this. What happens when we increase the light levels? You are normally used to thinking, "Well, I raise a dimmer or increase the light level." We all know that our pupils get smaller, spaces seem brighter and we see more clearly. Well the same thing happens if you keep the same light level but you increase the color temperature. When you increase the color temperature the pupils get smaller, the spaces seem brighter and we see more clearly. So in effect by raising the color temperature of the lighting it is effectively doing the same thing as increasing the light level.

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Now how do we use that? Well there are two ways that we use this in lighting practice and here is an illustration where you might have a light source, fluorescent – we are talking primarily about fluorescent but it does apply universally to all light sources, including LEDS -- but if you shift the spectrum of the light source to use a higher CCT on the left one strategy would be to say, "We will keep the same light level and the pupils will get smaller and we increase the visual acuity." But if you do that there is no energy savings. Your vision might be slightly better but there is no energy savings associated with that strategy.

The spectrally-enhanced lighting principle that the Department of Energy is advocating and through FEMP and this is why it has received such a high ranking is that by using the principle of this we can reduce the light level for getting the same pupil size as we had before, maintaining the same level of visual acuity, and when that happens that is how we save energy.

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Now we want to talk a little bit about light levels because this is going to be our frame of reference for interior lighting. In interior lighting the IES, the Illuminating Engineering Society has different categories depending on the different tasks. As I mentioned before the work with spectrally-enhanced lighting applies to those types of tasks or interior lighting where visual acuity is important, and I will use reading as an example here. Now the new IES handbook has just recently come out and when they issued that they have new categories. I am referring to the old categories D, E and F here; the new ones are P, R and T. But basically the categories fall into these areas of print size, where you might consider high contrast and large size and category D where the recommendation is 300 lux or 30 foot-candles to a category F, or T now, which is 1,000 lux or 100 foot-candles, which is recommended for low contrast and small-sized tasks.

Now these light levels that are recommended by the IES are called photopic light levels and they do not consider the spectrum of light as all. In fact, the IES recommendations are color neutral. But what does this mean when we are talking about photopic light levels? Well, what we have to do is take a little bit of a look at the history of lighting going back 80 years.

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And when the metrics for lighting were determined, foot-candles, lux, candelas and all these other units are the standard reference that was used, helped determine how does the center of the eye react to lighting, which is what is called essentially photopic vision which is how the cones of the eye respond to light. And in order to do this what they did is they isolated vision to a very narrow cone of vision, a 2˚ field of cone, which represents less than $1/10^{th}$ of 1% of the natural field of view.

Now I am sure that if you can all imagine this you would realize that there are not many real world applications where you do work under that kind of condition. And if you want to simulate it next Christmas cut a standard wrapping tube to the length of 28in. and look down it and realize that that is what our lighting metrics are based on, which was that kind of a field of view. And what this does is this ignores these peripheral photoreceptors.

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And new science has shown that the peripheral photoreceptors have a lot to do with our vision that current lighting metrics ignore.

The science of spectrally-enhanced lighting is now running on 20 years old and some of the inklings of it that showed that this might be in effect are actually over 40 years old. But more recently in the last 20 years have been six separate studies that the DOE has done, ranging from school children to older adults that have shown this effect that when you increase the color temperature of the lighting while maintaining the same light level, same photopic light level this does affect visual acuity and the result is that higher color temperatures result in improved visual acuity.

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Now this is the work that has been done over the last 20 years, which has been augmented by vision science research in 2001, really a striking almost phenomenal discovery was made that there is a photoreceptor in the eye that we did not even know existed does exist. And this photoreceptor that resides in the eye is around the periphery. It is very interesting because it does not give you any visual information; it does not actually help you

form images but it has direct linkages to the pupillary constriction muscle, the thing that drives the pupil size smaller and also to parts of the brain that affects circadian rhythm.

So this new science over the last ten years has actually added to the collective work and has added a lot more information as to why this effect occurs.

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In spectrally-enhanced lighting what has been done is using the pupil size effect and the visual acuity results from this they have formed a correlation between pupil size and visual acuity and the mathematical relationship is based on something called the SP value. And the SP value is a short hand for scotopic over photopic. Basically what it is, is a property of a lamp, and all lamps have this property and it is easily measured because when a lamp manufacturer measures their lumen output they are measuring it in photopic lumens

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But they also have all the information they need to have to generate the SP value and this is what we use in spectrally-enhanced lighting calculations. This diagram gives you a smattering of some of the values for these SP values for different light sources. And you notice the high pressure sodium source that Jeff has been talking about that is used predominantly outdoors has a very low SP value and as you climb up the scale of higher color temperatures that the SP values go much higher. So the practical range or values for light sources that we use range from a 0.62, which is pretty poor color rending light source and very yellow high pressure sodium so daylight reference sources which are 2.5. And for most of the work that we do in interior lighting we are looking at these ranges that are around 1.41, which is the incandescent reference source and then to the one that we are going to be talking about the most which is a 5000K fluorescent lamp, the 850 lamp is one we are talking about a lot, which is a 1.95 SP value.

