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Classroom Photosensor Control System Roundtable Report

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Classroom Photosensor Control System Roundtable Report

Executive Summary

This report summarizes the information provided and received at a roundtable meeting held on May 21,2003 to discuss daylighting and daylighting controls. The roundtable brought together a group of exceptional expertise. This report summarizes the group's insight into the priorities for daylighting control collected from the group in three ways: response to a written questionnaire, an individual statement of priorities, and an extensive group discussion. Providing better daylighting products as well as better application tools were very important to the group. Overall, the four priorities were:

- simplified installation
- simplified setup and testing
- occupant adjustment capabilities
- tools for providing information to commissioning agent

Introduction

On May 21, 2003, The Watt Stopper (TWS) held a daylighting roundtable at Lawrence Berkeley National Laboratory (LBNL). The roundtable was conducted as part of the PIER Lighting Research Program Project 3.3. This research project is funded by the California Energy Commission and managed by Architectural Energy Corporation.

The purpose of Project 3.3 is to develop an improved photosensor for daylight responsive dimming for a classroom application. Earlier work in this Project had entailed testing by LBNL of The Watt Stopper's existing photosensor, the LS-201, as well as a review of the state of the art in existing photosensors. Ongoing work in this Project includes research by Dr. Richard Mistrick of Penn State University on the daylighting performance of typical classroom designs. Dr Mistrick is doing computer simulations of classrooms. His research is providing guidance to this Project on photosensor design as well as placement guidelines. Dr. Mistrick presented the preliminary results of his work at the roundtable.

The purpose of the roundtable was to present the preliminary findings of the research and to solicit comments from a collection of industry experts. The 32 attendees included architects, electrical engineers, lighting designers, daylighting consultants, utility representatives, researchers and TWS senior managers. People were invited based on two primary areas of professional activity: school design and daylighting. The topic of daylighting apparently has a high level of interest. When invitations to attend the roundtable were sent, TWS received a very strong response resulting in a larger audience than originally targeted. Another indicator was the fact that almost all of the people who confirmed did attend except two.

The event started at 8:30 in the morning and finished at 4:00 pm, running an hour longer than originally scheduled. The majority of the attendees stayed for the entire program and participated in various parts of the discussion. It was a spirited day of information exchange. The photo below shows the group of participants during the opening session.

Questionnaire Response

Each of the attendees was asked to complete a questionnaire prior to the beginning of the formal program. The purpose of the questionnaire was to understand the priorities of the attendees for an improved photosensor control system.

The results of the questionnaire are summarized in the following tables. Participants were asked to rank order the listed features for each category in order of importance. For instance, a ranking of one or two has a high level of importance while a ranking of four or five is lower. Twenty-one of the 32 attendees completed the questionnaire.

It is important to note that the results may not agree in all cases with suggestions and opinions given later in the day. For instance, on the second to last question of the questionnaire, TWS asked the participants to prioritize the major performance characteristics of the photosensor control system. The lowest ranked answer was for “occupant control capability”. Yet, during the roundtable there was an extensive discussion of occupant control and there appeared to be agreement from the group that occupant control was critical to occupant satisfaction.

The consensus highest priorities, in respective categories, were for “commissioning in one visit” and to “integrate control of luminaires in daylit zone with other switching zones”. Both of these priorities were further supported by discussion throughout the day.

RANKING

Performance (ranking 1–7)	Avg rating	# responses
Maintaining target illuminance over time	2.4	21
Not over-dimming	3.0	20
Fade/restore rates that are not disturbing to occupants	2.3	21
Works with both pendant and recessed luminaires	4.2	20
Seamless integration with occupancy sensors	4.2	20
Operation with emergency lighting circuits (go to full under emerg. conditions)	5.8	20
Capability to set maximum light output level (i.e. cap the upper limit)	5.6	20

Commissioning and set up (ranking 1–6)	Avg rating	# responses
Integral lamp burn-in timer	3.4	19
Commissioning in 1 visit	1.4	21
Commissioning without using ladders	2.9	21
Ability to copy commissioned settings to other photosensors	2.8	19
Ability to provide commissioning summary report	4.2	18
Other (1)		

