



QUESTLINE

We Make Energy Engaging

Better Together:

Energy Efficiency and Public Assembly Buildings

Questline Academy



Meet Your Panelists

Mike Carter



Justin Kale



ENLIGHTEN



EDUCATE



ENGAGE

Contents

- Background
- Lighting
- Indoor Air Quality (IAQ)
- Building Envelope
- HVAC
- Building Automation Systems (BAS)
- Case Studies

Background

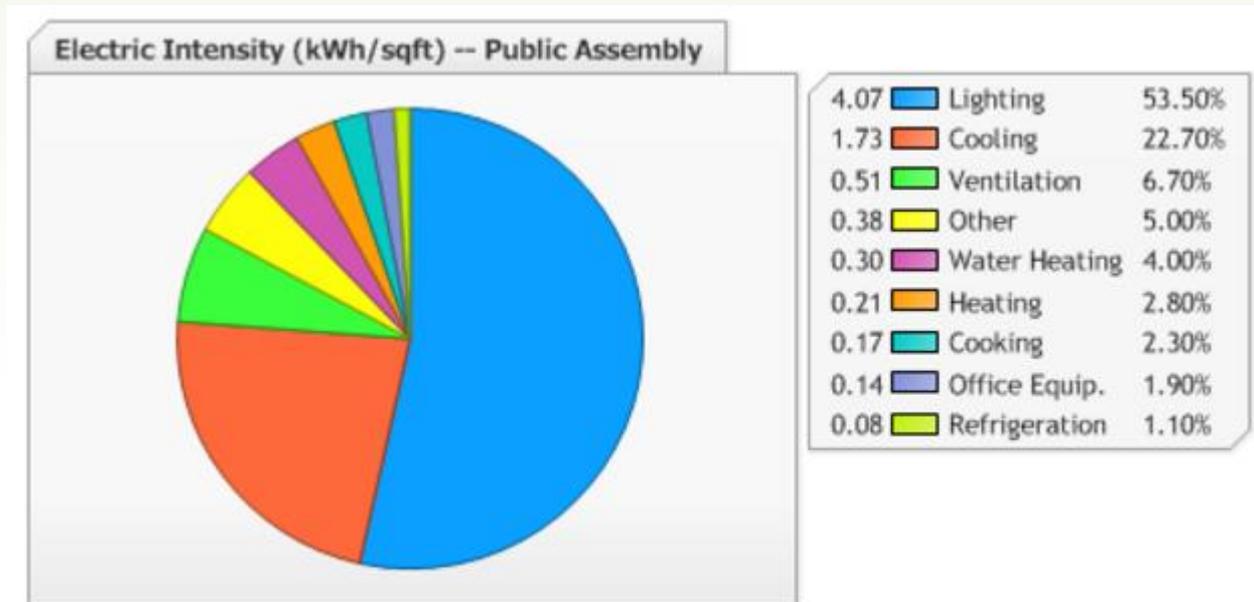
Public Assembly

- Museums
- Houses of worship
- Convention centers
 - Trade shows
 - Expositions
- Casinos
- Movie theatres
- Assembly halls
- Auditoriums
- Sports venues
- Dining halls/cafeterias
- Dance halls
- Gymnasiums
- Passenger depots
- Stage production theatres
- Botanical gardens
- Libraries

Background

Energy Benchmarking

- Multi-functional use (includes concessions, retail)
- Widely varying occupancy
- Entrances and exits challenges
- Restrooms



Total Electric Intensity (kWh/sqft, annual basis): 07.60 (20 all-electric)

Linear Fluorescent Replacements

- Recessed or zero plenum lighting



Tech Lighting's ELEMENT Merge



OSRAM

Osram Sylvania's OmniPoint

MR16 LEDs

- CALiPER tested 27 different 12V MR16 LED products
 - The 12V products have less lumen output than halogen lighting
 - Equivalency claims are very suspect
 - Center Beam Candlepower (CBCP) is still very poor
 - Compatibility with low-voltage transformers can be an issue

CALiPER = Commercially Available LED Lighting Product Evaluation and Reporting



Source: Verbatim Americas

Recessed Downlights

- Competition from reflector-rated CFLs from 13 to 26 watts that deliver 650 to 1,300 lumens
- Directional nature of LEDs is an advantage
- Removing heat from the can is a real challenge for R-CFLs and LEDs



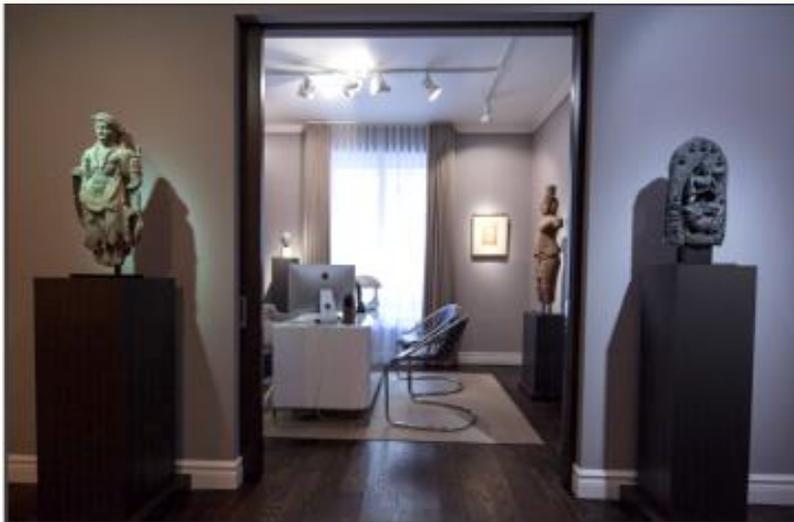
Source: Juno Lighting Group Indy™
ChromaControl



Source: Delray Lighting Kone 3

Directional PAR Lamps

- CALiPER tested 38 LED PAR38 and 9 LED PAR30 reflector lamp products
 - Best LED PAR38 are competitive with CMH
 - Much better than halogen bulbs
 - Can flicker when dimmed



Source: Ketra



Source: Ketra S38 Tunable Lamp

High-Bay Lighting

- CALiPER tested seven different High-Bay LED products
 - Efficacy still lags fluorescent
 - Narrow light beam pattern
 - Life claims are suspect



Source: ABB Lighting



Source: Dialight



Source: KMW GigaTera USA



Source: Albeo

High-Bay Lighting

- [Mogul Base LED Lamp Performance](#)
 - The Lighting Research Center, RPI
 - Roughly 30% of the average price of integral LED fixtures
 - Concerns
 - Only 57% of the area light and roadway lamps met DLC* criteria
 - Less than 30% of the tested lamps met the DLC efficacy criteria
 - Not enough light output for one-for-one replacement
 - Lamp length and weight may not be compatible with legacy fixtures



