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Addressable Lighting Control Systems

Strategies for Achieving up to 78% Lighting Energy Savings

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Presentation Objective

1. Reiterate importance of lighting control as a tool for reducing energy consumption and peak demand
2. Define “intelligent” addressable lighting control systems, & compare/contrast with localized lighting controls
3. Point out specific advantages of addressable networked lighting controls
4. Identify other advantages of addressable lighting controls (e.g. life safety, productivity, patient recovery, etc).
5. Review case studies that show overall savings of between 68% to 74%
6. Q & A session

Outline

- Presentation Objective
- Lighting as an Opportunity for Significant Savings
- Lighting Energy Management Strategies
- Definition of Addressable Lighting Controls
- Advantages of Addressable Lighting Controls
- Addressable Lighting Controls & Intelligent Buildings
- Non-Energy Related Benefits
- Case Studies
- Conclusions

Advanced Lighting Controls Not New…

http://repository.tamu.edu/bitstream/handle/1969.1/6676/ESL-HH-85-09-04.pdf?sequence=3 - Windows Internet Explorer

ESL-HH-85-09-04

CONTINUOUS CONTROLS:
LIGHTING ENERGY MANAGEMENT FOR RETROFIT AND NEW CONSTRUCTION PROJECTS

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ABSTRACT

The rising interest of specifiers and end-users in Lighting Energy Management (LEM) control equipment has led to an increased need for further education in the selection, capabilities and applications of such equipment.

This paper addresses these and related points

system can be selected for each client.

CONTINUOUS CONTROLS

There are several types of LEM control equipment that a specifier can choose from. One of the most technically innovative and economically justifiable of these is "continuous control", often referred to as dimming. In its truest sense, how-

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… in Use Since Early 1980's

http://repository.tamu.edu/bitstream/handle/1969.1/6676/ESL-HH-85-09-04.pdf?sequence=3 - Windows Internet Explorer

increase; those which occurred in 1974 and 1979 are good examples. Specifiers then, must become proficient at understanding the capabilities and applications of LEM equipment. They must gain the attention of building owners who expect energy-efficient buildings and realize that properly designed, high-quality LEM equipment will help ensure long term satisfaction. Conversely, building owners will seek out specifiers with a thorough understanding of LEM as well as a proven track record. It will then be to the advantage of architects, engineers and lighting designers to become knowledgeable about the various LEM controls that are available so that the optimum control

by capacity: sub-circuit, circuit, multi-circuit and panel control.

SUB-CIRCUIT

Sub-circuit control is used when the lighting level requirements or working schedules vary within a small area, typically less that 1,000 square feet. Sub-circuit control would be considered for areas less than 500 square feet for some older buildings with 120 volt lighting systems. The equipment is generally located above the ceiling in the plenum or in the fixture itself.

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Proceedings of the Second Symposium on Improving Building Systems in Hot and Humid Climates, College Station, TX, September 24-26, 1985

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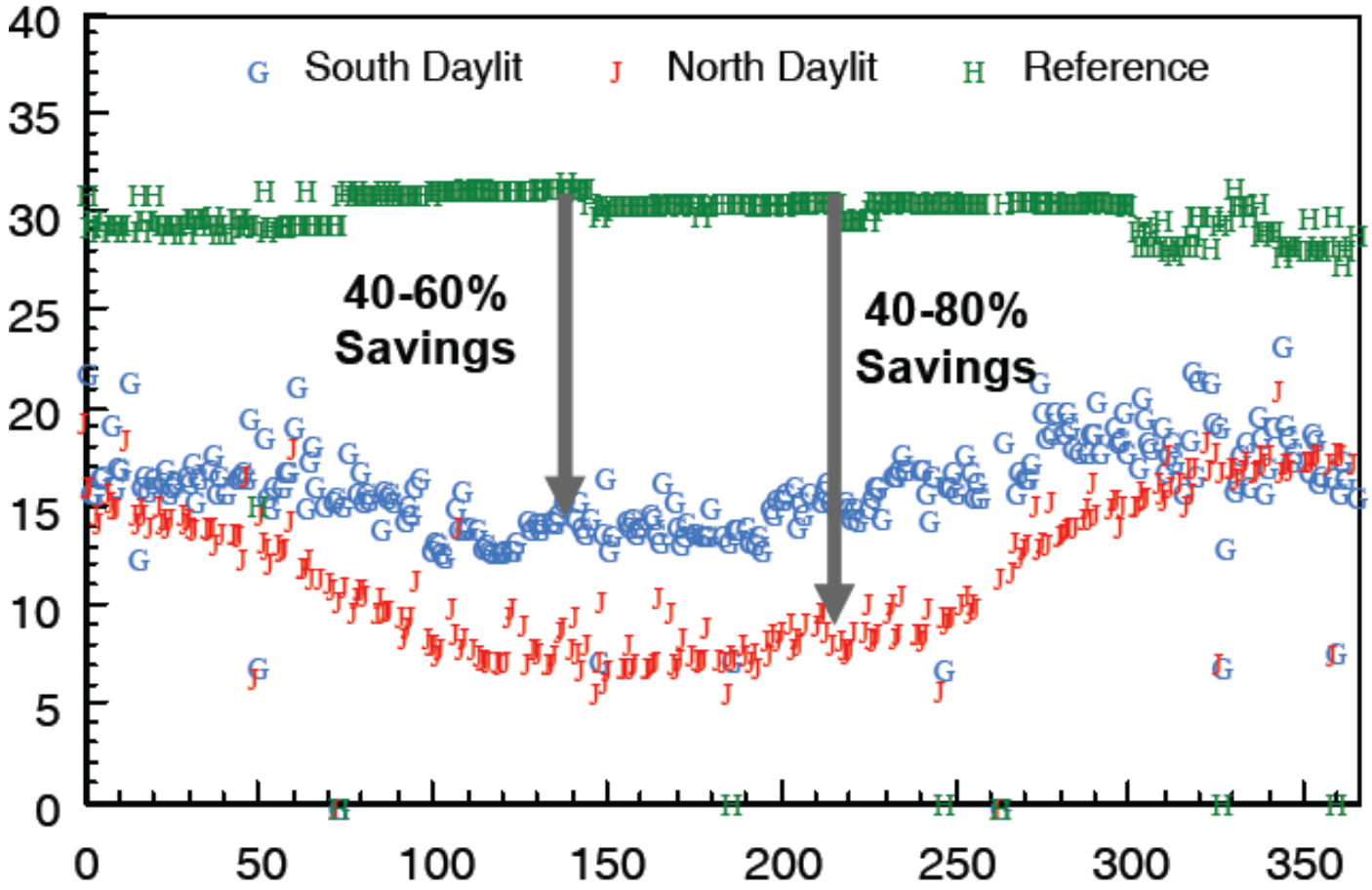
"All lighting should be dimmable and addressable…"