Installation and wiring (ranking 1–4)	Avg rating	# responses
Install and wire within 30 minutes	2.0	21
Install and wire by one electrician	1.8	19
Control wiring operates with 0 - 10 volt dimming ballasts	2.1	15
Other (2)		

Occupant control capability (ranking 1–6)	Avg rating	# responses
Override daylight dimming controls	2.1	20
Integrate control of luminaires in daylit zone with other switching zones	1.6	19
Integrate lighting control with A/V control	3.2	18
Simple scene preset capability	3.1	17
Dimming level status indicator	4.6	14
Other (3)		

Please rank order the photosensor product characteristics in order of importance to you. (ranking 1–5)	Avg rating	# responses
Reliable performance	1.4	21
Simple installation and wiring	2.5	20
Simple commissioning	2.4	21
Occupant control capability	3.3	19
Other (4)		

How much would you pay (including installation) for a photosensor control system that had your top 3 ranked characteristics (excluding the cost of the dimming ballasts)?		# responses
$0.10 to $0.20/ft2	**41%**	17
$0.20 to $0.30/ft2	**29%**	
$0.30 to $0.40/ft2	**18%**	
$0.40 to $0.50/ft2	**12%**	

Additional comments for 'OTHER'		
1. Commissioning and set up		
	a	No special tool or instrument required to calibrate
	b	Rapid commission or self commission
	c	Auto commissioning
	d	Ease of recommissioning if required by school maintenance personnel
2. Installation and wiring		
	a	Low voltage wiring (unshielded)
	b	Standards for components of daylighting system to allow easy mix and matching of components
	c	Easily connects with other controls - integrates
	d	Generic output (10V/3-wire/2-wire/DALI)
	e	Use Cat 5 or 6 wiring standard
	f	Compatible with any dimming ballast models
	g	Whatever it takes to make it simple and affordable
3. Occupant control capability		
	a	Easy, simple operation
	b	Integrate with window controls
	c	Not able to change calibration
4. Product characteristics		
	a	Good technical product documentation
	b	Affordable, simple, universal, integrated application
	c	Reliable prediction of performance

Priorities for Daylighting Controls

At the beginning of the day, Dorene Maniccia led a discussion where each attendee was asked to identify their top three priorities for daylighting controls. While in many cases the previously mentioned priorities were seconded, this format encouraged people to more broadly cover the subject and participants attempted not to duplicate previously mentioned concerns. Below is a summary of the responses:

- Easy commissioning
- Simple installation
- Reasonable/low cost
- Simple and intuitive occupant controls for teacher
- Reliable
- Broad compatibility with the available dimming ballasts on the market
- Well designed feedback loops integrated with installation and set up
- Predictability models for energy savings/design tools
- Integration with luminaires
- Seamless integration with occupancy sensors
- Lumen maintenance (one mention as an issue and one as not an issue)
- Integrated controls with shading controls and eventually with HVAC controls
- Sensor location guidance (eliminate the mystery and “black magic”)
- Scalable for stand-alone applications and be able to have option for integrating with whole building system
- Ability to work with the various combinations of daylighting and electric lighting design strategies (sidelighting, toplighting, both)
- Minimize the number of components
- Improved documentation and performance specifications
- Make control components plug and play by using color coded wires and quick connectors
- Design tools for application and modeling
- Maintenance Free

All of these priorities were further supported throughout the day in both the presentations and discussions.

Technical Program

The technical program consisted of five presentations as illustrated in the below photos.

1. Technical performance overview by Francis Rubinstein.

2. Classroom daylighting simulations by Richard Mistrick.
3. Things learned from the simulations by Richard Mistrick.

4. Overview of proposed product performance and configuration by Doug Paton.
5. Presentation on method for simplified commissioning by Doug Paton.

Copies of the presentations are attached separately as Appendix II.

Summary of Discussion Topics

Comments from the participants on the various discussion topics have been captured and are provided on the following pages.

Vertical Illuminance

Many comments were made about the importance of vertical illuminance to a satisfactorily daylit environment.

> "People will keep lights on in entire classroom just to light the walls. All four walls need to be well lighted".

In response, a comment was made that good lighting design for a classroom includes the provision of separately switched lighting to illuminate the walls, particularly the teaching zone.

> "Separate lighting must be provided for displays".