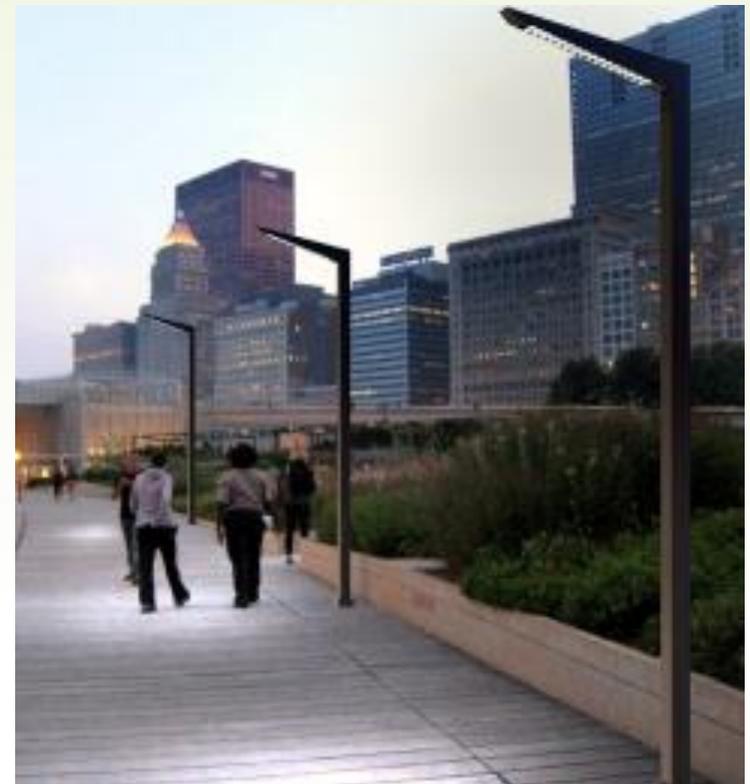
*DesignLights Consortium

Parking and Area Lighting

- Color rendering and uniformity for LEDs are better than HPS
 - Minimum illuminance levels equal to HPS (perceived as better)
 - LEDs are *Dark Skies* compliant



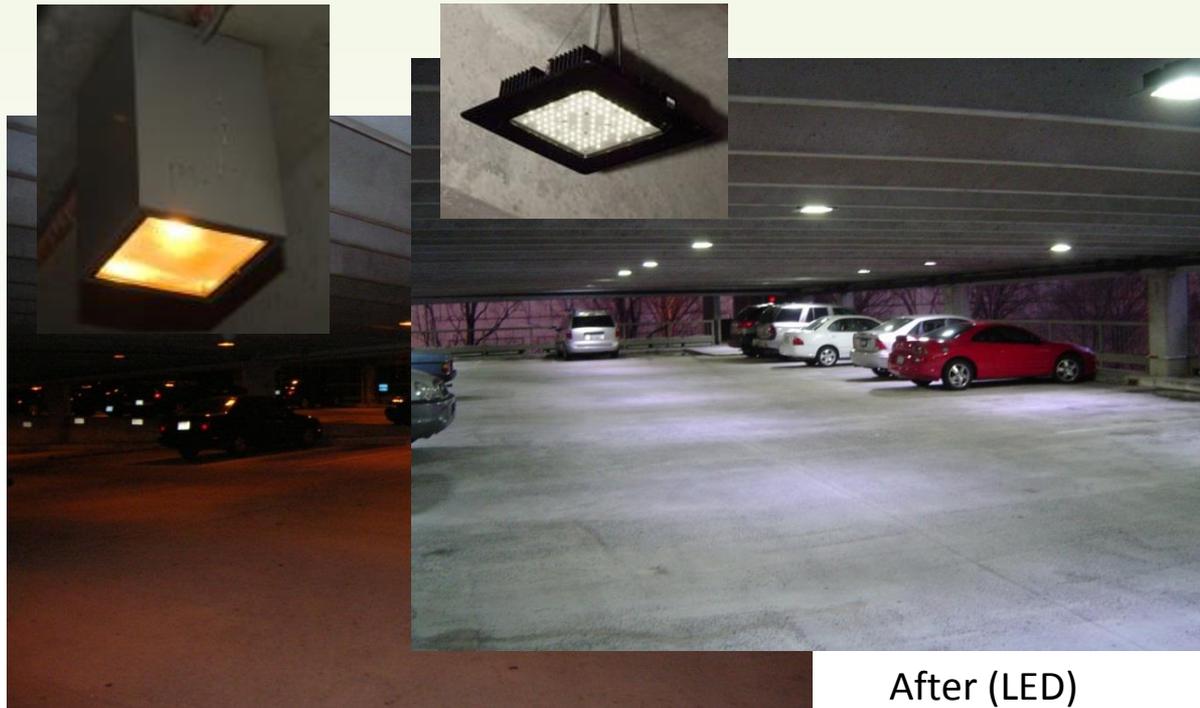
LED (left) vs HPS (right)
Source: Beta Lighting & EERE



Source: Architectural Area Lighting

Parking Garage Lighting

- Improved color quality allows for decreased lumen output



Before (HPS)

After (LED)

Source: Progress Energy



Used with permission of Cree, Inc.



Source: Philips Lighting

Poll Question

- Which two of the following **most** allows LED lighting to save energy compared to linear fluorescent fixtures?
 - a) Lumens per watt efficacy
 - b) Amount of light escaping from the fixture
 - c) Color quality
 - d) Cold temperature performance

Daylighting

- Skylights/lightpipes, clerestory windows, roof monitors, light shelves
- Photosensor layout is important



Source: LightLouver LLC

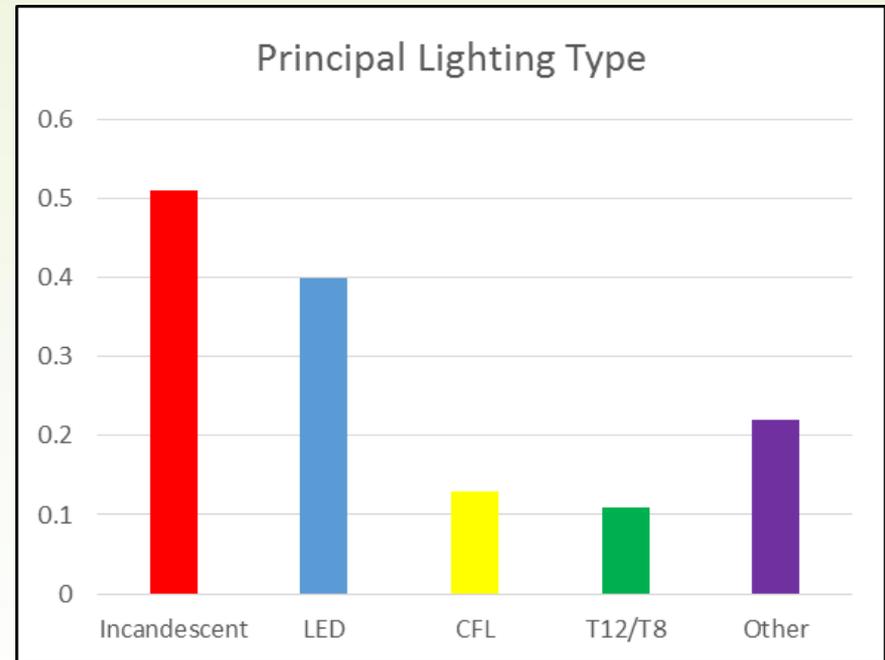


Occupancy Sensors

- Ultrasonic and/or infrared
- Can shorten life of fluorescents with instant start ballast
- \$30 to \$150 cost
- Two-year payback is normal

