



**Moving from Niche to Mainstream Markets:
Addressing the High Cost of Daylighting Systems**

Transcript of a lecture given by
Glenn Hughes, Managing Director of Construction, The New York Times at
LightFair International: Daylighting Institute, New York, New York, May 6, 2007

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ACKNOWLEDGEMENTS

This work was supported by the New York State Energy Research and Development Authority and by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technology, State and Community Programs, Office of Building Research and Standards of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

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This is a talk about how The New York Times approached the cost of these automated roller shade and daylighting control systems.

DAYLIGHTING SAVINGS ANALYSIS

- Savings
 - Lighting energy savings for daylighting @ 30% to 50%
 - Lighting energy savings for target setpoints @ 20% to 40%
 - High rise commercial office building reduced lighting load for 25,000 sf floor plate is: 83,200 kW-hrs per year per floor = \$15,000 per year per floor @ 50% lighting power density
 - High rise commercial office building HVAC savings due to lower lighting energy is: \$5,000 per year per floor
 - High rise commercial office building daylighting savings @ 50% is: \$20,000 per year per floor
- Productivity improvements will provide even greater value

We did not have an unlimited budget. I was not told, "Glenn it doesn't matter how much it costs. Go ahead and do this." So I had to figure out ways to make this reasonable. I tried to achieve what we called our "big, hairy, audacious goal", which is a *Harvard Business Review* term and it was an idea in the mid-1990's saying, "Create a standard or a bar of excellence that is so high you can't even imagine how you could get there," and then say, "That's what we have to do." And accept that you may never get there, but that it's going to give you some breakthroughs. If you try to just incrementally get better you'll miss some of the great ideas in this world.

So we went for our big hairy audacious goal: dimmable lighting at no premium. I didn't get us there, but I took us a long way down that road. I brought it way down to where we think The New York Times and I think the marketplace will find out it is truly palatable, especially with the increasing energy costs that we're going to face in the future. It's hard to say what the energy savings are worth, because - well, what year are you going to pick? And if I pick ten years from now and use somebody's prediction of what energy is going to cost in the United States, it would be easier to justify these projects and the same investment is still there. So I think this is going to pay back much, much greater than we

imagine in today's world with a myopic view when we look at what energy costs are today and we say, "What's the return on investment? Is it two years or five years or seven years?" You have to think about what's happening to the cost of energy as well. Just think about the gas that you're putting in your cars if you own them. I haven't owned one for seven years, so I haven't felt that pinch, but I'm sure plenty have.

Lighting energy savings. With just the daylighting controls alone, with Lawrence Berkeley National Lab's help, we proved that we could save 30 percent - almost without even trying based on the type of window wall we have, the clarity of the glass, the height of the ceiling, all the things I've told you about - that was just pretty much handed to us: a 30 percent savings, as long as the system works properly. And if you push it a little bit, you can get it to somewhere around 50 percent. We also have the target setpoint. Instead of 50 footcandles, which is the design output level of our lighting system, what if we go down to 40 footcandles, what if we go down to 30 footcandles? Well, now we're starting to save 20 percent, 40 percent that way. All spaces aren't going to be down at 30 footcandles, but some will. So we've got a mix, somewhere between 30 and 40 footcandles is what I think is where we're going to land for the vast majority of our space and we'll have some down at 20 footcandles, we'll have a few at 50 footcandles, but we're going to end up somewhere in the 30 to 40 footcandles range. So that's a significant savings over the standard lighting set up in a building. We looked at that and we said, "Well, using last year's energy costs here in New York City, we could save \$15,000 a year based on reducing our lighting energy with the combination of daylighting and reduction in the target set points. And I think that's conservative. I'm not going to give you the materials and installation cost per square foot, so don't even bother to ask me.

Now because we are using less lighting, we're using less air conditioning and a quick translation or correlation between those kilowatt-hours and BTUs tells me that we are saving another \$5,000 on air conditioning costs because our lighting levels are that much lower than would have been otherwise. So we're looking at \$20,000 a floor, our floors are 25,000 square feet, a pretty modest size.

We also, and this is where it gets qualitative, believe that these systems enhance the way we work. They make us better at what we do by living in a world full of natural light and less electric light and a dynamic workspace that's changing, that you allow your body to feel the changes of Mother Nature. This leads to, we believe, productivity improvements, but we don't know how to measure that. I wish I did. We ran around the country, we talked to a number of people and nobody convinced us that they really know how to measure productivity yet. So that's one of those great open topics for some really significant research in this generation of people coming up now. There are a lot of people going to school, grad school, going to college right now that are interested in these types of systems and care about it and believe in it and maybe they will be the ones that can get this done now.