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I am going to give you a little example of how we use this, not to get too technical but just to demonstrate the principle and that is for that any light source that has these color characteristics, I have shown four here, the 830, 845, 841, 850 -- these are standard fluorescent lamp colors -- what you can do if you can draw a line which shows that if there was a photopic lumen, say P value, let us say, that you have that you are targeting you can use this mathematical formula which is P times the S/P value to an exponent of .78. And you can draw a line. And as you notice the steeper the slope the higher the color temperature, the more visually efficient that lighting becomes.

If you look over on the left we equate this to something called visual efficiency illuminance. Now we cannot use that metric in any real way; the IES has adopted photopic units as our standard and we agree with that.

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But the principle here is that if you look at this slide that you will take the – let us say you have a requirement that your design level that you are looking at 40 foot-candles as an example and your standard lamp that you are using is a 735 fluorescent lamp and that is the most commonly-used lamp for offices. And that is why we have it in this example. Then you could use the mathematics and then basically what it does it goes up to that line which we just calculated and then to get equivalent visual efficiency you go across this -- from the 3500 to the 850 lamp which is the one that we are recommending for spectrally-enhanced lighting. And then you follow that line down to see what your new targeted illuminance is going to be. And so you can see how using this math in this particular instance immediately saves you going from 40 foot-candles to 30 foot-candles and having the same visual effectiveness for reading detailed information.

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This chart then shows the mathematical results of doing the comparison using the 850 lamp.

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And I want to emphasize here 850 is a generic term; all lamp manufacturers make lamps that have the 850 color characteristics and these are comparing them to, again, these are very commonly found lamps that you might find in your building. The one I have highlighted here again is the 735; your building might have 741s, it might have 835s, it might have any of these types of lamps. And one of the first things that you would do as the facility manager, as an example, would be to identify what the existing color characteristics of your lamp is.

In the case of the 735, and if you go to 850 then your potential for energy savings is actually 32%. And that is just based on the color and the vision principles we have been talking about. But generally when we do lighting retrofits we highly recommend that you do a lamp ballast retrofit and optimize the energy efficiency of the system. And when you do that then you can have the added efficiency of the improved ballast efficiency, and here you get an additional 7, 8% energy savings.

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And as you can see here if you go from a 735 lamp with a standard electronic ballast of let's say five to six years to ten years ago the extra efficient ballast will give you a significantly more energy savings. Not only that but you add to the system's life. So basically at this point we advocate that if you have any systems that are ten years old or older you do the complete lamp ballast retrofit and get the full benefit of the savings from the lamp and the ballast and the spectrally-enhanced lighting.

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I would like to talk a little bit about some of the real life experiences that we've had with this spectrally-enhanced lighting; it has been embraced by many as a result of these test cases that we've done.

The history of this really begins in terms of testing its application in California in 2001 when we had a series of brownouts and the northern California utility, PG&E had already essentially saturated the market with the T8s and electronic ballast because of the retrofit programs that were available and they were searching for ways to help improve energy efficiency and lighting. So we talked to PG&E about this and we said, "There's this new design approach that we might want to try," and said, "Okay, let's give it a try."

So we retrofitted seven PG&E buildings totaling 300,000ft^2. And this slide shows one of them. This was an informal study; we changed it all to 850 lamps, 850 fluorescent lamps in 2001. This was done with dimming ballasts; we allowed all of the building occupants to give us their feedback. We reduced the light levels to the predicted level that the mathematics would tell us. We found no objections to the color of the lighting even at the lowered light level and a high level of satisfaction. And as a result PG&E has standardized on using that lamp.

This then resulted in a formal study. PG&E and the Department of Energy partnered with the University of California and we did a building in which we compared two floors -- one was retrofit with an 835 lamp and one that was done with an 850 lamp and we asked the occupants about how they felt about the lighting retrofits and we found that there was no difference between the two. And this was a very important issue for us to address because there is sometimes the perception in the lighting industry that we prefer warmer color temperature lighting. And when it comes to working environments such as office spaces there really is no clear preference that you can say that people prefer that. All the indication from the research is that once adapted to the color temperature of the lighting there really is not preference.