Museum Lighting

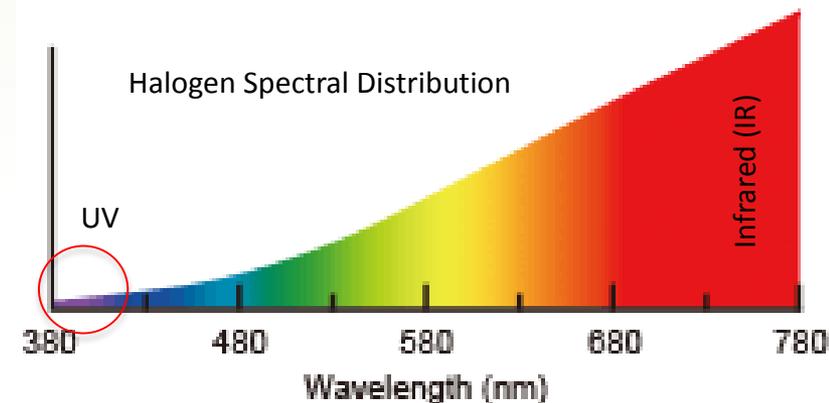
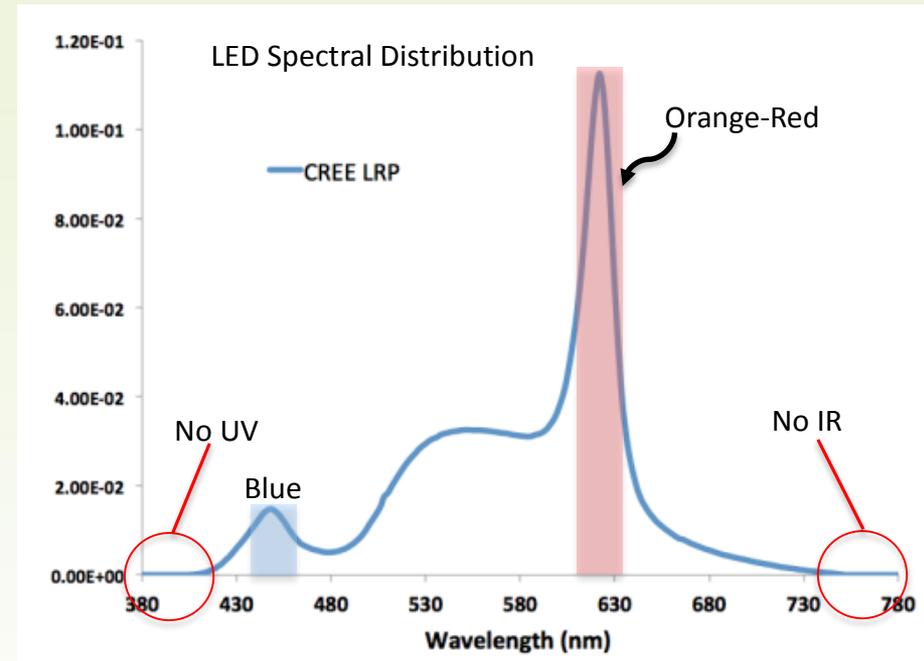
- LED adoption
 - From zero to 40% from 2009 to 2014!
 - Barriers to adoption
 - High cost
 - Difficult selection process
 - Resistance to change
 - Technology limitations
 - Heat in enclosed fixtures
 - Dimming
- Lighting goals
 1. Avoid potential damage
 2. Achieve highest light quality
 3. Save energy



Source: DOE GATEWAY report, SSL Adoption by Museums

Museum Lighting

- Light-induced damage
 - Light fades color, induces shifts in hue, and darkens some pigments
 - UV causes yellowing, chalking, weakening, and/or disintegration of materials
 - UV contributes less than half of the fading
 - IR heats the surface, reducing moisture content, which may induce physical stresses



Source: DOE GATEWAY report, SSL Adoption by Museums

Museum Lighting

- Visible Light Communication
 - LED light rapid switching
 - Too fast to be seen
 - Bluetooth positioning
 - Benefits
 - People tracking
 - Tailored information



Source: Image used with permission. Image may not be copied, transferred or otherwise used without the express written consent of Acuity Brands Lighting, Inc. ©2015 Acuity Brands Lighting, Inc. All rights reserved.

Indoor Air Quality (IAQ)

Air Contaminants

- What contaminates air?



- Occupant daily consumption
 - Air (30 pounds)
 - Water (4 pounds)
 - Food (2 pounds)

Indoor Air Quality (IAQ)

IAQ Impact

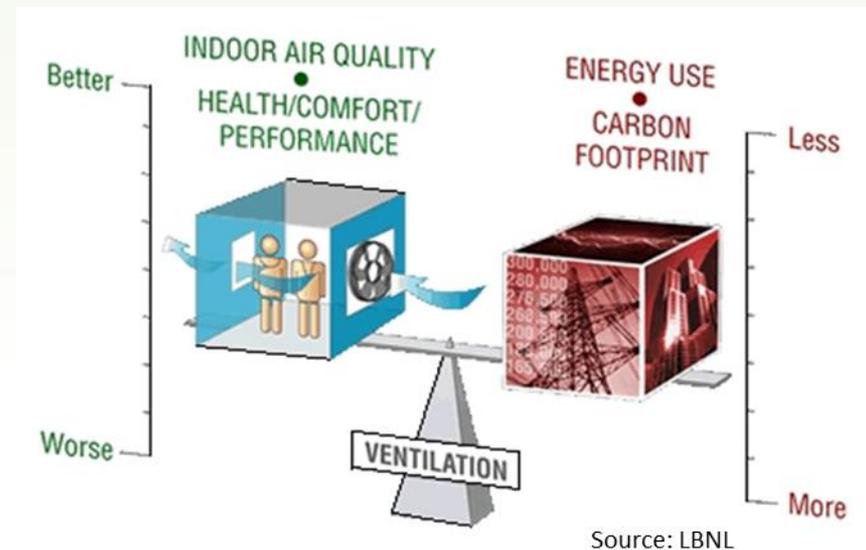
- Occupant health
- Occupant comfort
- Occupant productivity

“Buildings do not exist to save energy. Buildings exist for people to live, work, learn and heal.”