DAYLIGHTING COST ANALYSIS

- Automated shade control components
 - Digital addressable motors with encoders
 - Photosensors
 - Manual override stations
 - Communication wiring
 - Commissioning

The automated shade system: what is it made up of? It's made up of digital addressable motors with encoders. The encoders are telling the shade how far to move for the different preset heights. They're addressable motors so that we can individually control them, either with our manual override on the touch screen or with our shade control algorithms. There are photosensors. There are the manual override stations themselves. There's the wiring of these systems and there's the commissioning. So those are the basic components. Let's see how we can save some money talking about these.

So first, how many motors are there in the system? If you would imagine the simplest possible world, and this is how somebody estimated the job when I first suggested it, one of our owner reps said, "Well, every 5 feet of your curtainwall is going to be a shade, right?" And I said, "Yes, we're going to have to have a shade band in every glass window. That's true." Okay. So they assumed one motor per 5-foot curtain wall module. So every shade band had its own independent motor. Wow, is that really necessary? Why would you have one shade band, one motor? So when we built the mock-up, we pushed back and said we want four shade bands per motor or control of each 20 feet of shade. And after they did that, I wrote in the spec we want 30 feet. So right now we've been delivered 30 feet. So there's one motor instead of six. We've saved 84 percent of the cost of wiring motors simply by going from a one-to-one correspondence to a 1-to-6 correspondence. This is the kind of thinking but my ideas aren't the only answer here. Again, all we say is that we've opened the door, opened your mind. This is the way to approach things and you'll find lots of ways to save money.

Photosensors. How many photosensors do we need? We talked about that earlier. There's a lot of ways to reduce the number of photosensors if you can. And how do you network them? I think there are a lot of opportunities to find savings. LBNL has talked about how we piggybacked the photosensors in the lighting control system right on the DALI loop. So the photosensor is in the light right next to the ballast. The photosensor was delivered with a 29-inch flying lead. All the electrician - and it was already trimmed - had to do was drop the two leads into two pressure terminals on the ballast and the lighting sensor was in service. Done! This is a tremendous savings, instead of running another whole loop for the photosensors in the lighting controls.

The manual override stations. When we first approached this, in the mock-up and we had two different companies showing us what they could do. We said, "Okay, we're going to

need individual control of the motors so that we can see what's going on and how manual control is going to work." So they gave us switches. So for every motor they gave us a switch and on the switch it had six positions for preset heights. And so imagine the electricians went crazy trying to create a box on a column and they had six shade motors. So they had six switches, trying to line them up, make it look neat and clean so the architect would approve it. Wiring all six of those and they made so many mistakes that we went back three times to correct them. Then we finally had all of the motors working exactly according to the switches. And then we tried to label the switches so we knew which motor we were talking about every time we pushed a button. And I said, "You know, there's got to be a better way. How about one communication line and a touch screen?" And that's how the touch screen concept was born. I couldn't stand watching all of that extra work being done for no real value. So the touch screen now has a map on it that tells you where the motors are. And all it needs is one power supply to give it power and one communication cable back to the main vertical riser. Tremendous savings in terms of costs of electrical wiring.

The communication wiring itself - I've just explained how that can be reduced in cost. And in terms of the commissioning we told our contractors, "Find ways to build diagnostics into your head in systems. So you're policing yourselves with your system. If you're getting numbers that don't make sense, if your sensors are reading back numbers on a window wall that's in shadow and your sensors are telling you 50,000, 20,000 candelas per meter squared, wake up! Send yourself an alarm. Something's wrong with my sensor." This makes a big difference when you try to commission things. So you're not looking for a needle in a haystack. You're actually letting the system do a lot of work for you.