Stephen Selkowitz, Chairman, Building Technologies Department at Lawrence Berkeley National Laboratory



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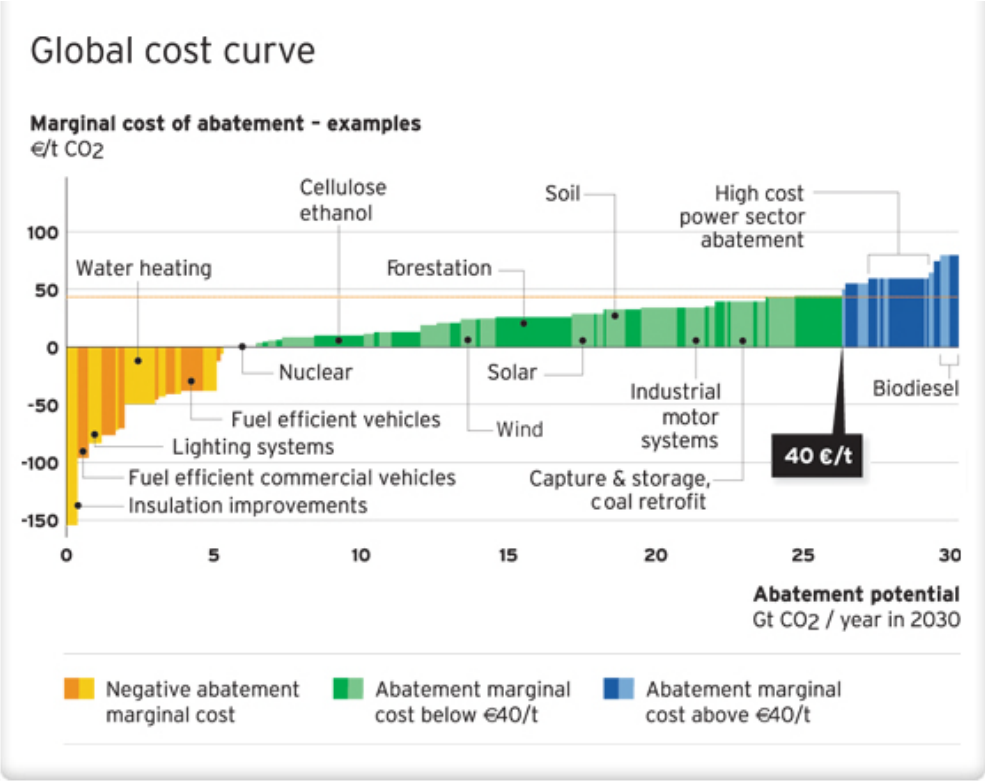
Other Reasons to Consider Addressable Lighting Controls

Meeting the Federal Governments Energy Mandates

- Energy Independence and Security Act of 2007
  - 30% energy reduction by 2015
- E.O. 13423
  - 3% reduction yearly through 2015
  - Established High Performance and Sustainable Buildings Guidance
- E.O. 13514
  - Establishes GHG emissions as metric and increases renewable requirements
- Best Practices for GSA High Performance Green Buildings

GHG Emissions – The Case For Addressable Lighting Controls



Cost of CO2 Abatement

- Graph demonstrates relative CO2 abatement to cost required to implement the strategy
- Items below the curve have a negative cost or in essence provide an economic payback
- Lighting systems fall to the extreme left of this curve making them a good candidate for high abatement and strong payback

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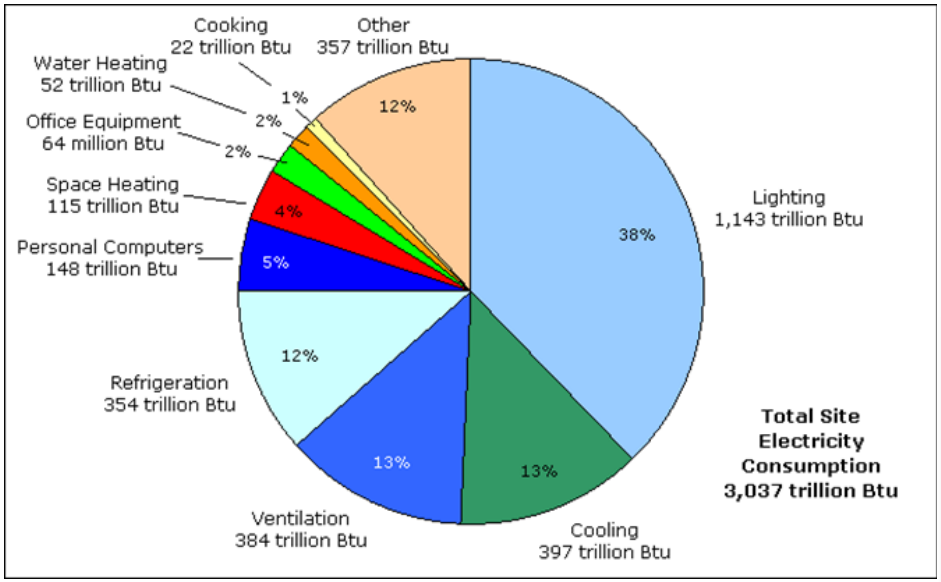
Lighting – One BIG Opportunity

- On average, lighting accounts for one-third of energy use in office buildings, and thus often dominates the opportunity for energy savings among all electrical systems
  - Buildings consume more than one-third of the total primary energy used in the USA
  - About two-thirds of a building's primary energy use is attributed to electricity [1],[5],[6]



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Lighting – One BIG Opportunity con't

- <20% of commercial & institutional construction uses some form of lighting control (relay switching and/or occupancy sensors). *(NEMA March 2010)*

- 79M sq ft of existing commercial and institutional floor space, addressable lighting controls = 0.15% ?