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So we then followed up with a different study with the Department of Energy and the reason for this is to validate these occupancy studies on the one hand but also to fully demonstrate the economic validity of it using on/off ballasts, using standard retrofitting procedure. We found three different buildings that were owned by three different entities, they each had their own contract and bid out the job as you would a normal lighting retrofit project. Each building had a different manufacturer associated with it of the big three manufacturers, so each of the lighting manufacturers, the lamp manufacturers participated.

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And in one of the buildings, the base case they had 735 T12 lamps; in another case they had a 730 T8 lamp as their baseline, another had 741 T8s as a baseline.

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In other words what we wanted to do was test this out in a variety of applications with a common theme that they were similar occupancies but just a different baseline scenario to see if we would find whether there was differences in their opinions of the lighting retrofits. The things that were similar: they are all parabolic fixtures, they all had mixed private and open offices, mixed day lit and non-day lit areas and they all had to have over 100 full-time workers because we wanted to make sure we got a good statistical basis for the occupant surveys that

we ran. As I mentioned they all had coming into it different lamp colors and different lamp ballast technologies which would have resulted in different energy savings potentials.

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And the results of that study is that we got full occupant satisfaction with the lighting, everybody loved it. We got 50% energy savings on the T12 building and 20% energy savings on the T8 conversions. Another very interesting aspect of this is we were monitoring task lighting usage because as you know we were dimming down the photopic light levels and there was a suspicion that if you did reduce the overhead lighting then that might increase the use of task lighting -- that did not happen. And then no difference in occupant satisfaction.

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Another scenario that we did, and this is a very interesting case is we explored in some cases the changing from a direct lighting system which, like in this case, a parabolic to go in with indirect lighting. And we have found through several projects that we have worked on that an indirect lighting system with the spectral-enhanced lighting really seems to provide the highest level of occupant satisfaction and actually seems to give you a lower power density when you leave it up to the office workers. In this case it was done with dimming ballasts; we asked them to set the light levels to their preference: half a watt a square foot is where we landed, which was pretty impressive.

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Now what we want to talk about here is basically because of these results several entities, especially in California because a lot of this work has been done -- they have adopted this as their standard. Pacific Gas & Electric now calls SEL one of their top five strategies for energy efficient lighting and they have adopted it for their own buildings. San Diego Unified School Districts, the City of San Diego and Oakland, counties of Napa and San Mateo all use this.

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Basically what we have found is that once agencies start using this and start realizing the benefits of it it becomes a natural extension and they just continue using it. And that has just been the pattern.

The projects that we have done in the Federal sectors, Port Hueneme, Washington Navy Yard, Navy Techval Program, the U.S. Forest Service have all used this with great success. One project that I do not list on here was Fort Huachuca. In that case the energy management team wanted to go to 6500˚ Kelvin lighting and that was met with great success.

So another recent project, the NARA project is very recent. They did a sample area, they surveyed their occupants, found a high response rate to it, positive response to the lighting and as a result they retrofit their entire building as well.

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When it comes to the light levels and we want to talk about this a little bit -- basically because the IES currently is color neutral with its recommendations the key thing here is that you do want to make sure you meet the IES minimum recommendations. When you look at the IES handbook basically they give you a single number which is said to the be the IES recommendation. There are pluses and minuses to that recommendation; it is not an absolute minimum; it is not an absolute maximum. And the IES is actually pretty vague about what they mean by minimum, in fact they do not define a minimum light level for interior applications.

So in general what the accepted rule is that if you go beyond a 33% reduction, below that recommendation you have gone too far. So you do not want to go to lighting levels which are below 33% of what the recommended level -- and we do not recommend going below 30%. That would be a minimum level for an IES recommendation. As long as you can do that and be comfortable that you are meeting IES recommendations then there is nearly no problem using higher color temperature lighting.

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So in summary spectrally-enhanced lighting, it is more like daylight, it is more energy efficient, it is easy to implement, it is cost-effective for retrofit, there are immediate savings for new construction because if you plan

ahead for it from the very get-go you get those energy savings immediately. That can result in fewer lamps, fewer ballasts, fewer luminaires, in some cases, and so if you plan ahead you get immediate savings.

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And as long as you are meeting the IES minimums then there is no problem using higher color temperature lighting.