– Andrew Persily, NIST

IAQ Tradeoffs

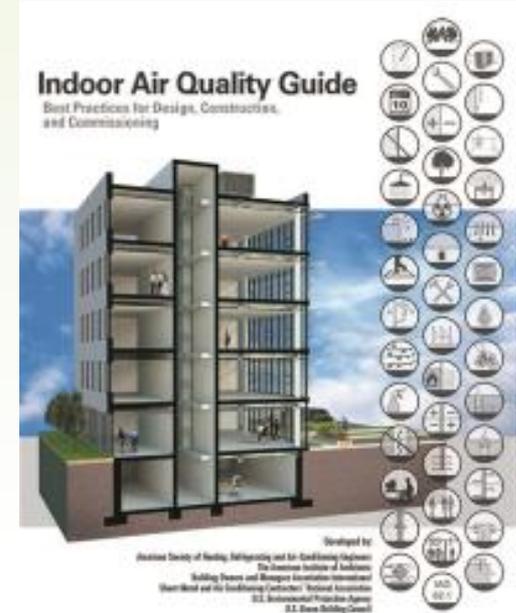
- Energy consumption
 - ASHRAE Std. 90.1-2010 Energy Standard for Buildings
- Thermal comfort
 - ASHRAE Standard 55-2010, Thermal Environmental Conditions for Human Occupancy



Indoor Air Quality (IAQ)

ASHRAE: The Indoor Air Quality Guide

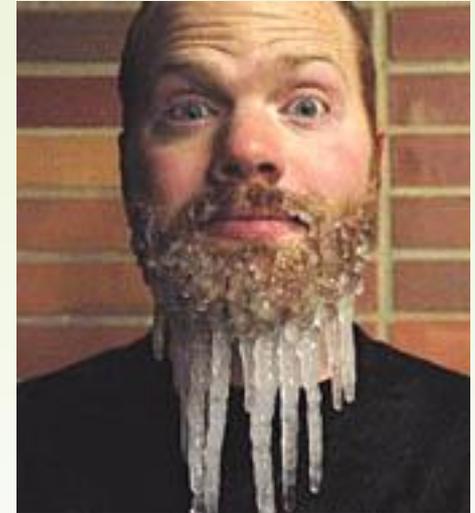
- Best Practices for Design, Construction, and Commissioning
 - Collaborative effort between ASHRAE and AIA (architects), BOMA (building owners and managers), EPA (funder), SMACNA (contractors) and USGBC.
 - Free copy is now available!
- Eight Key Objectives:
 1. Manage the design and construction process
 2. Control moisture in building assemblies
 3. Limit entry of outdoor contaminants
 4. Control moisture and contaminants in mechanical systems
 5. Limit contaminants from indoor sources
 6. Contain and exhaust indoor contaminants
 7. Reduce concentrations through ventilation and air cleaning
 8. Apply more advanced ventilation approaches



Indoor Air Quality (IAQ)

Dehumidification

- Why is it important?
 - Comfort
 - Productivity
 - Expense
 - De-icing
 - Microbial growth
 - Possible reheating
 - Lower HVAC chilled water or evaporator temperatures
 - Wood damage
 - Low relative humidity (RH) can cause wood damage
 - Need >30% RH at all times
 - Better cold than dry



Source: <http://top10kid.com>



Source: www.bcs.org

Dehumidification

- Three major ways to remove moisture
 - Condensation (cold-coil)
 - Desiccant
 - Combination of both



Source: Stock Exchange

Vestibule requirements for 3,000+ sf

ASHRAE 90.1-2007/2010 Section 5.4.3.4 Vestibules

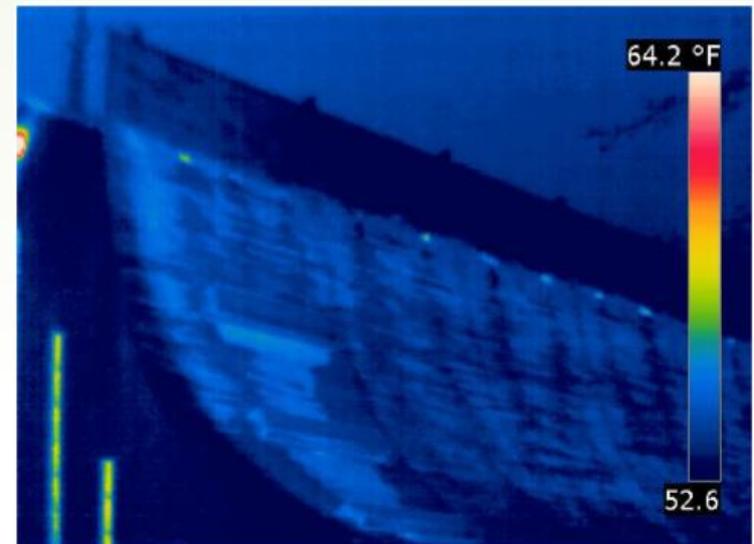
Building entrances that separate conditioned space from the exterior shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices.

- Interior/ exterior doors not open simultaneously
- Interior/ exterior doors at least 7' apart when closed
- Conditioning of space determines envelope requirements of the vestibule
- Exceptions for some doors:
 - Revolving doors
 - Not used as a building entrance
 - Directly from dwelling unit

Building Envelope

Thermal scan - why do it?

- Anywhere water or air can enter, heat and energy can leave
- Useful for measuring unseen conditions
- Leaky, older buildings = difficult to control temperatures, humidity



THE THERMAL PATTERNS SHOWN ARE REPRESENTATIVE OF THAT OF A FAILED OR FAILING ROOFING SYSTEM. DARK AREAS ARE TYPICALLY TRAPPED WATER. EVAPORATION PRODUCES A COOLER TEMPERATURE WHICH IS VISIBLE IN THE IR SPECTRUM.

Building Envelope

- **Thermal scan – results**

- Reduce heat loss

- = U-factor x Area x D_t x Hours

- = $0.25 \times 20,000 \text{ ft}^2 \times 6 \text{ }^\circ\text{F} \times 5,000 \text{ hours}$

- = 1,450 Ccf (natural gas) or 44,000 kWh (electric)

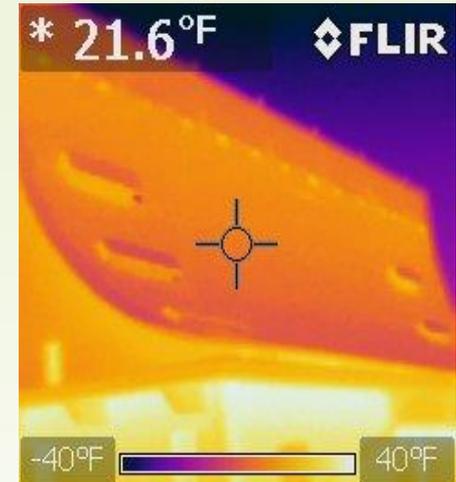
- Eliminate indoor air quality problems

- Deliver cost effective (and correct) solution

- Replace windows (high cost)
 - Tuck pointing, caulking, sealing (low cost)