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Lighting – One BIG Opportunity con't

- Lighting load reduction measures traditionally restricted to high performance lamps/ballasts, large area conventional low voltage relay switching & controls, and occupancy sensors.

- Lighting has historically not been considered to be a "controllable" building load for demand management purposes

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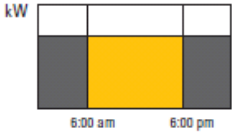
Challenges With Conventional Controls

- No ability to address & control individual fixtures or small lighting zones
  - Zoning restricted to lighting circuits or quadrants
- No workspace or task specific control
  - i.e. tuning light levels based on use
- Lack of centralized "intelligence" to allow deployment of combined energy management strategies
- Limited ability to integrate or share data with other building systems such as HVAC, Security, and Fire/Life Safety
- Lack of granular (small zone) control increases cost to reconfigure lighting when space needs to be reconfigured
- Lack of granular (small zone) control eliminates ability to provide personal control and the associated benefits (energy savings and productivity improvements)

Six Smart Strategies

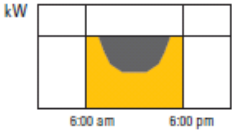
SMART TIME SCHEDULING. In areas of a building where occupancy control is not appropriate, time scheduled switching or dimming of lights can be employed for zones as small as a room or even individual light fixture.



10-50%

DIM

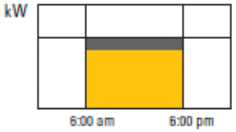
DAYLIGHT HARVESTING. Through the use of photo sensors, light levels are automatically adjusted to take into account ambient natural sunlight. Appropriate light levels are maintained and artificial lighting is dimmed when necessary.



17%

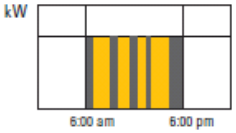
DIM

TASK TUNING. Setting default (maximum) light levels to suit the particular task or use of a workspace in order to eliminate over lighting.



28%

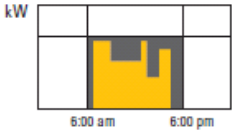
OCCUPANCY CONTROL. Through the use of occupancy sensors, lights are automatically turned on or off or dimmed based on occupancy detection.



35%

DIM

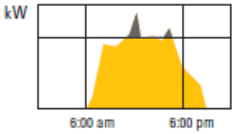
PERSONAL CONTROL. Through the Personal Control Software, individuals can control (dim) the light levels in their workspace to suit their personal preferences from their desktop PC.



38%

DIM

VARIABLE LOAD SHEDDING. The automatic reduction of electrical demand in a building by shedding lighting loads dynamically (through dimming or switching) either to shave peak demand or reduce energy consumption. Load shedding can be done selectively by lowest priority areas first.



10%

COMBINED ENERGY SAVINGS. Potential cumulative savings from above strategies.

71-79% combined

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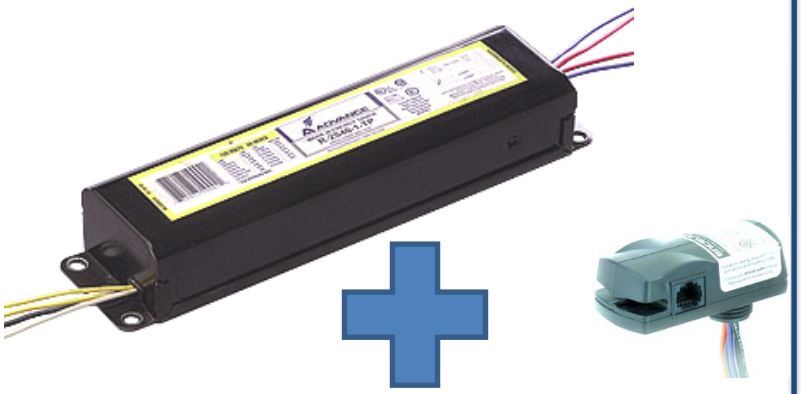
What Are Addressable Lighting Controls?

- The ability to address and control each fixture individually, or small groups of fixtures (zones)
- Control zones defined by software (not via physical wiring or circuiting)
- Increased use of dimming ballasts
- Change peripheral devices (occupancy sensors, photo sensors & wall controls) from physically hard-wired “switches” to input control devices
- All devices have a unique IP address, are networked and centrally controlled through a central software interface.
- Integrate with BAS & other building systems (life safety, elevator & access control, etc.)

BACnet™

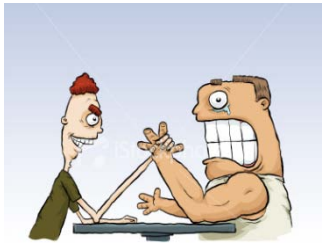
Making a Lighting Fixture “Addressable”



- Option A – Use 0-10V dimming ballasts or LED driver + external digital input/output module (IOM)

- Option B – Use DALI digital dimming ballast or LED driver (when available) and DALI bridge