For your facilities things to think about is where you might use this. Offices are a natural place to use this because reading is going to be of fundamental importance. Educational facilities, again where reading is important. Medical facilities, reading charts and prescriptions and things like that are going to be very important. Warehouses where the identifications of parts and pieces, and again, reading is important, or being able to see, identify pieces and parts accurately is important. Correctional facilities -- any type of place where the ability to discern detail is important; this is a very appropriate place to use this. We are not saying that it should be used in every single application -- relaxing, lobbies, dormitories, places like that might not be an appropriate application for it.

And for interior lighting retrofits specifically any building with T12s will give you 50% energy savings and if you have HPS lighting the energy savings will probably be more than 50% using spectrally-enhanced lighting, the color characteristics will get you that and the efficiencies of the fluorescents over the HPS. And if you have a T8 fluorescent system certainly anything that is over ten years old you should be serious about changing out and in some cases systems that are less than ten years old.

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So just to give you a little bit of a guideline here: if you have fluorescent T12 lamps or T8 systems that are ten years old you are going to be wanting to consider the 850 T8 lamps, the super T8 lamps and extra high efficiency ballasts. Those will get you that 20 to 30 to maybe even 40% energy efficiency depending on the equipment that you actually have and T12 will be 50%.

High pressure sodium fixtures in industrial facilities, some applications still use those as a standard for interiors; we would recommend that those be changed to something that has higher color temperature like high color temperature fluorescent lighting or metal halide lighting. Another thing that we have run into in some occasions in Federal facilities are those that have been over lit. And if you have facilities, and some of them have been fairly new that have been using older standards and they are over lit and they need to have lighting retrofits done then please consider this as part of that retrofit to gain the extra energy efficiency.

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For measurement and verification basically when we are looking at this, especially on a retrofit basis it can be done on a fixture to fixture retrofit basis and those can be easily spot-checked and monitored or just doing calculations based on the pre and post energy usage. Another way that is typically done with this is monitor the lighting panels themselves. That would be particularly useful if you are going to be using this in conjunction with controls.

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In closing, like to just thank everyone for participating with us today.

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We have a number of Web links that you can go to -- the FEMP exterior SSL program link is here on spectrally-enhanced lighting; there are two links that we like to forward people to: one which discusses the science and some of the stuff that I have been talking about in more detail. Reports that we have done are published there. And then FEMP has their website which has some interesting things on spectrally-enhanced lighting, specifically some good case studies to look at.

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FEMP Exterior SSL Initiative, we have a link to that, a link to the Commercial Building Energy Alliance, the Municipal Solid-state Street Lighting Consortium and the U.S. Department of Energy Solid-state Lighting website as well.

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And with that we are closing and our contact information is on this last slide.

Kathy Hyland:
Okay now time for your questions. We do not have a lot of time left so call in immediately. And in fact I believe we have Jose Sanchez from El Paso on the line. Jose can you hear us?

Jose Sanchez:
Yes I can.

Kathy Hyland:
What's your question?

Jose Sanchez:
Okay, in regards to the LED technologies one thing that I noticed was they mentioned lumen maintenance decaying over time. The first part of my question is is there public tables or charts where they show lumen maintenance, in other words the lumen output over time? And then also what would be the typical decay at the end of the life of the lamp? And lastly what would be the effects of heat on LED lighting fixtures?

Jeff McCullough:
Thank you, Jose. That was three questions, by the way. The first question you asked are there tables available to you. And what you do here is that the device manufacturers, so the major manufacturers do lumen maintenance testing on their individual devices. They do them at various drive currents and they do them at various temperatures. So you can request that information from your device manufacturer and that will give you a sense as to the lumen maintenance for those particular modules.

What becomes a challenge then is when I put those modules into a luminaire, into a fixture you have to remove the heat. And your third question was is heat an issue, and absolutely it is. These are semiconductor devices; they are neither a perfect insulator nor are they a perfect conductor, and so the more current that you put across them, you drive them with the hotter they get. And so we have to manage that heat, either by the use of cooling fins or using the fixture chassis, the fixture itself to help dissipate that heat.

One of the things that I would direct you towards is LM80 data and that is what I talked about earlier; that is where the individual manufacturers provide lumen maintenance data for their products over a range of temperatures and at various drive currents. That data is collected for a minimum of 6000 hours. To project forward we now have a new standard that is in place called TM21 and that allows you to take the LM80 data and project forward.

Your second question was well what is the life of these products. So in general what happens is they exhibit somewhat of an exponential decay; I will not get into what happens initially but there is typically an exponential decay for LEDs because they do not fail catastrophically. We define the point at which 50% -- check that -- the point at which 70% of the initial light output is still maintained. And depending on the drive current, depending on the temperature that can be anywhere from 35,000 hours to 100,00 hours. And that is where you have to exercise your due diligence. I will stop there but thank you, Jose.