- Identify problems not visible

- Lowers maintenance costs
 - Focus effort directly on the problem
 - Preserves sometimes priceless assets



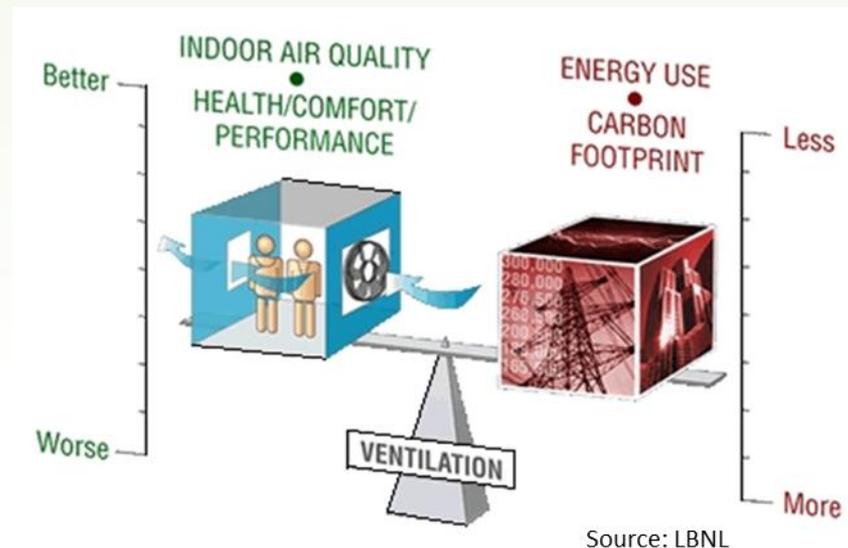
Result of roof replaced previous slide



Creative alternative to replacing original windows

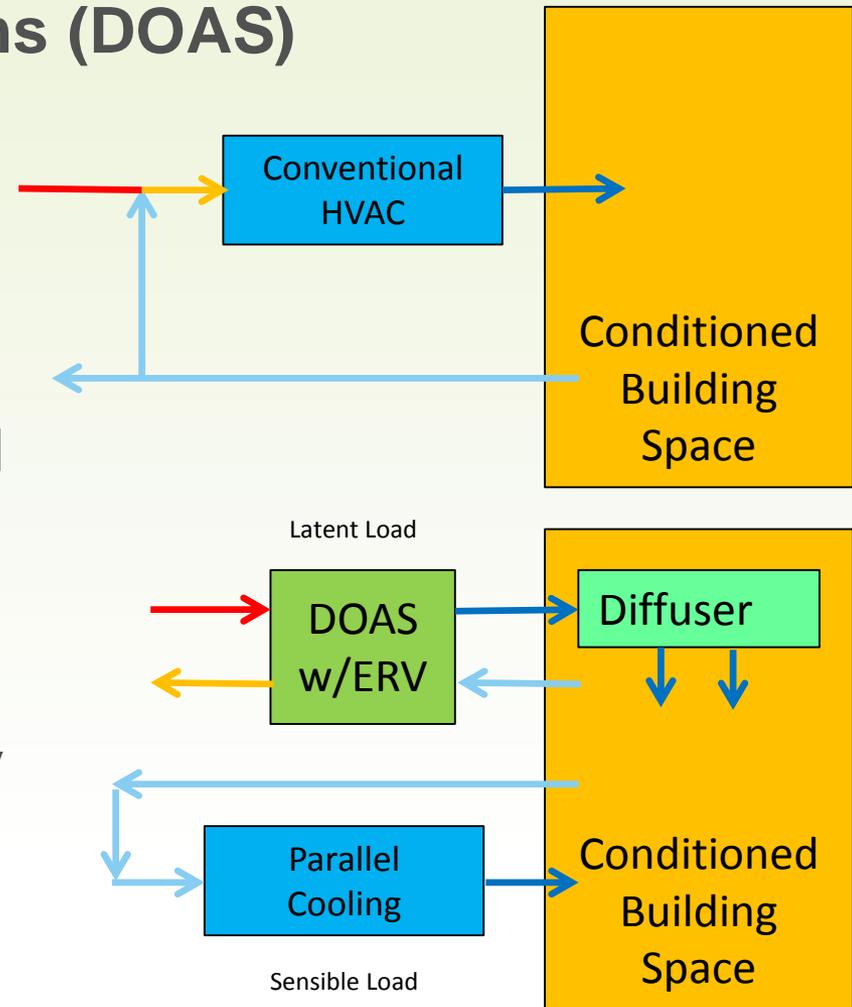
Poll Question

- Generally, how does improving indoor air quality (IAQ) affect energy consumption?
 - a) Increases energy consumption
 - b) Decreases energy consumption



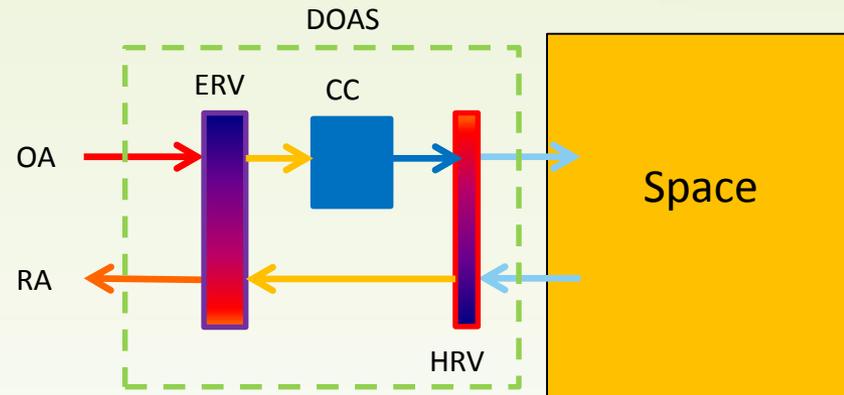
Dedicated Outdoor Air Systems (DOAS)

- Use to decouple space sensible/latent loads
 - 100% OA delivered to each zone via its own ductwork
 - Generally constant volume
- Only system to meet the thermal loads is parallel sensible cooling
- Flow rate generally as specified by ASHRAE 62.1 or greater
- Employ thermal energy recovery as specified by ASHRAE 90.1
 - Sensible heat recovery (only) possible in dry climates



Dedicated Outdoor Air Systems (DOAS)

- Sensible only cooling
 - Radiant cooling panels
 - Fan coil units
 - Chilled beams
 - Unitary ACs
- Easier to defend compliance with ASHRAE Standard 62.1
- Typically 30% to 40% reduction in tonnage
- Up to 20% operating cost reduction at peak load
- First cost savings and payback is not always clear