DAYLIGHTING COST ANALYSIS

- Electric lighting control components
 - Digital addressable dimming ballasts @ \$30 to \$40 premium
 - Photosensors
 - Communication wiring
 - Commissioning

Similarly for the lighting controls. Let's talk about what are the basic components and what can we do to try to save or reduce costs. We have the digital addressable dimming ballasts themselves. We have the photosensors. We have the wiring and we have the commissioning. So for the ballasts themselves, we found out from our lighting designer that DALI existed. We said, "Well, what's it [DALI] worth?" So they called up a company that makes digital dimming ballasts and asked them, "What's the cost of a DALI dimmable ballast?" And they said, "Oh, it's about \$130 each, something like that." And so they brought that back and then they took out the drawings and they looked at how many light sensors and light fixtures there were and they said, "Oh, you have 20,000 fixtures and a normal ballast would cost, let's say \$20 and the dimmable is \$130. So it's a \$110 premium, multiply that by 20,000, that's your premium." I said, "What a bunch of baloney." Why do I need to pay people to give me that kind of analysis? That doesn't mean anything. Is that how you buy ballasts when you buy 20,000 of them? Of course not! So we started working on the marketplace and we tried to transform the marketplace to change these ballasts from a luxury product to a commodity. And I think that's what we've done. It still costs more. I didn't get my big hairy audacious goal all the way, but it still costs more, but we got it down to about a \$30 premium on our job, which is pretty amazing. That was the first job that bought a big batch of these. The next job and the next job is going to keep driving prices down, because there's going to be competition amongst these ballast manufacturers. And I know there's been a lot of work done on them since August of 2004. So we should be able to find better pricing than I have.

Okay, the photosensors themselves we talked about, piggyback them on the communication loop, saved a pile of wiring costs. Communication wiring, the DALI wiring and the power wiring are allowed to be in the same raceway. This is not a control loop in a 0-10 volt world. This is a communication pair of conductors and those are allowed to sit in the same raceway as the power to the fixture. So we have the 277 volts and the DALI conductors, the communication conductors, pulled at the same time by the electricians as one pull. They just combine the ground, the hot, the neutral and the DALI conductors, pulled them all at once. That saved a secondary set of electricians coming through the space and pulling all of the DALI conductors as a separate operation. A big, big savings there. It's not the cost of the wires. The wires are almost insignificant. It's the cost of the labor to pull and terminate them at the fixtures. At least we have the pulling costs. We still have to terminate the extra two wires on every ballast, understood.

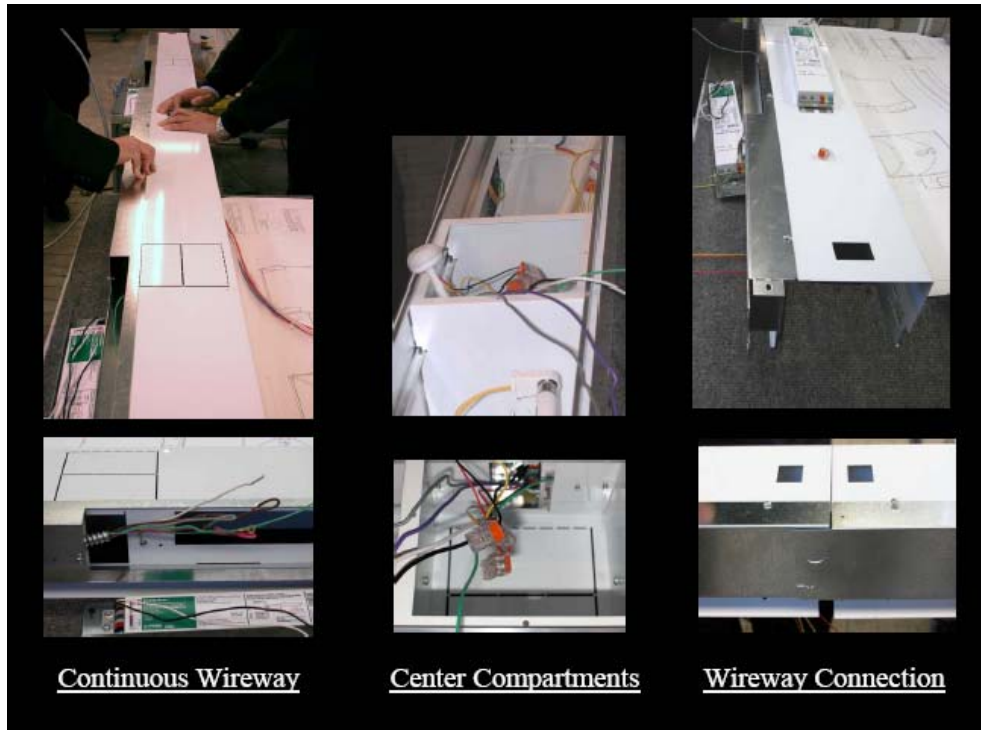
There was a slight premium there. And again the commissioning, the challenge was to build a system that self-commissions. Well, that one we're a long way off yet.