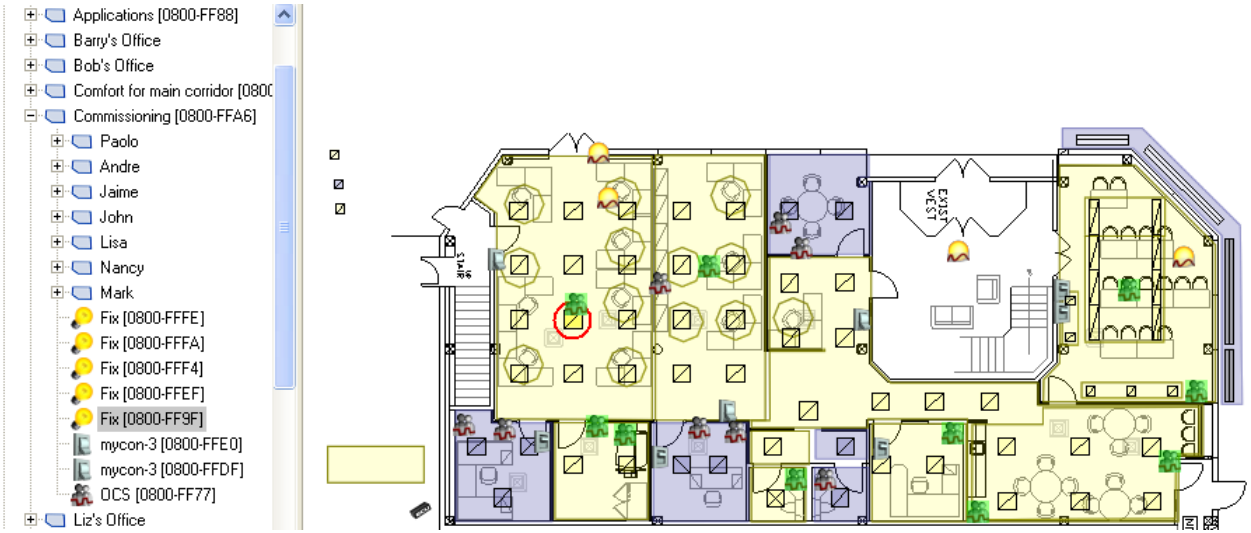
0-10V vs. DALI



- COST:
  - 0-10V + Digital IOM is less expensive than DALI (but cost differential dropping) per controlled fixture
  - 0-10V + Digital IOM will always be less expensive per project UNLESS every fixture must be controlled separately
- FLEXIBILITY: DALI by default provides fixture level control
- MAINTENANCE: Replacing DALI ballasts may require rezoning & reprogramming
- LED Upgrade: Digital IOM works with future 0-10V LED drivers; DALI LED fixtures will require DALI LED drivers

Addressable Leverages Software…

- An example illustrating the Graphical User Interface (GUI) for an "Addressable Lighting Control System".



- Once installed, commissioning and administration of the entire system can be performed via the front-end software.

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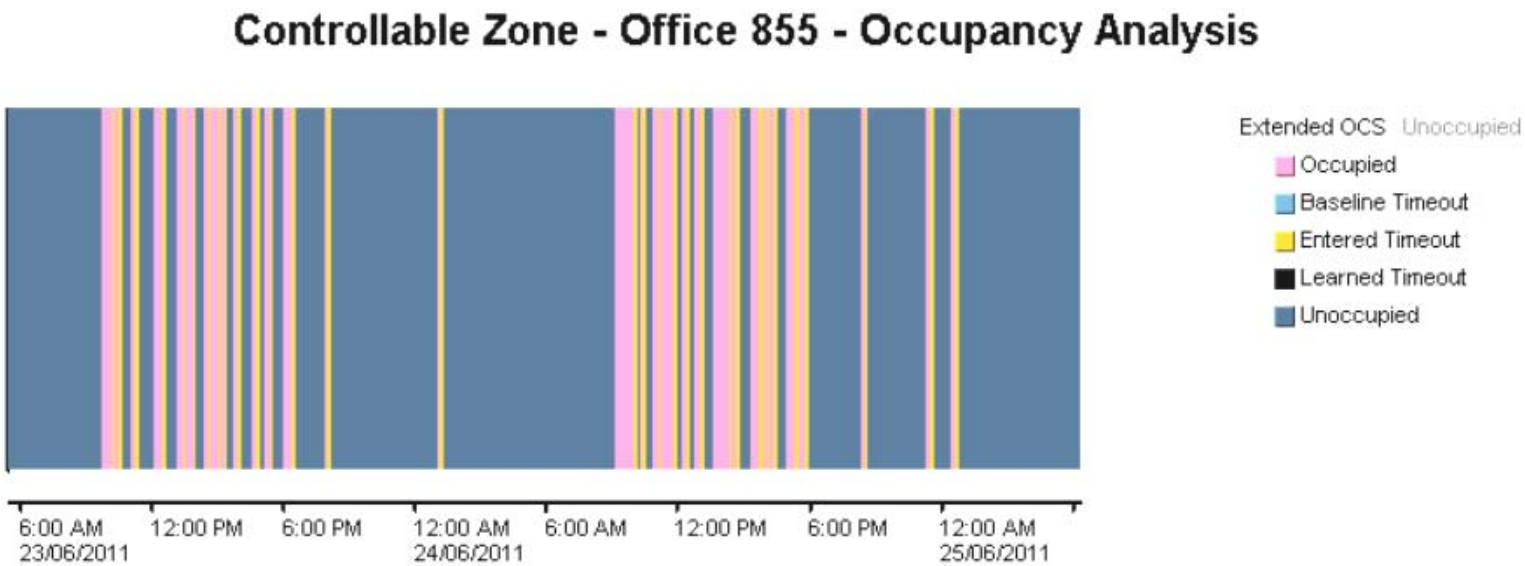
Some Advantages..

1. Share and/or analyze data and make more intelligent decisions
   - Shares occupancy sensors with BAS system
   - Change sensor time-outs based on actual data