High-Volume Low-Speed (HVLS) Fans

- Up to 24' diameter
- Mixes stratified air
 - 15°F heat gradient from floor to ceiling
- Comfort and energy savings

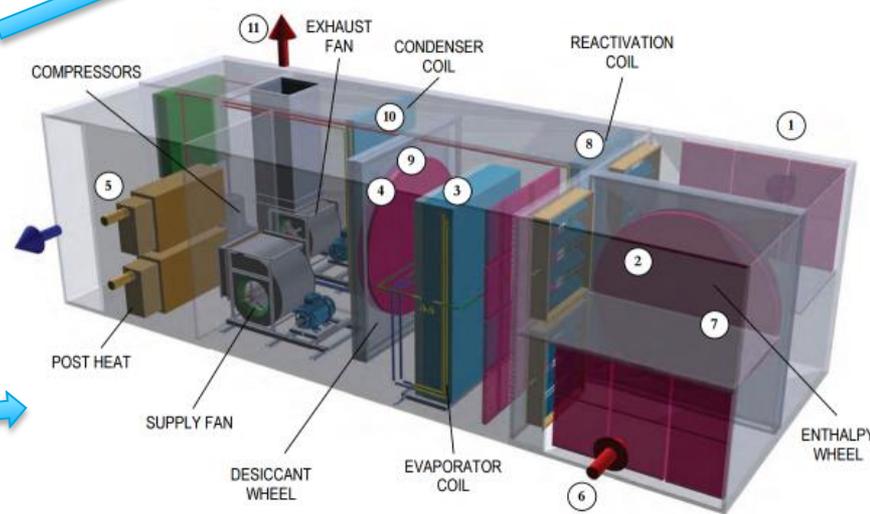


Source: Big Ass Fan Company

Size	CFM	Watts	CFM/Watt
24 feet	375,000	830	450
16 feet	125,000	370	340
30 inches	5,600	415	13

2016 AHR Expo Innovation Award Winners

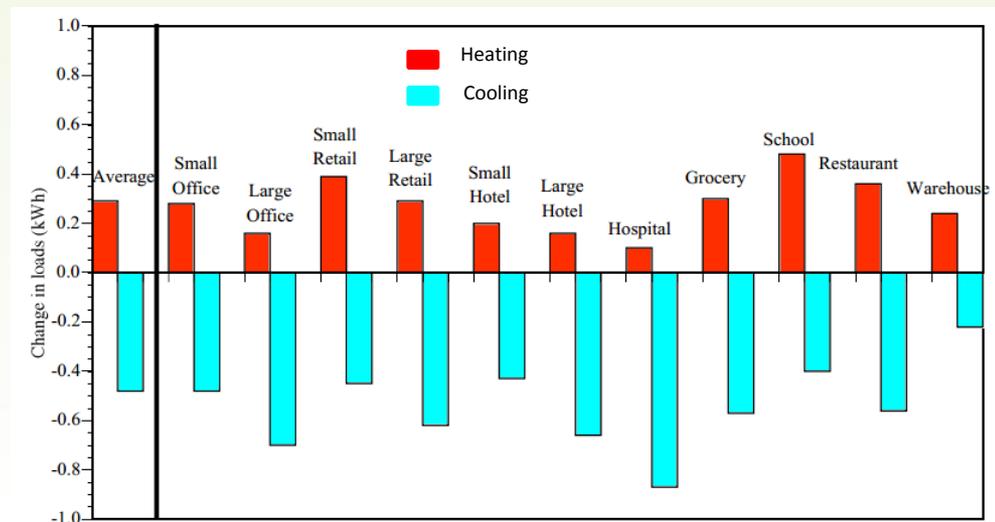
- PlasmaSoft 2.0 from Plasma Air Int'l
- ASCENDANT active-desiccant hybrid system, SEMCO LLC
- Allure EC-Smart-Comfort room sensor, Distech Controls
- Series 3000 Cooling Tower with ENDURADRIVE Fan System, Baltimore Aircoil
- DL Series hybrid humidifier, Nortec Humidity
- DryCool ERV, Munters



Effect of Lighting Reduction

- Synergistic relationship with HVAC
 - Occupancy sensor for lighting can trigger HVAC as well
 - Cooling savings **may** counter heating increase from lighting reduction
 - Tracking of operating hours can determine maintenance needs

Effect of 1 kWh Lighting Reduction on HVAC

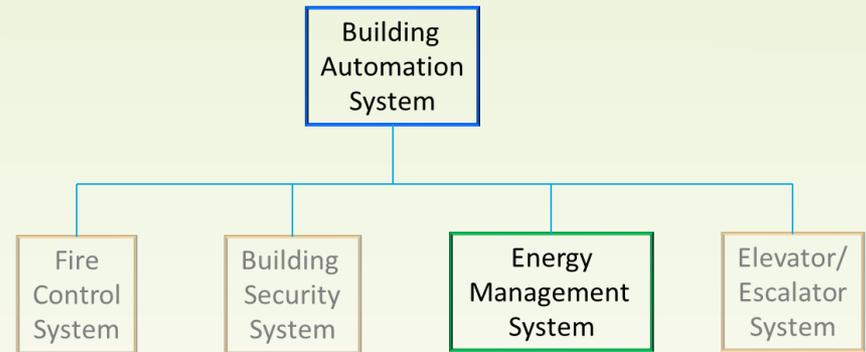


Source: Lawrence Berkeley National Laboratory

Building Automation Systems

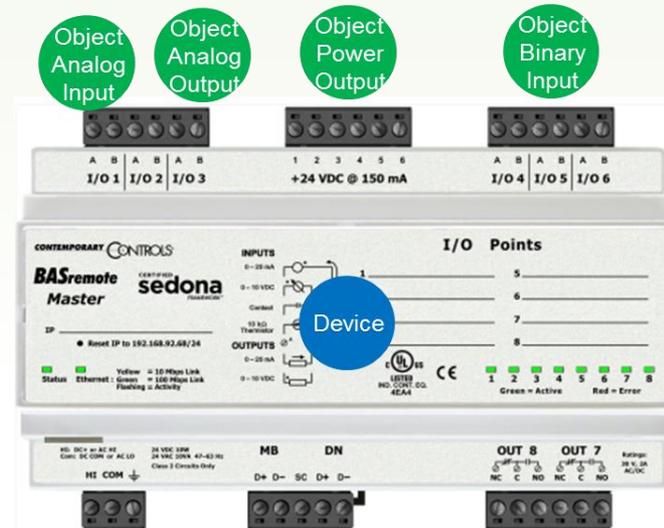
Core BAS Functionality

- **Controls** the building environment
- **Operates** systems
 - Based on occupancy schedules and demand
- **Monitors** system performance
 - Implements corrective actions
- **Provides** alerts and alarms