VALUE ENGINEERING for DAYLIGHTING SYSTEMS

- Owner's cost saving ideas
 - Light fixture internal raceway system
 - Composite pulls of power, ground and communication wires
 - Sensor network eliminated by utilizing digital communication loop
 - Lighting power panels consolidated with dimming panels
 - Low voltage power panels consolidated with dimming panels

The light fixtures. When you build a lighting design for the ceiling and if you go with a universal pattern like The New York Times did, we built the lights to tie into each other and we actually screw them together at each fixture. So they are allowed to now become a single raceway as long as they're connected to each other. So the light fixtures are the raceway. There are no conduits in our ceiling except for the emergency lights. The emergency lights have to have their own raceway, that's understood. All the emergency lights have an independent conduit system. All the other fixtures, which is 98 percent of the fixtures, I didn't put a conduit in the ceiling. Not one. I used the fixtures. Everything runs through the fixtures. The only time I had to come out of the fixture was to jump to the next row and then run another row. The jump we did in an armored cable system that was pre-cut before it came to site. Again, thinking about ways to make these things cheaper. Think about means and methods. I know everybody wants to say nothing, the means and methods are up to the contractors. Give them some good ideas. When you do that, you save a lot of money.

The lighting power panels. The lighting power panels are usually independent panels set in the electrical closet separate from the power panels, from your low voltage power panels. For instance, you're going to feed a pile of other outlets in your space and why not make the lighting power panel do that same job? You have a main, you have a main breaker, and you have 277 volt controls going on in there. How about adding some 120 volt feeds as well? So we put a 75 kva transformer, we put another batch of breakers in the panel and we eliminated low power panels low-voltage power panels for a large amount of our space. I'm not going to say we got rid of all of them, but we got rid of a very significant number of low-voltage power requirements. So think about things like that, just don't do the same thing we've done in the past. Find ways to combine things so that manufacturers can deliver it to you that way. It also costs us a lot less because there was a lot less electrician wiring in the field. We have do a lot more of the work back in the factories.



These are just a couple photographs about what I was talking about. This is a continuous raceway. This is one of the sensors and this is a center box in the fixture that the sensor will be mounted in. The way we did the job and I didn't show that to you, inside the fixture, each fixture is 5 feet long, the center is a 6 by 6 square and we can perforate that metal plate with any size hole we want. So we put our sprinklers through it. We put our lighting control photosensors through it, our occupancy sensors. All of the sensors in the space, including speakers in conference rooms are sitting in that plate in the middle of our fixture. It shortened a lot of wire lengths and it sure cleaned up the ceiling. We don't have any cut tiles, because we didn't have to cut tiles for anything except the emergency exit signs.

Commissioning Cart



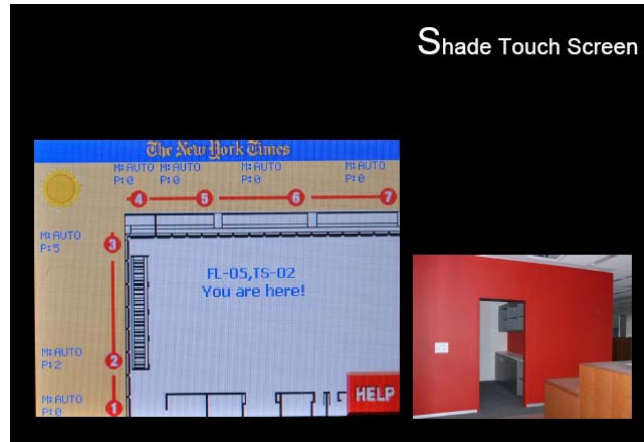
Okay, the commissioning carts that we've talked about here today are one of the ways that I believe we value engineered these systems. When our contractors knew that we were going to verify them with scientific tools, they took it seriously and so as they come out and do the commissioning of these floors for us, we're not finding so many mistakes. We're finding some software issues, some programming issues, but in terms of the hardware, the wiring, making sure the wiring is right, making sure the devices are working, making sure that the wires are plugged into the right terminals, not just whatever terminals the electrician might have thought was right. This all matters a lot. And if you do that right, the verification process goes pretty smoothly.