Kathy Hyland:
We have Alan Weiss from Winter Park, Florida on the phone. Alan can you hear us? What's your question?

Alan Weiss:
My question is regarding the second part of the seminar on spectrally-enhanced lighting. And it occurs to me that nothing has been mentioned about the ongoing discussion taking place regarding blue-rich lighting, where the Kelvin temperature, when it is increased, has the possibility of causing damage to already affected eyes. I would like to hear the speaker to discuss at least that in part.

Brian Liebel:

Okay. The question that you are asking has a lot more complicated issues with it: the already damaged eye is one part of that and when you are talking about lighting recommendations of course we are talking about general practice and what can be done for that.

The specific issue I think that you might be referring to here is some of the work that has been done which cites a potential problem and that potential problem is not necessarily isolated to just the blueness of the light but the quantification of that light, in other words the overall dosing. And generally speaking when we are talking about interior lighting conditions the combination of the amount of the light and the spectrum of the light and the shifts that we are talking about are fairly very small and would not be such a problem. I think that the issues that you were talking about are more about having to do with daylight levels of light and much higher intensities than we are talking about.

Kathy Hyland:
Shawn I have a question directed at you. It says do you anticipate possible Federal requirements for LED use in exterior lighting?

Shawn Herrera:
Yes, we direct agencies to use current existing mandates and legislation. We encourage agencies to us the energy efficient technologies such as these lighting systems to help them meet their energy efficiency goals.

Kathy Hyland:
I have a question from Amy McElroy: and this directed towards you, Brian. Why hasn't the IES adopted SEL and its illuminance recommendations?

Brian Liebel:
That is a very good question and the answer to that is, to be quite honest and frank, is that it is an ongoing discussion with the IES. Historically speaking this has been a topic that has been quite contentious in the industry because of come perceived lack of evidence; that has been I think for the most part addressed. There is a standing committee within the IES now that is seriously looking at this. It is called the Visual Effects of Lamp Spectral Distribution Committee, of which I am the chair. We have put together a proposed technical memorandum that is working its way through the IES and we are hopeful that we will soon have that out or hopefully it will be out this year, which will address it.

I think the one thing that you would consider here is that we are talking about a paradigm shift in lighting where we have been using photopic lighting levels for 80 years. The idea that spectrum might have a role beyond standard illumination is something that is very new to this industry and it takes a while, as it should, to ferret through all of the science to make sure it is right, to make sure it can be done effectively and I do think that we will see something within the next year that will address this in the IES.

Kathy Hyland:
Amy has a follow-up question. It says basically: If I have to justify the use of SEL can I present the SP ratio multiplier as a justification for sub-IES photopic illuminance?

Brian Liebel:
Yes, let me put it very clearly and I think this is the way we did this presentation does address this but I will be very specific about this. The IES does not have minimum light levels for interior lighting applications and I want to stress this is for interior lighting levels. The recommendations are a recommendation and when pressed the IES will say, "Well it is just a recommendation." The science behind this is very well founded and if your basis is to do this for the purpose of maintaining visual acuity, as I have stated is the main reason for doing this, then you have a well-founded argument in science that would stand up, in my opinion.

Now there might be others that might contest this but at this point in time our office specifies it, a number of other offices specify it and I am quite comfortable in doing that.

Kathy Hyland:
Final question is directed towards Shawn: Shawn how is FEMP working with DOD to advance solid-state exterior lighting on military bases as Jeff mentioned?

Shawn Herrera:
Yes, FEMP is working with the DOD through its interagency task force and also we coordinate with the tri-services. And that will give us a huge impact because the DOD is FEMP's largest customer.

Kathy Hyland:
Good. Okay that is all the time we have today. Before I return to close let us look at the upcoming First Thursday Seminars.

Please take a moment to complete the brief evaluation that Tim Unruh mentioned to help us determine what future training topics you would like FEMP to offer and ways we can improve these First Thursday Seminars. You can also complete a quiz to reinforce your learning and that allows you to print a certificate for your records. You can access the quiz and evaluation in one of three ways: go to the website, www.FEMP.energy.gov/FirstThursday and find the quiz and evaluation there. If you registered for this course you will get a follow-up email with the link, and if you are watching this today by live webcast you can click on the paperclip icon and it will take you to the evaluation and quiz.

We would like to thank our instructors Jeff McCullough, Brian Liebel and Shawn Herrera. We would also like to thank FEMP for sponsoring the First Thursday Seminars and thank you for joining us today. We will see you on March the 1st for High Density Data Center Cooling and the New ASHRAE standards.

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