

## Skylighting and Photocontrols Savings



Urban Myths and Realities from a Field Study



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## Project Team

- Southern California Edison
  - Gregg Ander, FAIA
  - Jack Melnyk, P.E.
- Heschong Mahone Group (HMG)
  - Douglas Mahone, Principal-in-Charge
  - Jonathan McHugh, Senior Project Manager
  - Abhijeet Pande, Project Manager
  - Sean Denniston, Research Associate

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## Context Photocontrols



- What are photocontrols?
- Photocontrols system components
  - Photosensor – the device that senses light and converts it into an electrical signal
  - Controller – the “brain” of the system containing control algorithms and calibration settings
  - Control device – the relay or dimming circuit that controls power to the lights

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Context

## Photocontrols

- Photocontrols performance reliability
- Urban myths
  - Photocontrols don't work
    - They are too hard to understand
    - They are too hard to install
    - They fail often
    - They irritate occupants
  - Skylights cause too much heat gain
  - Skylights leak

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Context

## Energy Savings

- 58% of Commercial Floor Space in the US\*
  - Low-rise
  - Directly under a roof
  - Potential for toplighting
- Energy savings of 23,548 GWh/yr possible from skylights and photocontrols
- Demand savings of 11,800 MW



*Do we really need those lights?*

\* From an analysis of the Energy Information Agency's Commercial Building Energy Consumption Survey (CBECS) database, (McHugh et al., 2003)

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## Project Background

- Follow-on to prior studies with PG&E
- SCE Photocontrols Field Study
  - 46 existing buildings with skylighting and photocontrols
  - Low-rise non-residential new buildings
    - Up to 10 years old
    - Located in southern California
  - Sample drawn from:
    - Savings By Design Participants
    - Leads from Manufacturers, Installers, Designers

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## Project Goals

- Characterize existing photocontrols applications
- Assess operation status and actual savings
- Assess characteristics of working/failed systems
- Develop guidelines for effective installation
- Recommend utility program enhancements
  - Ahead of the 2005 CA Title 24 code changes

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## Project Methodology

- Telephone screening
  - 150 sites called
  - 62 sites completed interviews
  - 46 sites recruited for surveys
- Onsite observations – 46 sites
- Power metering and weather data
- Savings Analysis (for skylit buildings only)
- Photocontrols characteristics database
- SCE Skylit Photocontrols Guidelines (for skylit buildings only)

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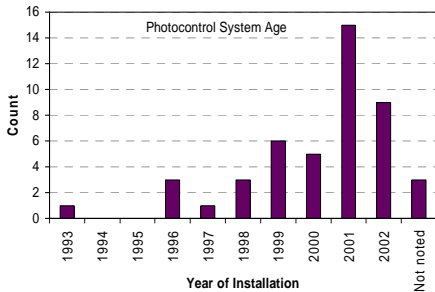
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## Building Vintages

- Photocontrol system installation year (46 sites visited)



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## Surveyed Space Characteristics

- Occupancy Type (46 spaces total):
  - Manufacturing/Warehouse – 20
  - Retail – 17
  - Office – 5
  - Classroom – 4
- Photocontrol Equipment Type
  - EMS Tied – 16
  - Control Panel – 13
  - Control Pack – 8
  - Fixture Integrated – 3
  - Outdoor Sensor – 3
  - No Photocontrols – 3

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## Photocontrol System

### Operational status reported by site contact

- Range of operational conditions\*: (46 sites)
  - 16 sites – Photocontrols working well
  - 20 sites – Photocontrols working w. problems
  - 2 sites – Photocontrols not working
  - 4 sites – Supplemental switching OFF
  - 1 site – Overridden by turning lights ON
  - 3 sites – *No photocontrols*

- Based upon the building owners/operators observations of lighting operation, and surveyor's onsite observations.
- Actual performance per design intent may differ from above.