BAS Components

- Collector
- Controller
- Output device
- Communications protocol
- Dashboard

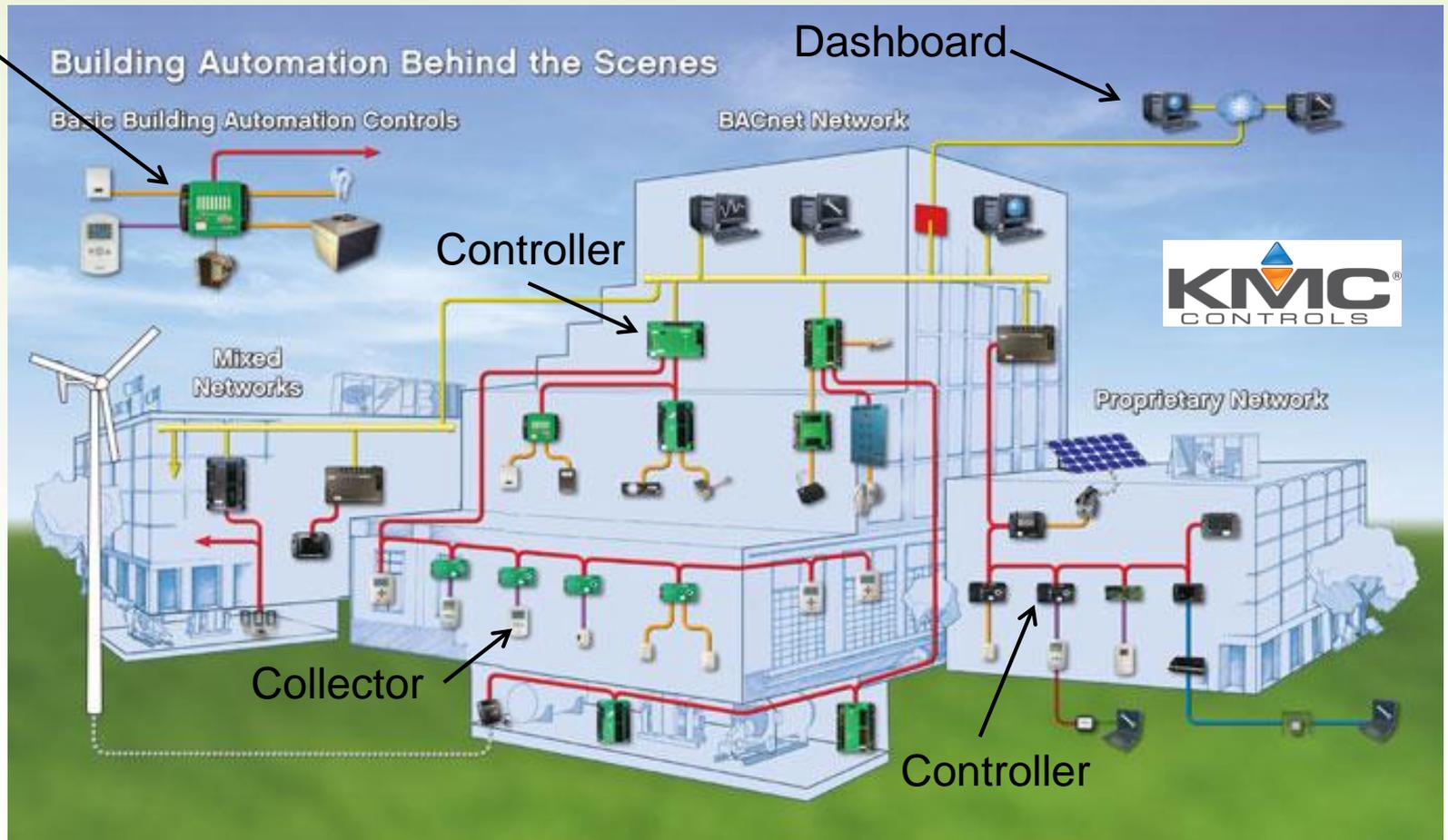


Source: Contemporary Controls

Object Binary Output

Building Automation Systems

Communication Protocols

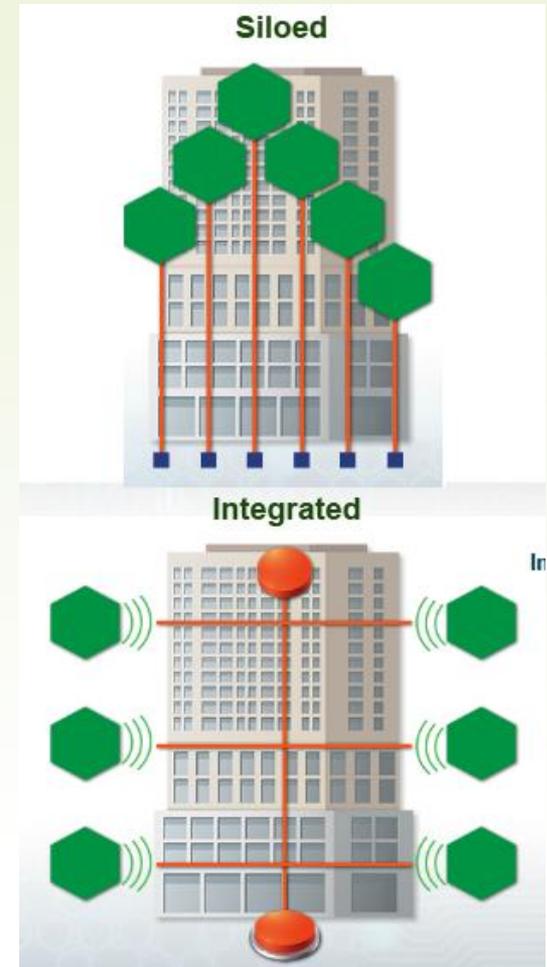


Source: KMC Controls

Building Automation Systems

What Are BAS Benefits?

- Use less energy (5% to 15%)
 - Outside air optimization
 - Vacancy sensors
- Decrease cost of operation
 - Decreased maintenance costs (short cycling)
- Achieve security/safety
- Improve indoor environmental quality
 - Offer a comfortable visitor environment
 - Fewer occupant complaints