VALUE ENGINEERING for DAYLIGHTING SYSTEMS

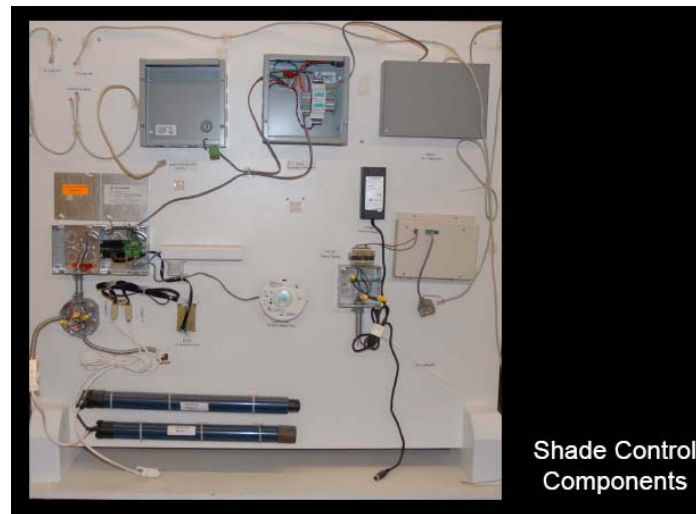
- Owner's cost saving ideas
 - Multiple shade bands per motor group
 - Touch screens for manual override
 - Cx cart for brightness control
 - Cx cart for work plane illuminance
 - Owner seminars to electrical contracting community for educated bidding
 - Owner direct relationships reduced contractor overheads and intermediaries

I worked overseas most of my life before I came here to New York and we always did big presentations to our contractors before they went out to bid. We didn't just send them the documents. We made them come to us and sit there and talk with us, listen to us talking first and then ask us questions if they wanted to ask them amongst each other. Sometimes they weren't happy about that, but regardless, break down some of the myths. Lighting control systems, every electrical contractor will tell you, "Ah, it's just so much more expensive." So it is almost a ticket for them to write up their bid price dramatically. And if they ALL are thinking the same way, then the owner or the developer is going to pay a significantly higher price than is necessary. If you educate them, which is what we did, we brought the fixtures and put them on boards. We brought all the lighting control components, all the shade control components, put them out on boards, said, "This is the kind of wire you're going to use, this is the kind of termination we're going to give you. We're going to pre-do all the jacks. So you just plug in." Help them understand that. We insisted that the estimator, the chief estimator of each of the electrical contractors that wanted to bid the job and at least a vice president had to come to our seminar. And in doing that, at least we knew the estimating department was going to pay attention and there was some executive in their company saying, "Are you sure we're staying competitive here?" Because other people, our competitors heard the same thing. And it forced them to think about what that premium was going to be in terms of their work.

We bought a lot of these systems directly ourselves. We didn't go through our contractors. So we bought the lighting control system from Lutron directly. The New York Times entered into a contract with Lutron. We bought our automated shade system from MechoShade with a direct contract of our own. We bought other things that aren't related to daylighting directly as well. We pre-purchased them when the market was right. That's another way of trying to save money. I'm just trying to help you understand the ideas, the good ideas that can be played out.



Touch screen we've talked about. Now you actually get to see one. So these are the motors on the touch screens. This is a staircase. So, when you are operating this, you get a chance to orient yourself with something in the building, either a column or a staircase so you understand where the motor groups are and then you can say, "Okay I want to raise this corner," so you touch three, you touch four and then you have an opportunity to change the shade position.



This was a board showing the shade control components. This is every component in the shade control system. Every type of wire. I brought this to the site so that the contractors that won the job, now their foreman can come down, take a look at this and see what they are going to do. They actually get a chance to visualize what they were doing up above in the ceiling and inside vertical raceways before they send their workers out. And it was a big help.

R&D

- Owner's market activities
 - Control algorithms specified for side lighting daylight schemes
 - Lighting controls components have been developed
 - Shade controls components have been developed
 - Panel layouts redefined for digital lighting control system with power & control features
 - Wiring schematics defined for lighting and shade control systems
 - Powerful new head-end systems developed per Owner's specifications
 - Ready for use by others

The marketing activities. Another way to save money. I talked about luxury to commodity prices. One of the outputs is the control algorithms that we've developed for the sidelighting daylight schemes. They've been achieved. They're public knowledge now. So use them in future jobs. And I think you'll find that the jobs will come in at better prices than you thought because this stuff's now been developed. Same with the lighting controls. The components themselves have now been developed. There is a lot of research that had to go into this. That's why we awarded in 2004, in August of 2004, to give the shade and the lighting controls contractors time to develop the products. This was going to be R&D and we knew it. Future jobs don't need that R&D or at least need a lot less.

The panel layouts, and the wiring schematics. We got into all of this prior to the final bid. So we understood, the owner understood, our engineer understood by the time we went out to bid how these systems should be wired up. What kind of components were going to be in them. So we gave very good documents to the bidders.