> "If walls are not bright enough, then this a lighting design problem."

> "The good news is that the problem areas are outside of the working area. The bad news is the negative psychological reaction. The human reaction wants the core wall to be lit."

However, it was pointed out that using daylighting controls could make a bad design worse. Daylighting controls, in a bad design, are likely to increase contrast ratios between the daylight source and darker interiors.

> "If glare is controlled, then illumination can be almost anything."

This led to a discussion of what daylighting controls should be trying to control. Agreement was reached that daylighting controls should control for horizontal illuminance even though less emphasis is now being placed on the importance of horizontal illuminance in the IES guidelines.

> "The controls must be commissioned for something and at the end of the day, it will be illuminance."

An alternative suggestion was made to have the photosensor look at the core wall. However, it was pointed out that in a classroom, particularly an elementary school, the reflectance of the walls would change when artwork or seasonal displays are posted.

Richard Mistrick responded that information is available in his study about vertical illuminances in the classrooms, but that his study had not analyzed the vertical illuminances.

DALI

It was suggested that the photosensor design should interface with DALI.

Stepped Switching

An alternative control strategy of stepped switching was suggested because dimming ballasts are cost prohibitive in schools.

> "Cost of dimming ballast is a big issue."

> "People have expectations of brightness on the ceiling. Switched off lights can make them think the ceiling is dark."

> "Stepped switching is a human factors problem. It is distracting to occupants. In a classroom or office, automatic switching is not liked."

The group was polled on whether they agreed with this comment. More than half of the room raised their hands.

> "People accept fluctuations in daylight but do not accept fluctuations in electric light."

> "The perfect control system is one where the occupants never notice control of the lights."

Ease of Installation

There were many comments about installation difficulties with low voltage wiring.

> "Keep it simple or the installer will screw it up. Make it Bubba friendly!"

> "Make it plug and play." (Strong support from the rest of the audience)

> "Do not use gray, white, black, brown, red or green for your low voltage wiring."

> "Line voltage is more installer friendly because they are more familiar with it."

There were several suggestions on simplifying installation:

> "Use RJ 45 connectors to reduce installation time."

> "Use standard Ethernet cables and connections."

> "Label device for the application. If two zone controller, label one zone 'inner row' and the other 'outer row.'"

Power Pack

In the TWS presentation, Doug Paton presented a product concept that required a power pack where previously a power pack had not been required. The audience was asked for their reaction to this added piece.

> "In a classroom, occupancy sensors are required by code. The best occupancy sensors use a power pack. Therefore, the power pack is already required. In most situations requiring a power pack will not be an issue."

Number of Ballasts in a Control Zone

It is typical for photosensors to be designed to dim up to a maximum of 50 ballasts in a control zone. The group was asked what is the maximum number of ballasts necessary for control. For a sidelit application, the answer was 24 for a classroom and a more general answer applying to open offices was up to 30. For sidelit applications, no one contradicted those two numbers. Others mentioned that toplit zones could possibly be more than 30.

Direction on Locating Photosensor

Several comments were made about the need for better guidance for designers in correctly locating the photosensor.

Many people spoke in support of needing better design tools that could help with the following areas: simplified daylighting analysis, integration with lighting, guidance on photosensor locations, and selection of the critical point for setup as well as commissioning.

Mounting on Pendant Fixtures

Several people spoke of compelling reasons to mount photosensors in the pendant fixtures.

> "In existing schools, there are rarely lay-in ceilings. There are no opportunities to run control wires in the ceiling."
>
> "Fixtures integrated with photosensors become an item or product and not a service. There is less dependence on the installers. I can have more confidence specifying this product as a solution."
>
> "Fixture integration helps to make it plug and play."
>
> "Reduces the number of components."

> "Potentially more savings by providing individual fixture control. Row next to window can be fully dimmed and inner row can be partially dimmed."

The following comments were made in counterpoint:

> "Fixture mounting reduces the cone of view therefore increasing the problem of changes in response to changes in reflectivity."

> "Additional diligence is required in coordination for fixture mounted sensors. There are no site options to change photosensor position."

> "Integrated solutions do not have to be fixture mounted. They can be coordinated with fixtures, perhaps provided turnkey by fixture manufacturer, but for ceiling mount. Just make it plug n play."

