MA ENERGY EFFICIENCY ADVISORY COUNCIL

→ CONSULTANT TEAM

SMART HVAC & LIGHTING SYSTEMS

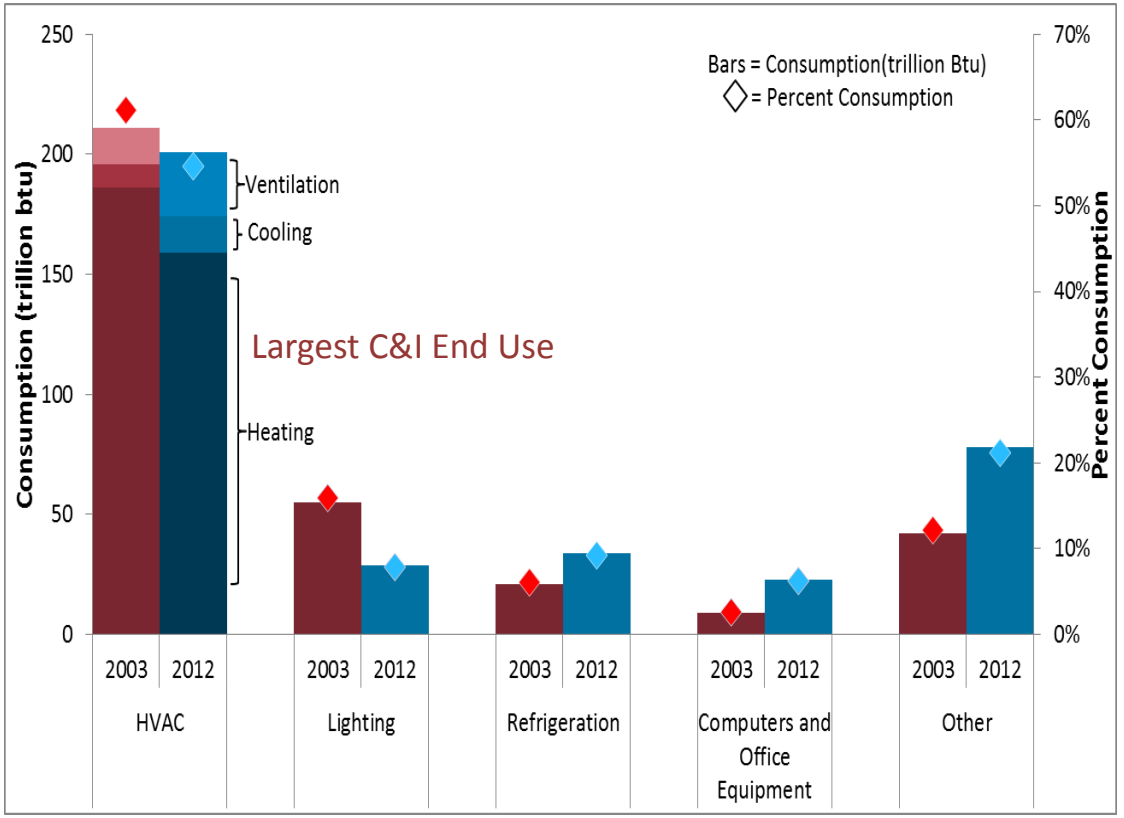
Savings From Two Major C&I End Uses

▶ September 21, 2016

www.ma-eeac.org

PRESENTATION OVERVIEW

- **Why this focus?**
  - Significant savings potential
  - Smart controls coupled with more efficient technologies provide new opportunities for savings
- **HVAC**
  - Technology
  - Controls and EE opportunities
- **Lighting**
  - Technology and controls