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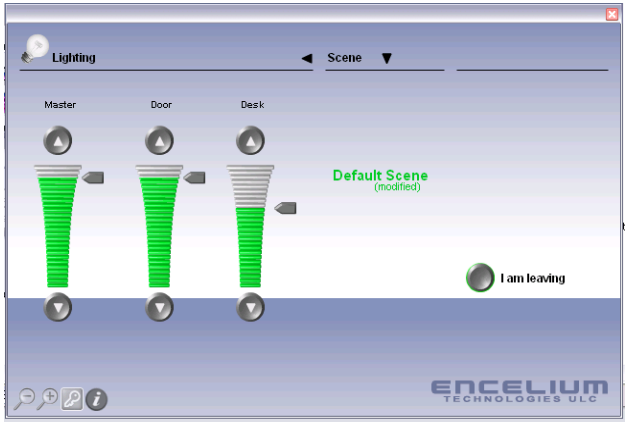
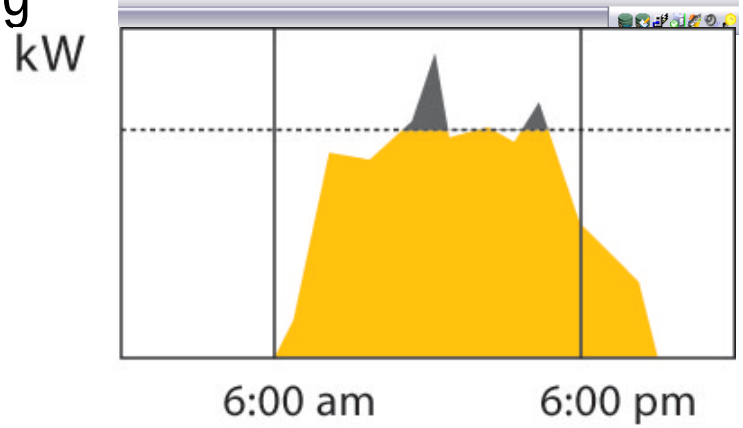
Some Advantages.. con't

2. Connectivity between lighting zones, sensors, & switches across a building or campus provides new opportunities
   - Demand response/load shed
   - Emergency notification services
   - Integration with shading systems
   - PC-based personal control
   - Auto-extend of after-hours lighting based on virtual occ. sensors





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Some Advantages.. con't

3. Energy-saving strategies are additive, thus maximizing savings

Energy Management Strategies	Lighting energy savings due to Addressable Lighting Controls				Average Savings by Strategy *
	Multi-Tenant office building (300,000 ft.^{2})	Headquarters of a major entertainment company (400,000 ft.^{2})	Hospital Administration Building (175,000 ft.^{2})	Major sports complex (1.3 million ft.^{2})	
Smart Time scheduling	13.91%	8.91%	22.2%	24.01%	15 - 25%
Daylight Harvesting	0.60%	3.96%	8.15%	3.4%	20 - 50%
Task Tuning	9.0%	10.95%	13.24%	5.32%	10 - 25%
Occupancy Control	31.3%	24.94%	25.38%	37.21%	20 - 43%
Personal Control	6.12%	10.64%	1.8%	2.1%	7 - 23%
Variable Load Control	0.03%	4.65%	3.2%	5.1%	0 - 5%
Cumulative savings due to Addressable Lighting Controls	60.96%	64.05%	73.97%	77.14%	

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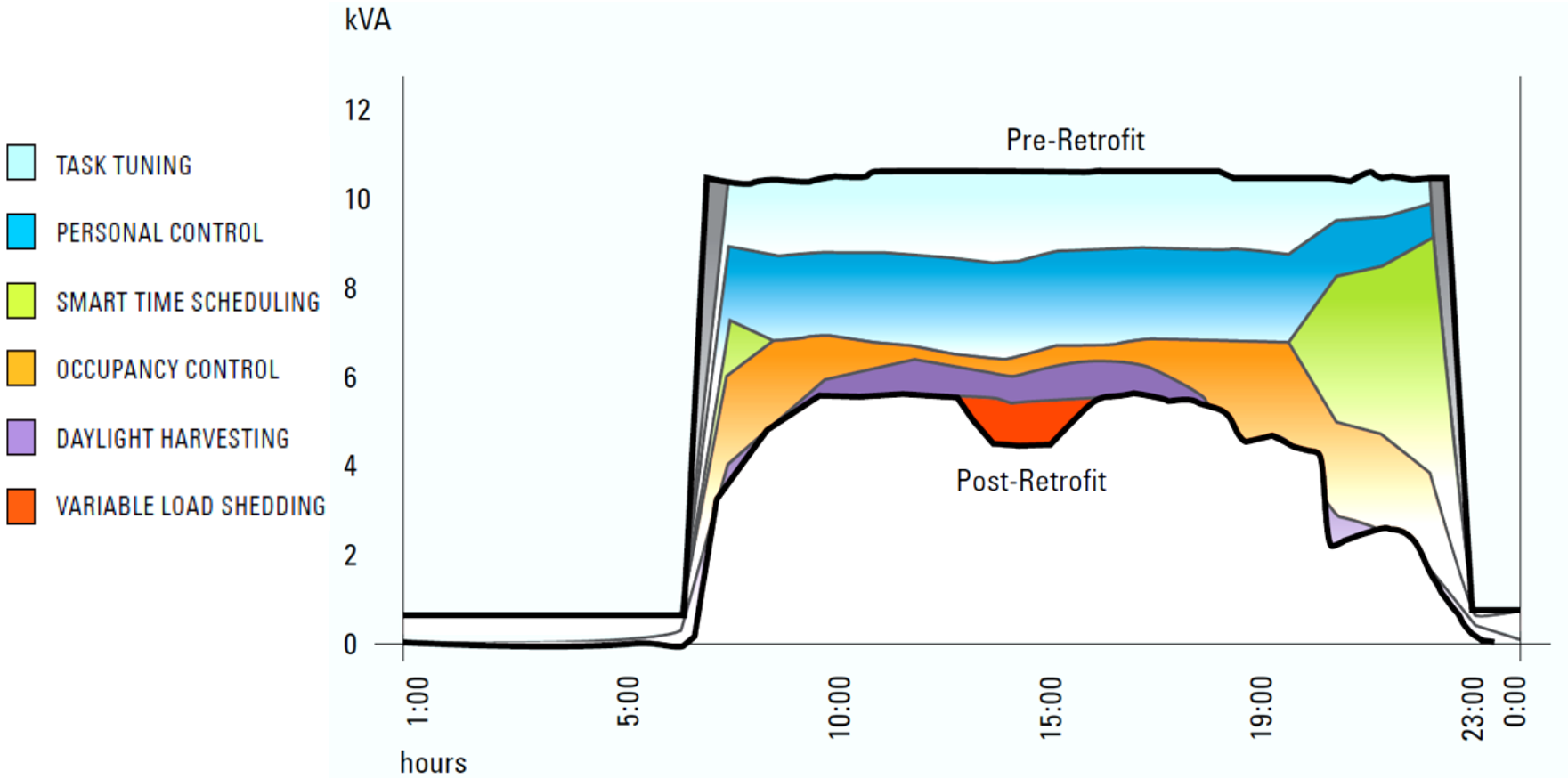
Hospital Administration Building