Combining Dimming and Non-Dimming in a Classroom

The comment was made to avoid mixing and matching ballast types. The recommendation was made to use a standardized ballast type throughout any application type in a building, such as a classroom.

> "If dimming and non-dimming ballasts are mixed, the dimming ballasts will get replaced with non-dimming ballasts when they fail. The dimming control will be defeated."

Memory Retention

The following comment was made regarding memory retention.

> "Photosensor must retain memory if powered down. I have had unfortunate experience with another manufacturer's product that lose their memory when power fails."

Integration of Photosensors and Occupancy Sensors

Questions were asked about opportunities to combine photosensors and occupancy sensors, both to simplify installation and provide enhanced control strategies.

> "The power pack is the key. The power pack is the nerve center. It can prioritize the control inputs."

> "With gyp board ceilings, a combined device with occupancy sensor, photosensor and power pack could be very helpful. It would simplify the installation. It would eliminate the low voltage wires that have no place to hide."

Photocell Performance

A question was asked about the technical performance of the photocells over a period of time and under a variety of conditions. The request was made for manufacturers to provide information on linearity and stability of photosensors.

> "What is the photocell performance after five years? This is parallel to lumen maintenance information provided for lamps. Data is provided by the manufacturers to predict behavior over time."

> "What is the photocell's accuracy in high temperature conditions? Low temperature conditions? "

> "What is the performance of the plastic after five years? Is the transmittance reduced?"

Differentiation of Light Sources

The question was asked about advantages of measuring the electric light and the daylight in the controlled area.

> "Ability to differentiate electric light and daylight will improve control corrections."

> "If lumen maintenance is important, then really need to differentiate light sources."

In response, this comment was offered:

> "The requirement for lumen maintenance has been greatly decreased by improved lamp and ballast performance."

Possible methods of differentiating light sources were described. One method was to measure the spectral qualities of daylight, particularly the IR quantity:

> "The IR component of daylight varies wildly by time of day. For instance, it is quite different at sunrise and sunset. Also, the IR content is affected by the glass as well as the blinds. Newer glass technologies are drastically reducing IR transmittance and may eliminate it."

The Critical Point

The "critical point" is the reference spot used to adjust and test the system. Typically, it is a task surface onto which a setup tool would be placed. Several definitions were suggested for finding this point:

> "Most useable task location closest to the interior wall."

> "Turn off the dimmed lights, walk back from the window and find the darkest point."
>
> "I do not want the contractor picking the critical point. I need a design tool that allows me to specify this point."
>
> "It is important to realize that the critical point is typically not in the same location as the photosensor."

Commissioning (Setup and Test)

There were many comments about the use of the term "commissioning". Commissioning refers to a formal review and report by a commissioning agent. For the roundtable discussions, commissioning refers to the contractor setup and test of the system. Furthermore, the 2005 revision of Title 24 will require a commissioning report as part of the building acceptance process. The group strongly suggested that different terminology be used. The alternative suggestions for contractor setup and test were:

> Initial Setup
>
> Final Calibration

The group also strongly reinforced that calibration and setup must be simple.

> "If it does not get done in one visit, it is not likely to get done."
>
> "Most practitioners need it to be dead simple if it is going to work."

Other setup requirements were addressed:

> The setup and test tool must be able to talk to a selected photosensor in a space that may have multiple photosensors such as an open office.
>
> "Interaction between adjoining dimming zones is an important problem to solve. Must be easy to setup. Must not have interplay where one zone dims and the adjoining brightens. May require sensitivity adjustment."
>
> "For setup and testing, need an override for the normal operation to test that the system is working. Must be able to bypass time delays."
>
> It was suggested that it might be appropriate to be able to calibrate the same zone from two different reference locations (critical points). It was further suggested that it would be advantageous to select the more conservative settings to operate the photosensor.

> It was suggested that calibration and setup should be able to occur when it is not acceptable to turn off the controlled lights. For this situation, calibration and setup should be able to be done in two visits. One would be a daytime visit measuring the daylight contribution and the other would be a nighttime visit measuring only the electric lights.
>
> Separation of the installation phase completed before the installation of furniture, and the calibration phase completed after the installation of furniture was supported. Not having to use a ladder during the installation phase was considered a plus.