CBECS New England, Major Fuel Consumption (Btu) by End Use

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HVAC OVERVIEW

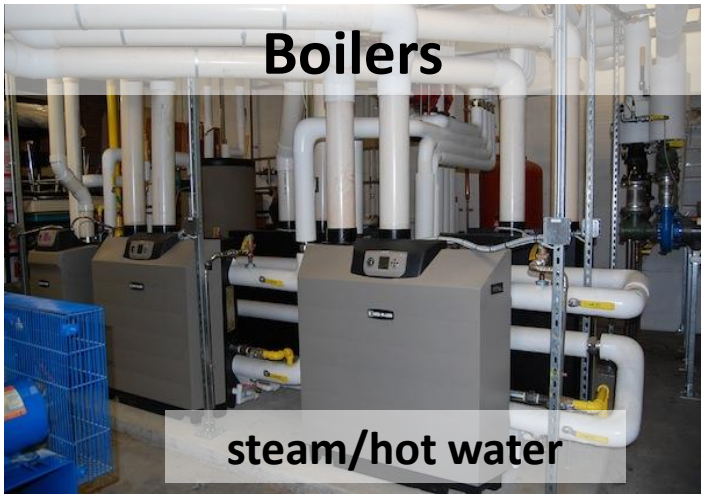
Richard Malmstrom

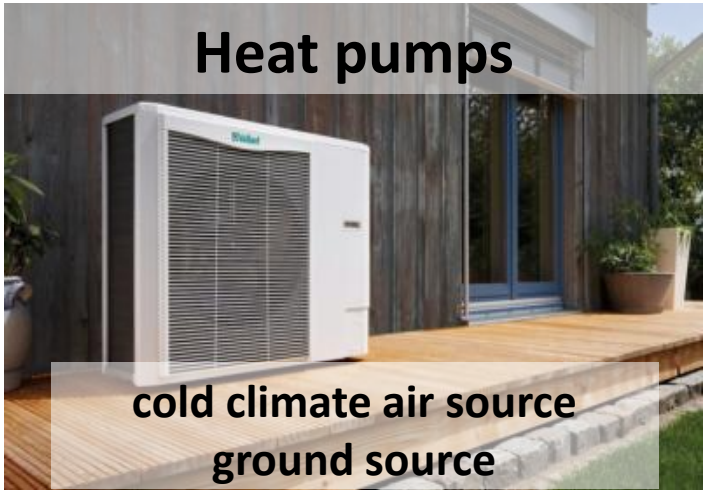
▶ September 21, 2016

WHAT IS HVAC?

Heating
Ventilation
Air **C**onditioning

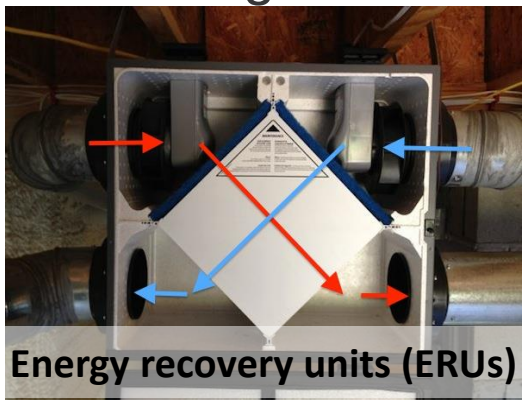
HEATING SYSTEM TYPES



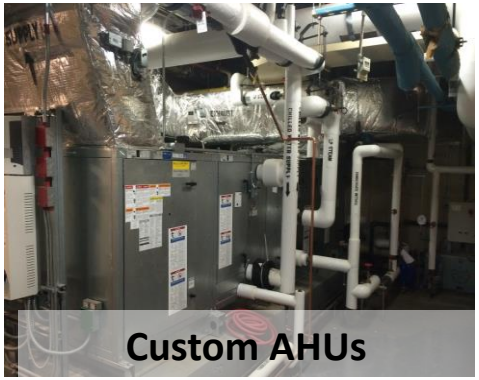


VENTILATION – WHAT AND HOW

- **What ventilation systems do:**
  - Distribute air throughout the building
  - Often provide heating and cooling
- **Fan Systems**
  - Air Handling Unit Examples (AHUs)


Energy recovery units (ERUs)

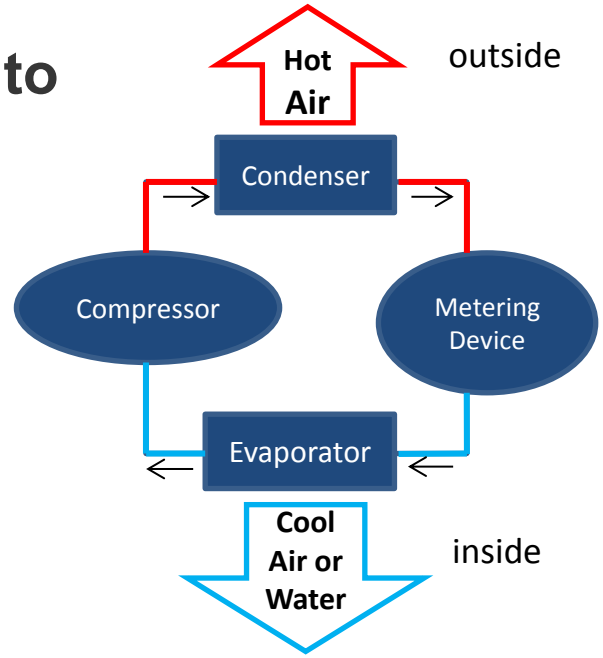
Roof top units (RTUs)