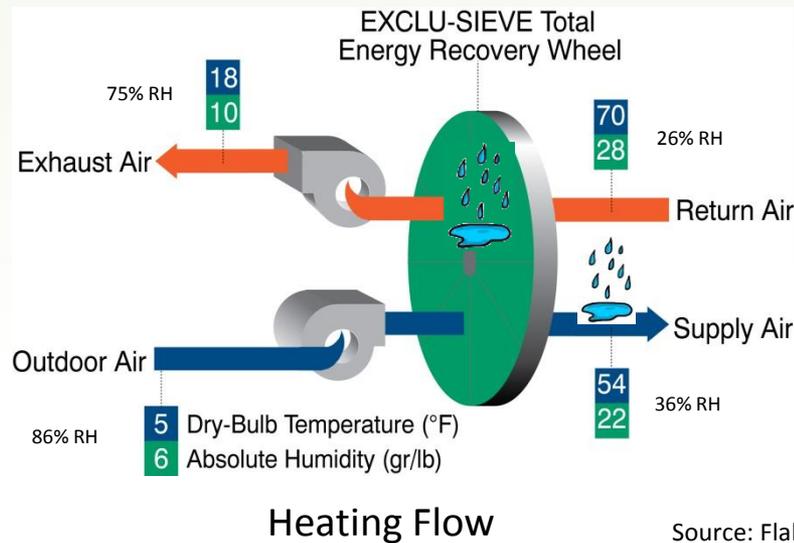


Source: FEMP

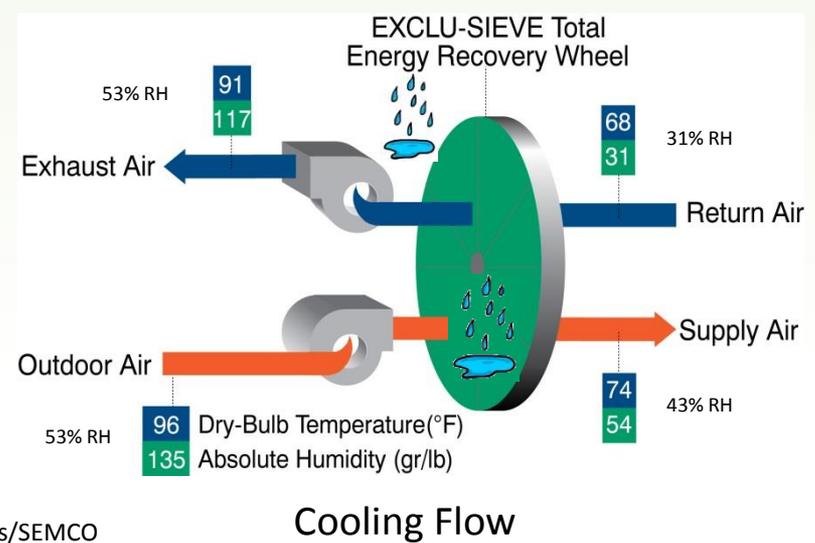
Case Study

The Family Arena (St Charles, Missouri)

- Passive upstream desiccant wheels
 - 10,000 seat arena
 - 110,000 cfm of outside air
 - (4) energy recovery wheels save 450 tons of cooling capacity



Source: Flakt Woods/SEMCO



Case Study

San Diego Natural History Museum

- 800 daily visitors and has office space for its 80 employees
 - Five climates plus offices and classrooms
- Various types of control systems that didn't work together
- Honeywell WEBs-AX™ system allows seamless integration of multiple protocols
 - Allowed use of legacy HVAC components
- Achieved LEED-EB: O&M Certification
- Next phase is demand control ventilation (DCV)



Source: Honeywell

Case Study

J. Paul Getty Museum (Malibu, CA)

- Gallery space with 34 display lights
 - Incumbent 60W PAR38 halogen lamp
 - Cree 12W LED PAR38 2700K lamp



Source: www.energy.gov

Saint Andrew Lutheran Church (Racine, WI)

- Local Green Team and nationwide Energy Stewards Initiative
 - Reduce carbon footprint
 - Decrease utility bill
- Lighting
 - Removed 50 100-watt flood lights
 - Replaced them with 50 23-watt CFLs
 - Removed 24 45-watt CFL lights
 - Replaced them with 12 3-watt LED and 12 7-watt CFL flood lights
- HVAC
 - Installed 5 new programmable thermostats with locking covering boxes
 - Installed two new energy-efficient furnaces



Source: Google Maps

Poll Question

How valuable has this webinar been to you?

- a) Not valuable at all
- b) Slightly valuable
- c) Moderately valuable
- d) Very valuable
- e) Extremely valuable

Dennis Union Church (Cape Cod, MA)

- Landmark 1838 sanctuary
- Benchmarked using ENERGY STAR Portfolio Manager
- Renovation and expansion
 - Added central air conditioning
- Energy Action Plan
 - Retrofit and install new ENERGY STAR qualified lighting and controls
 - Replace obsolete gas furnaces
 - Make envelope improvements to doors, windows, and insulation
 - Replace two large tank water heaters with a central tankless unit
 - Install a photovoltaic array



Source: ENERGY STAR

San Diego Convention Center (SDCC)

- Hi-bay lighting fixtures retrofit
 - Mezzanine and corridors
 - Loading docks
 - HID to fluorescent fixtures with motion sensors
 - \$353,000 investment returns \$211,000 savings per year
- VFD and controls upgrade for AHUs
 - \$498,000 cost returns \$119,000 per year
- Vending Misers on 15 machines
- Installation of a cool roof
- Annual savings of 1.3 million kWh of electricity
 - 427 KW demand reduction

Space Type	Size (ft ²)
Exhibit	525,700
Lobby/prefunction	284,500
Meeting/ballroom	204,100
Pavilion	90,000



Source: Green Building Services, Inc.

Case Studies

Safeco Field

- Seattle Mariners are first MLB team to illuminate field with LEDs
 - 578 LED fixtures replaced metal halides
 - GigaTera SUFA LEDs
 - 800 watts each
 - 81 CRI
 - 60% energy savings
 - Expected 50 year life
 - MLB staff measured results:
 - Met or exceeded all standards
 - Ultra-slow motion replay without any flicker



Source: Planled

Resources

- ASHRAE: [The Indoor Air Quality Guide](#)
- NREL [Low-Flow Liquid Desiccant Air-Conditioning](#)
- DOE GATEWAY report, [SSL Adoption by Museums](#)
- DOE Rooftop Challenge [High Efficiency RTU Spec](#)
- Organizations
 - [Interfaith Power & Light](#)
 - EPA ENERGY STAR

Resources

- ENERGY STAR – free online
 - [Portfolio Manager](#)
 - [Action Workbook for Congregations](#)
 - [Guidelines for Energy Management](#)
 - [Battle of the Buildings](#)
- [Energy Stewards](#) – non-profits, community based
 - Customizable platform
 - Interacts with Portfolio Manager
 - Technical forum
 - Custom built checklist of action items
 - Cost to operate

The steps:

STEP 1: Make Commitment

STEP 2: Assess Performance

STEP 3: Set Goals

STEP 4: Create Action Plan

STEP 5: Implement Action Plan

STEP 6: Evaluate Progress

STEP 7: Recognize Achievements

Source: EPA ENERGY STAR

1. Program Milestones
2. Engage Congregation/ Building Users
3. Set Stage for Action
4. Initial Energy Action (free or low cost)
5. Advanced Energy Action (higher cost)
6. Minimize Water Use
7. Confirm Everyday Good Practices
8. Leadership Action

Source: Energy Stewards



QUESTLINE

We Make Energy Engaging

Thank You!

Provided by Questline

www.questline.com

800.824.0488

mcarter@questline.com