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## User Satisfaction with Photocontrol System Summary

- User dissatisfaction is NOT specific to any
  - Lamp type
  - Occupancy type
  - Controller type
  - Control algorithm
  - Amount of daylight (Skylight area to Floor area Ratio)
  - System age
- Users dissatisfaction mainly related to system setpoints
  - Most of the problem sites had problems right from time of installation/setup

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## Photocontrol System Onsite Verification

- 32 sites analyzed for this study\*
- Sites re-classified into two categories post-monitoring
  - 21 sites – System Fully Automated
  - 11 sites – Automated + Manual Assist

- \* 14 of 46 sites ineligible for analysis due to
- 2 Spaces – No photocontrols
  - 4 Spaces – Sidelit
  - 2 Spaces – Could not install loggers
  - 4 Spaces – Loggers lost
  - 2 Spaces – Logger data corrupted

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## Photocontrol System Onsite Verification

### ■ Automated + Manually Assisted Systems (11 sites)

- Occasional Manual Control (5 sites)
  - Occasional supplemental control to increase savings
- Consistent Manual Control (4 sites)
  - Site operators manually switch lights OFF at set times during the day
- Overridden System (1 site)
  - Site operators bypass the photocontrols, and manually control lights at all times
- Disabled System (1 site)
  - The photocontrol system is taken offline, and does not send control signal to fixtures



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## System Operation vs. Space Type

Building Type	Fraction of Sample	Fully Automated	Automated + Manually Assisted
Mfg/Warehouse	50%	10	6
Retail	38%	10	2
Office	3%	1	--
Classroom	9%	--	3
		21	11

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## System Operation vs. Control Type

Photocontrols Equipment Type	Fully Automated	Automated + Manually Assisted
EMS Tied	8	3
Control Panel	7	3
Control Pack	1	4
Fixture Integrated	3	0
Outdoor Sensor	2	1
	21	11

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## Savings Estimation

- Potential Savings
  - SkyCalc™ runs based upon site data
    - Technical potential of a system working per design
    - Extrapolation based upon weather data
  - Approximates an 'ideal' photocontrol system
- Measured Savings
  - Measured power data from sites
    - 2-week monitored data on lighting circuits
- Realized Savings Ratio (RSR)
  - Measured Savings (kWh) / Potential Savings (kWh)
    - RSR<1 = system works less than ideal on site
    - RSR>1 = system works better on site than the 'ideal' control

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## Savings Analysis Realized Savings Ratio vs. User Satisfaction

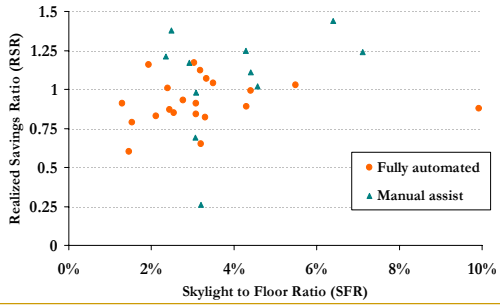
User Perception (Subjective)		Actual Performance		Mean Realized Savings Ratio	Mean SkyCalc Savings (kWh/sf.yr)
Subjective Assessment of Condition	# sites	Fully Automated	Automated + Manual Assist		
Working well	13	13	0	0.96	1.58
Working	14	7	7	1.02	0.90
Not Working	2	1	1	0.36	0.62
Supplemented	2	0	2	1.28	0.83
Overridden	1	0	1	0.69	1.16
<b>Total # of sites analyzed</b>	<b>32</b>	<b>21</b>	<b>11</b>		
Mean Realized Savings ratio		0.92	1.07		
Mean SkyCalc Savings (kWh/sf.yr)		1.39	0.79		
Std.dev of Realized Savings Ratio		0.15	0.34		

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## Skylight to Floor Ratio vs. Realized Savings Ratio



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Notice the electric lights?