Other comments on the setup tool:

> "If only one is required, then you can afford to have an expensive tool."
>
> "For a small installation, the sales rep goes out and brings his own setup tool."
>
> "You could also have your sales people loan the device to the contractor if cost was an issue."
>
> "Download of setup parameters is useful for troubleshooting."
>
> "Look at the settings data and you may chose to repeat the setup and testing for units whose setup parameters did not match the others."
>
> "USB connectivity is good."

The commissioning agent is likely to require a tool to verify the operation of the photosensors.

For commissioning documentation, it would be useful to provide setup information for the photosensors. It was suggested to have the setup tool download the setup information from the photocell so that it could be included in a commissioning report.

> "Download setup parameters for commissioning agent or inspector."
>
> "You could make it like a smog report for each photosensor."

<u>Occupant Override</u>

The group was asked if an occupant dimming adjustment wall switch was mandatory in a classroom. The group said overwhelming that it was mandatory.

The response was that a handheld remote is not appropriate for a classroom because a handheld remote will get lost or stolen.

It was suggested that many occupants may use override capabilities to reduce the lighting levels from design conditions, thereby saving energy.

It was suggested that the photosensor could learn occupant preferences.

> "The photosensor recalibrates itself based on occupant preferences."

Several alternative suggestions were made for occupant override ability:

> "Only allow an occupant to reduce their light level. If system works well, there is no need for them to raise their lights. If they have the option of going up, they will. The controls should only allow going down and restore to the automatic level."

> "Allow occupant to adjust their lights up 20 percent from the automatic level and then restore it to the automatic level the next day."

In response, there was a question pointing out the challenges of defining limits:

> "Twenty percent of what? Footcandles? Perceived value?"

> "Give people some sense of control. Change the slew rate for fast response to occupant adjustment. Make the change in real time."

> "If the occupant can raise it up but it is already at its maximum, then what happens?"

> "Do not use a slider for a wall switch. The teacher will complain if the slider is not always at the top."

The response to this last question was to add an LED bar chart on the wall switch. The LEDs would light only when, or immediately, following an adjustment was made. The analogy was made to a volume indicator on a television. It was suggested to the group that this visual indicator would add cost to the system and at least one additional wire to the wall switch. The answer was that it would provide value if it could be added at a minimal cost.

The group was also asked if having "scene" control was useful. Several people responded 'yes' particularly due to increased audio/visual use in the upper grades.

> "Very desirable if not too expensive."

> "Not having scene control is not a show stopper."

<u>Multi-zone Daylighting Control</u>

Several comments were made stating the need for multi-zone control.

> "There is an opportunity here to optimize control based on your research. There are additional savings available by dimming the inner rows differently than the window row. Having all lights dim together is not as good."

The suggestion was made to provide two zones of control from one photosensor. It was pointed out that this would be a more complex device. It was also pointed out that a closed loop device is only closed for one zone. There were several suggestions on providing control for the outlying zone.

> "Send a reduced signal to the second zone."

> "Setup and testing tool may need to take two sets of readings for a two zone control. One set of readings for zone one and one set for zone two."

> "Make the setup of two zones as easy as setup of the one zone device."

> "Going beyond classrooms, for instance, in open offices would need three zones of control."

> "With multiple zones, may want window zone to shutoff when there is enough daylight but have inner row stay on. However, both rows should able to be shut off for manual control."

Summary

The group's comments were exceptional. They were very supportive of the Project work as well as being insightful with suggestions. Many people praised the work and reinforced the need for better daylighting controls and tools. Several people commented on how important this work was. No one suggested that the direction was not correct. Furthermore, none of the suggestions contradicted the current specification and direction. Instead, the suggestions added applications and concerns that the Project team may not have anticipated as well as a prioritizing of function and features.

At the end of the roundtable, several people suggested that sites that they were working on might be possible beta sites for testing. These volunteers further reinforced the feeling by the Project team that the audience supported the Project's direction.

In reviewing what was learned or heard from the group, it is important to evaluate possible contradictory information. For example, there were many concerns about keeping the cost of the controls inexpensive, but there were many more requests for additional features that would increase the product cost. It is also important to evaluate the suggestions against a very tight schedule and budget for this PIER Project. To achieve the Project goals, it is critical to maintain the original focus. As stated to the group, the goal of this PIER Project is, first and foremost, to provide improved daylighting control.