Custom AHUs

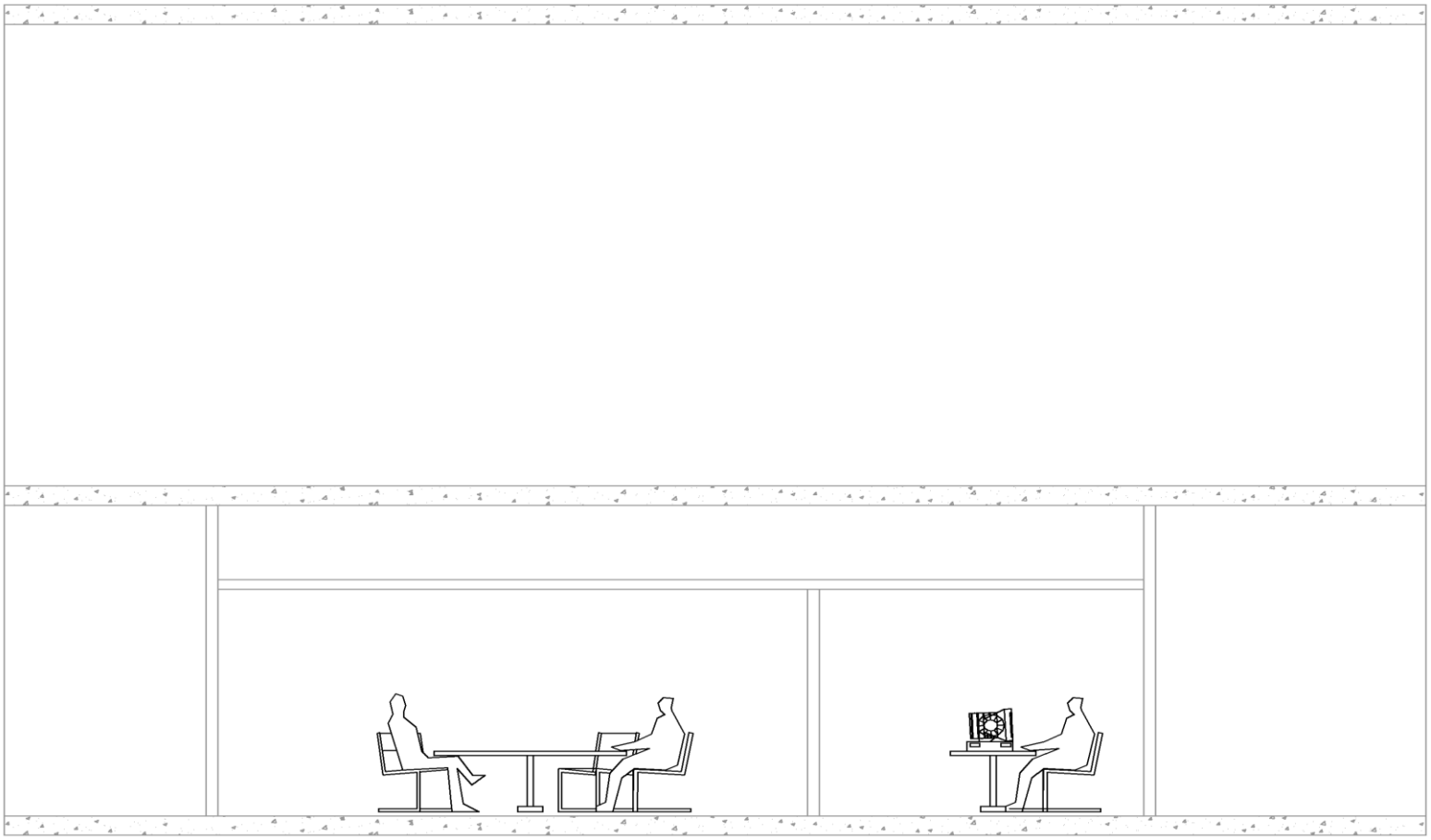
  - Variable air volume – vary amount of air (and sometimes temperature) to maintain comfort
  - Constant air volume – same amount of air with varied temperature to maintain comfort