CONTRACTING ALTERNATIVES

- CM approach
 - CD set for GMP
 - ✓ Integrated lighting fixtures and daylighting controls
 - ✓ Daylighting control riser diagrams
 - ✓ Daylighting control schematics
 - ✓ Daylighting control layouts
 - ✓ Daylighting specifications
 - Subcontractor community
 - ✓ Buy design, electrical components
 - ✓ Install components & wiring
 - ✓ Buy Cx

CONTRACTING ALTERNATIVES

- Design Build approach
 - 35% CD set
 - ✓ Integrated lighting fixtures and daylighting controls
 - ✓ Daylighting controls intent diagrams
 - ✓ Daylighting control specifications
 - Design Builder to purchase daylighting system
 - Design Builder to integrate daylighting design
 - Design Builder to subcontract installation of daylighting system
 - Design Builder to purchase daylighting system Cx

The last thing I'm going to talk about is the contracting approach and how we can save money if you package things together. We were looking at light fixtures that were custom designed. We were looking at dimmable ballasts. We were looking at lighting control system, everything except for the ballasts. And we're looking at a shade control system, plus the shades themselves. So we said, "Okay, is there anybody out there that can do it all? If you're out there, bid this whole job turn-key." We gave them an offer. Nobody came to the table on that basis. Nobody wanted one to handle the electrical contractors themselves. So turn-key fell out even before we went to bid, because no one wanted to handle the electrical contractors. They were okay with handling the installation checkouts. But the contract, the electrical folks themselves, they found that difficult. That may or may not happen in the future. I'm just giving you our experience. So, the light fixtures themselves, should I buy them with the ballast installed in the fixture from the same company that makes the fixture? We invited a number of lighting fixture manufacturers to bid the job and said, "Here's the ballast spec, if you want to you, can buy that ballast from someone that can make it. You just deliver it in your fixture to us." And we said to the lighting controls contractors, "Do you want to make the ballast yourself? It is such a critical component in your lighting control system, wouldn't you want to have that under your control?" So why don't you bid lighting controls plus the

ballast? And maybe you make a deal with the lighting manufacturer and come in as a team, as a consortium. And the same with the shades. If you can do lighting controls and shades and ballasts, why don't you put all of that together as a package? So we allowed people to bid, we found enough vendors that could do shades, lighting controls, ballasts and fixtures to have a bid list of about 12 companies. And we said you can package this anyway you want. Submit it to us. The best deal you can give us. And so we came up with some pretty interesting possibilities. In the end, what we ended up awarding was a single shade package. We awarded the ballasts and the lighting controls as a second package and the light fixtures as a third. But the competition that was forced by the possibility of these combinations is what saved us money. That's really how it came out.

Q&A:

If you do all of these things before you bought your chillers, you could reduce the size of your chillers, absolutely. I can't claim the savings on the purchase of large assets for us. But we had to do all of our own R&D, so we just didn't have a chance. We had to make decisions - we made a lot of decisions before we knew all of what we were going to do with these energy efficient systems. If you can attack it early on, you can save some money on those chiller plans as well.

We don't know what the maintenance costs are. What we did is put very stiff warranties into our contracts. We are getting warranties anywhere from two to five years, depending on what we're talking about from our vendors. Then we would know what was going on and we would determine if we could maintain it ourselves or if we'd need a long-term maintenance agreement with these folks. We didn't want to just jump into a maintenance agreement that we may not need. Then we would just have a commitment of - whatever number it is per year and then find out, "Gee, what are we getting for that?" I didn't want to get into that. Plus it's a decision outside of my realm in the company, so the building operations folks in the end are going to have to make those decisions. We could not make it for them.

There is a possibility that we will get some tax credits because of the lighting system. We have people looking into that.

We have more lights than you might need because we did this continuous grid. But I can tell you that it makes the space very flexible. We have partitions, office front partitions that don't go through the ceiling. Just go up to the ceiling grid. But with the lighting system the way it is I can move walls on a five-foot module anywhere. I don't have to change a single light. I can change the groupings of the lights, but I can do that in the computer, probably take about two minutes.

The New York Times had very strict criteria about what happens, for instance, near walls, or near the interface between one place which is 350 lux and another which is 500 lux. Lutron actually tweaked the end fixtures on each one of those individual zones, tweaked them up a little bit if it was say near a wall. So it really did get the 500 lux all

the way to the wall. So, in fact you really can, if you have that individual control, tune your system to exactly the level you want.