Many of the suggestions will not be immediately included in the scope. However, once the Project team completes the original scope of work, then several of the suggestions will be considered and may be worthy enhancements. Summarized below are the suggestions that will be immediately incorporated into the revised project specification and suggestions that may be incorporated into future versions of daylighting control systems.

Suggestions that will be incorporated into the present specification

Plug and play wiring including color-coding and quick connectors.

Maintain the flexibility to mount photosensor on a ceiling or in a pendant fixture.

Use "setup and testing" instead of "commissioning" to refer to initial adjustment made by the installing contractor.

Add a port to the setup tool to support reporting on photosensor setup and testing. Begin to look at report formatting.

Consider additional possible application requirements such as individually addressing a photosensor in an area with multiple photosensors.

Provide a wall switch for dimming adjustment. Wall switch may include a visual indication of current adjustment.

Suggestions that may be incorporated into future versions of daylighting control systems

Support for DALI ballasts.

Provide photocell performance specifications over the expected life of the device and under a variety of temperature conditions.

Add scene control capabilities.

Add multi-zone capabilities.

In closing, the Project team received several enthusiastic emails from participants after the roundtable. A sampling of the emails are listed below:

First email

Thank you VERY much for having us. We would very much like to stay involved in the process, and are looking for schools who might be interested in being "beta test sites" for this project. Let me know if you want a few rooms or a building or a campus.

<u>Second email</u>
Yes, thank YOU, for a very invigorating and intriguing day! I want you to know that I meant it, when I raised my hand to volunteer knowledge of actual sites to serve as beta test sites for your new products and/or PIER research participation.

I would be interested in hearing more about what your project needs might be to see if there was a fit. We have lots of classroom work!

<u>Third email</u>

Great job by you and your staff (Rick too!) on presenting and moderating the roundtable. The energy from the group was great and the comments enlightening.

<u>Fourth email</u>
Thank you for inviting me - and setting up such a stimulating roundtable!

<u>Fifth email</u>
Thanks for inviting me. I wanted to elaborate on one or two things I said yesterday. My goal is to come up with a system that people accept, that creates a reasonably good visual environment, and that saves energy. I sometimes think that the more we try to automate the system and bypass the occupants, the higher the standard for occupant acceptance becomes. At any rate, I appreciate your efforts and those of everyone at LBNL. I didn't want my comments to be perceived as negative about the project and the overall effort. Thanks for involving me in the meeting.

Appendix I: List of Attendees

Oyvind Aschehoug, LBNL (visiting professor from Norwegian University of Science and Technology)
Don Aumann, California Energy Commission (by phone)
Jim Barnett, SMUD
George Beeler, Aim Associates
Jim Benya, Benya Lighting Design
Steve Blanc, PG&E
Mike Boltz, Associated Lighting Representatives
Bert Braden, Braden Professional Engineers
Bill Burke, PG&E Energy Center
Peter Colenbrander, O'Mahony & Myer
Leslie Davis, Auerbach and Glassow
Neall Digert, Solatube
Harold Jepsen, TWS
Karl Johnson, consultant
David Kaneda, Integrated Design Associates, Inc (IDEAS)
Paul LaBerge, Solar Graphic
Eleanor Lee, LBNL
Brian Liebel, AfterImage + Space
George Loisos, Loisos/Ubbelohde
Dorene Maniccia, TWS
Jon McHugh, Heschong Mahone Group
Richard Mistrick, Penn State
Jerry Mix, TWS
Steve Mix, TWS
Kostas Papamichael, LBNL
Doug Paton, TWS
Radu Pitigoi-Aron, TWS
Judie Porter, Architectural Engineering Corporation
Frank Rice, WHM
Francis Rubinstein, LBNL
Pete Samaras, Flack and Kurtz
Steve Selkowitz, LBNL
Jaime Soriano, TMAD Engineers
Pomme Suchato, Integrated Design Associates, Inc (IDEAS)
Alice Sung, VBN Architects
Prasad Vaidya, the Weidt Group

Appendix II: Presentations

Presentations are provided separately.