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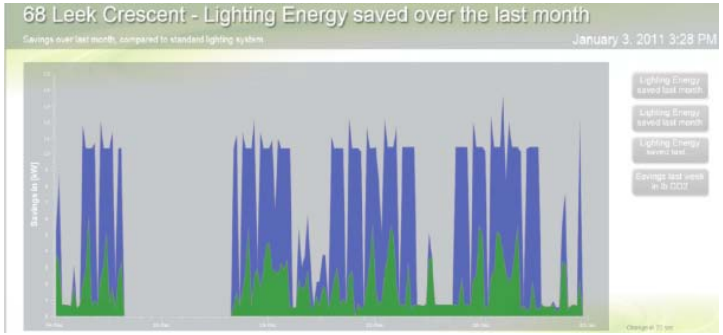
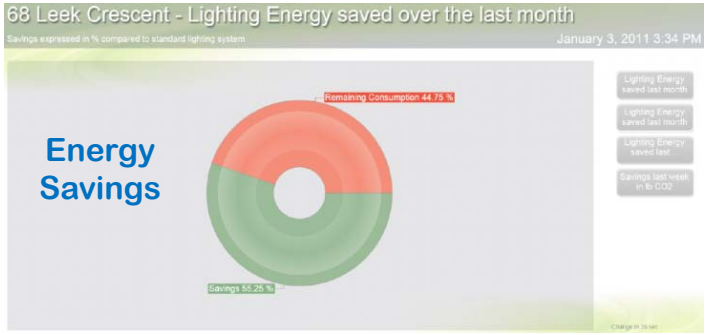
Some Advantages.. con't

4. Detailed Presentation of Information & Results

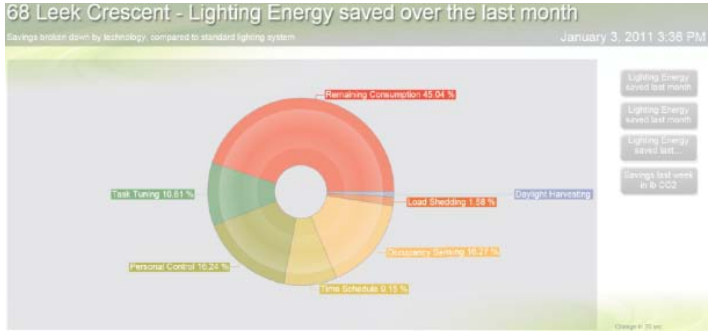
Energy Demand History
(by space, by hour, day, week, month, year)

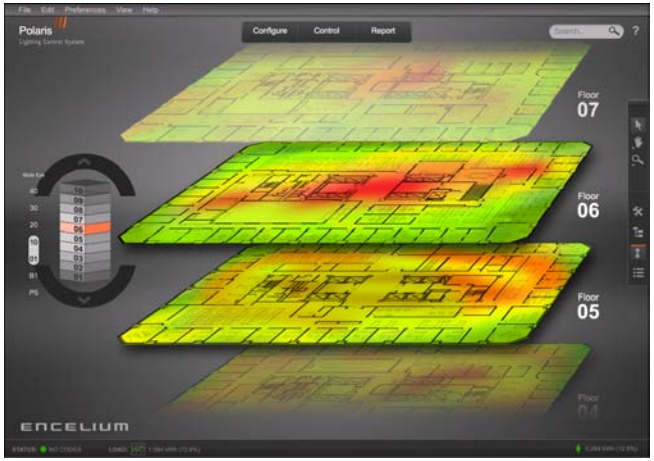


Energy Savings



Energy Savings by Strategy





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Some Advantages.. con't

5. Flexibility for if/when the space usage changes..

Reassigning which lights control which specific areas is software driven and requires no re-circuiting or re-wiring

Achieving 50% energy savings cost effectively requires an integrated building design—an approach that analyzes buildings as holistic systems rather than as disconnected collections of individually engineered subsystems."

- *DOE NREL: Strategies for 50% Energy Savings in Large Office Buildings, Sep 2010*

Addressable Lighting Controls & Intelligent Buildings

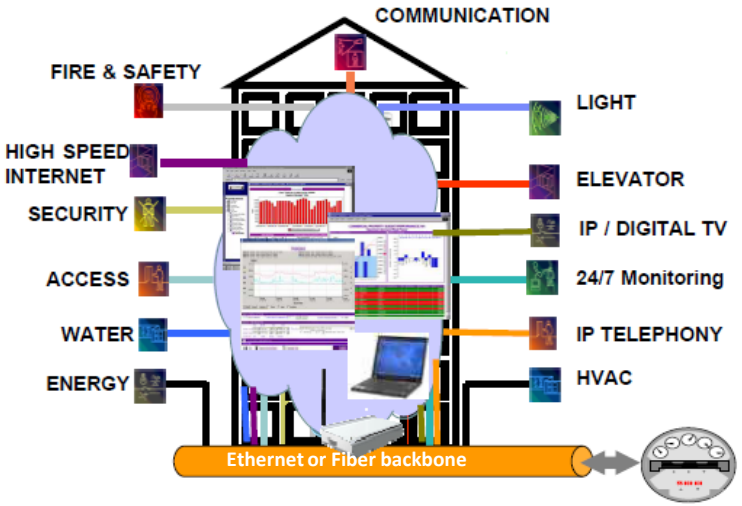
-Centrally manageable through front-end software

-Based on TCP/IP or other open protocol;

-Capable of sharing a common IP backbone with other building systems;

-Capable of exchanging data with building management or energy management systems in a seamless manner

-Granular fixture level lighting control.