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## Urban Myths Debunked

- Photocontrols fail:
  - None of the systems physically failed
- Users will undermine system operation:
  - No one taped over photosensor
  - No one clipped control wiring
  - Most manual over-rides occurred due to aggressive savings goals
- Photocontrols do not save energy:
  - Mean savings from operational sites – 97% as compared to the savings potential

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Things we learned

## The cup is $\frac{3}{4}$ full



- Most toplit systems are functioning
- In aggregate, the systems are saving as planned
- Realized savings = estimated savings
  - But, there is a large individual range
  - Fully automatic systems 60%-117%, avg 92%
  - Partially manual systems 20%-144%, avg 107%

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Where are the photocontrols when you need them?

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Things We Learned

## The cup is $\frac{1}{4}$ empty



- If systems don't work right at the start, they don't get fixed later.....
  - ...users report that problems started at the time of installation on
    - 9 of the 11 sites with automated + manual assists
    - 7 of the 21 sites with fully automated control
    - Most of these systems were 'simple' On/OFF controls...
  - Problems range from
    - Lights levels too low after controls installed
    - Lights switch too infrequently (!)
    - Control setpoints too high or too low

*In one warehouse the commissioning was done without stacks. Once stacks were installed, the light levels were too low, and the system was overridden...*

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Things We Learned

## The cup is 1/4 empty



- Many operators don't know how to adjust systems
  - 1/3 don't even know where the sensors are
    - We even found 3 spaces that had NO photocontrols...
    - ... even though the owners were convinced they were present
- Few systems annoy people
  - Only one system lights were overridden ON
- If lights not turned off, building energy use increases due to skylights

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## SCE Skylit Photocontrol Guidelines 2003

- Aimed at Manufacturers to improve products
  - First, do no harm
    - Make sure system does not interfere w productivity
  - Second, KISS
    - Simple, understandable and adjustable
  - Third, publish commissioning instructions
    - To meet design intent and optimize energy savings
- Manufacturers train their customers

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## SCE Skylit Photocontrols Guidelines 2003

- Guidelines split into various sections
  - Building Designers Guidelines
    - Integrate skylighting and controls in the building design
  - Lighting Systems Designer Guidelines
    - Choice of fixtures, layout, circuiting
  - Lighting Controls Designer Guidelines
    - Control strategy, photosensor type, location
  - Photocontrols Installer/Commissioner Guidelines
    - Open Loop and Closed Loop Commissioning Protocols
  - Building Operators Guidelines
    - Understand, optimize and troubleshoot

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## Next Steps

- Photocontrols credits already included in 2005 California Title 24 Energy Code
- Photocontrols and Skylight credits in ASHRAE 90.1 (2007?)
- Do photocontrols perform well in sidelit applications?
  - Following presentation
- EDR Photocontrol Guidelines 2007

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## New EDR Photocontrol Guidelines in 2007

- Toplighting and Sidelighting
- Sponsored by CA utilities for energy savings
- To be available through Energy Design Resources
  - An educational component of Savings By Design
  - [www.energydesignresources.com](http://www.energydesignresources.com)
- Targeted at designers
- Not representing any controls company
- Based on "lessons learned"

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## The Skylighting Guidelines 1998

- Design guidelines for commercial and industrial buildings
- Uniform illumination in simple, open-plan buildings
- Download free from [www.energydesignresources.com](http://www.energydesignresources.com)
- Design software (SkyCalc spreadsheet)
  - Free download from [www.h-m-g.com](http://www.h-m-g.com)



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## More Information

- Photocontrols studies and issues
  - Abhijeet Pande, HMG
    - (916)-962-7001
    - [pande@h-m-g.com](mailto:pande@h-m-g.com)
- For copy of SCE Skylight Photocontrols Guidelines
  - Lisa McNamara at SCE
    - (626) 633-7171
    - [lisa.mcnamara@sce.com](mailto:lisa.mcnamara@sce.com)
  - Report soon to be posted on
    - <http://www.calcodescouncil.com>



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