O&M costs which represent 75 percent of a building's lifetime costs can offer a "ROI" of less than two years with intelligent building approach[24][25]

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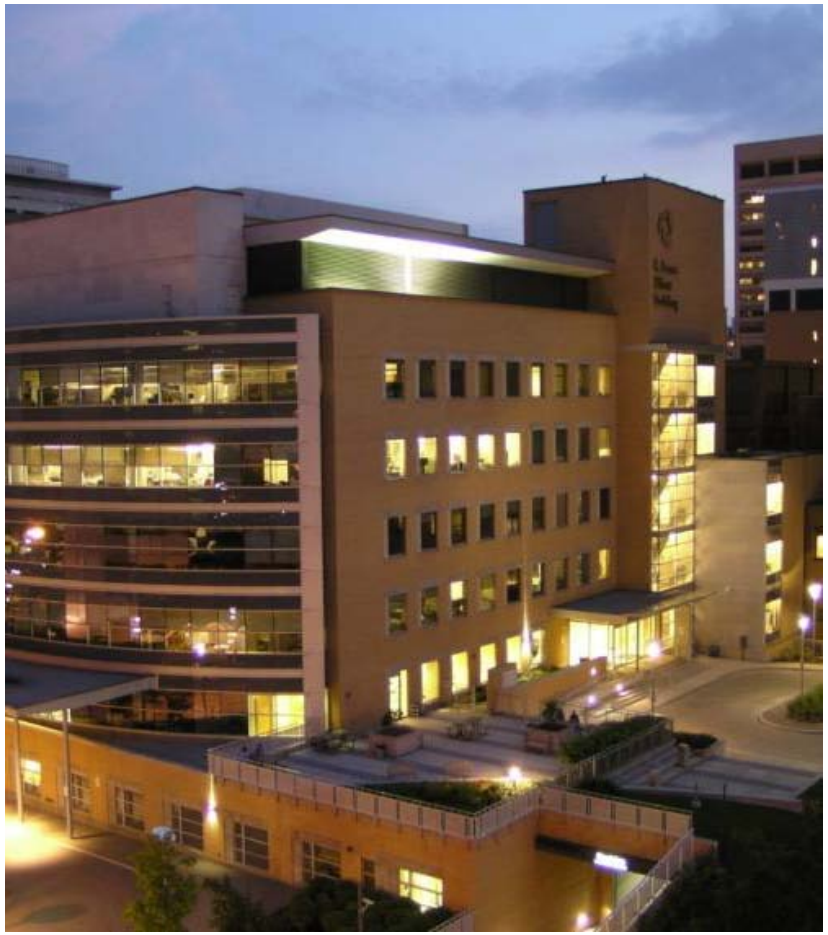
Non-Energy Related Benefits con't

- Integrated building or campus-wide emergency notification – flash lights in prescribed manner to indicate intrusion and/or evacuation or lockdown scenarios
- Create defined egress lighting pathways – integrate with life safety control systems
- Reduced lamp maintenance costs – less operating hours due to granular control
- Software validates energy savings and allows others less familiar with control system to understand energy impact

Case Study –General Hospital



- 6 story 175,000 sq. ft. building constructed in 2001
- Executive and admin. offices, research facilities, food services, and emergency medical services
- Equipped with high efficiency T8 & T5 fixtures with electronic ballasts
- No facility wide lighting controls

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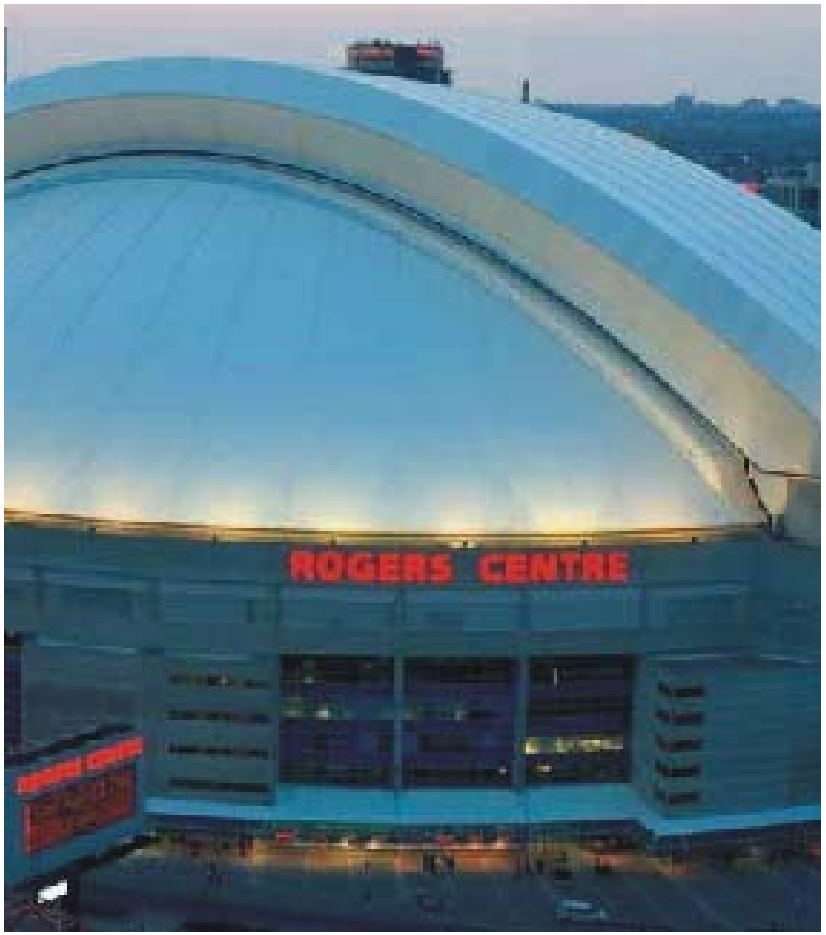
Results

- Lighting energy consumption reduction of 74%
- Lighting energy demand reduction of 37%
- “Personal Control” capability for over 300 users
- Annual energy cost reduction of $47,000 of $0.45/sq. ft.
- Simple payback from energy savings of 4 years (net payback of 3.2 years with incentives)

Case Study – Stadium



- 7000 light fixtures distributed over a total area of 1.4 million square feet
- Parking garages, concourses, offices, media lounges and luxury boxes

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Results

- Lighting energy consumption reduction of 77%
- Lighting energy demand reduction of 39%
- Annual energy cost reduction of $303,000 annually
- Simple payback from energy savings of 3 years

Case Study – Office Building

- 420,000 sq. ft. retrofit 3L T8
- 21 Floors of office space, parking garage, exit signs
- 2000 perimeter light fixtures, 2000 interior light fixtures
- Retrofitted ballasts, lamps, Occupancy Sensors, Wall control stations

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Results

- Lighting energy consumption reduction of 68%
- Lighting energy demand reduction of 62%
- Annual energy cost reduction of $216,000 annually
- $725,000 contract ($557K for retrofit, $168K for addressable control system)
- Simple payback from energy savings of 2.9 years with rebate, 3.36 years if rebate is ignored

Some Conclusions

- Addressable lighting control systems yield the greatest verifiable lighting % savings (up to 77%) vs. simple lighting retrofits or vs. simple relay switching or occupancy sensors
- Addressable lighting controls have been identified as having the greatest potential for lighting energy savings
- Addressable lighting controls have payback periods of 2 to 6 years in most cases
- Centralized control capabilities provide ability to display to constituents energy and greenhouse gas reductions

References

1. "Scenarios for a Clean Energy Future" report commissioned by the U.S. Department of Energy
2. HVAC Systems Design Handbook by Roger W. Haines
3. "Considering Lighting System Performance and HVAC interactions in Lighting Retrofit Analysis": E. Franconi & F. Rubinstein, Lawrence Berkeley National Laboratory
4. "Integrated Lighting Approach Saves Energy in Post Office Facilities", Jeffrey C. Mitchell, Michael J. Siminovitch, Eric R. Page, Kevin W. Gauna, and Douglas A. Avery, Lawrence Berkeley National Laboratory.
5. "Energy Saving Lighting Control Systems for Open plan Offices: A Field Study", Anca D. GALAŞIU1, Guy R. NEWSHAM[1], Cristian ŞUVĂGĂU[2], Daniel M. SANDER[3]
   [1] National Research Council Canada, Institute for Research in Construction, Indoor Environment Program; [2] BC Hydro, Technology Solutions Power Smart; [3]National Research Council Canada (retired)
6. "Wireless Networked Lighting Systems for Optimizing Energy Savings and User Satisfaction", Yao-Jung Wen, Alice M. Agogino, IEEE Publications.
7. "Comparison of Control Options in Private Offices in an Advanced Lighting Controls Testbed", Judith D. Jennings[1], Francis M. Rubinstein[1], Dennis DiBartolomeo[1], Steven L. Blanc[2]
   [1]Building Technologies Department, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory; [2]Pacific Gas & Electric Company, Customer Energy Management Dept., Research & Development Group.
8. "Specifier Reports", Photosensors, National Lighting Product Information Program, Rensselaer Polytechnic Institute.
9. "An analysis of the energy and cost savings potential of occupancy sensors for commercial lighting systems", Bill VonNeida[1], Dorene Maniccia[2], Allan Tweed[2]
   [1]Lighting Research Center, Rensselaer Polytechnic Institute;
   [2]U.S. Environmental Protection Agency, ENERGY STAR Buildings Program.
10. "Effect of dimming control on office worker satisfaction and performance", Guy Newsham, Jennifer Veitch, Chantal Arsenault, Cara Duval, Institute for Research in Construction, National Research Council Canada
11. "Energy savings due to occupancy sensors and personal controls: A pilot field study", Anca D. Galasiu and Guy R. Newsham, Institute for Research in Construction, National Research Council Canada
12. "Energy savings for Load shedding ballasts for fluorescent lighting systems", Yukio Akashi, Jason Neches, Andy Bierman, Lighting Research Center, Rensselaer Polytechnic Institute.
13. "How to Select Lighting Controls for Offices and Public Buildings", U.S. Dept. of Energy, Energy Efficiency & Renewable Energy, Federal Energy Management Program, December 2000.
14. "Tips for Daylighting with Windows", Lawrence Berkeley National Laboratory.
15. Deep dive into Deeper Savings", CEE Winter 2020 Meeting, presentation by Thor Scordelis, Dave Alexander, Pacific Gas and Electric Company Lighting Team.
16. "Demand-responsive Lighting – A Field Study", Guy Newsham and Benjamin Birt, National Research Council Canada, Institute for Research in Construction (NRC-IRC)
17. "Research Matters", Guy Newsham, National Research Council Canada, Institute for Research in Construction (NRC-IRC), published in LD+A, Illiminating Engineering Society journal.
18. "Advanced Lighting Guidelines", 2003; New Buildings Institute, White Salmon, WA 98672.
19. "Lighting Quality and Office Work: A Field Simulation Study", Peter R. Boyce[1], Jennifer A. Veitch[2], Guy R. Newsham[2], Michael Myer[1], Claudia Hunter[1], Prepared for US Dept. of Energy by Pacific Northwest National Laboratory.
    - [1]Lighting Research Center, Rensselaer Polytechnic Institute; [2]Institute for Research in Construction, National Research Council Canada.
20. "Demand Responsive Lighting: A Scoping Study", Francis Rubinstein, Sila Kiliccote, Lawrence Berkeley National Laboratory.
21. "Energy Efficiency Perspectives: Intelligent Networks and The Challenge of Zero Energy Buildings" by Stephen Selkowitz, Head of the Department, Building Technologies, Lawrence Berkeley National Laboratory.
22. U. S. Department of Energy, Building Energy Codes, Online training program
23. "Integrated Lighting Approach Saves Energy in Post Office Facilities", Jeffrey C. Mitchell, Michael J. Siminovitch, Eric R. Page, Kevin W. Gauna, and Douglas A. Avery, Lawrence Berkeley National Laboratory.
24. National Institute of Building Sciences
25. CISCO's Connected Real Estate group

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Questions??