AIR CONDITIONING – WHAT AND HOW

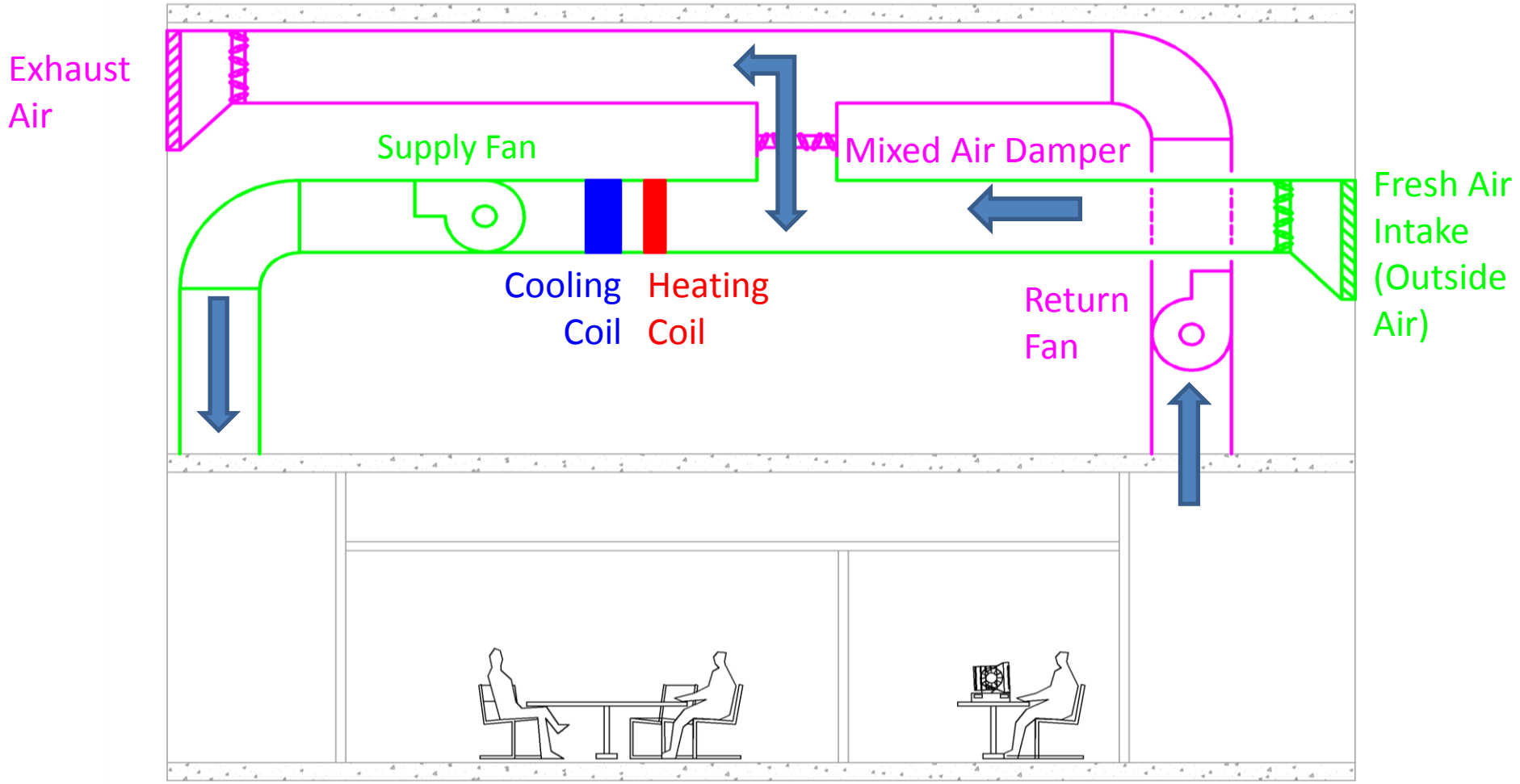
- **Equipment uses the refrigeration cycle to move heat**
  - Hot air discharged outside
  - Cool air released indoors
- **Chillers (water cooled)**
  - Generate cold water that is pumped through building
- **Direct Expansion (DX)**
  - Typically found in RTUs
  - Packaged Terminal Air Conditioning Units (PTACs)
  - Heat pumps (air or water cooled)



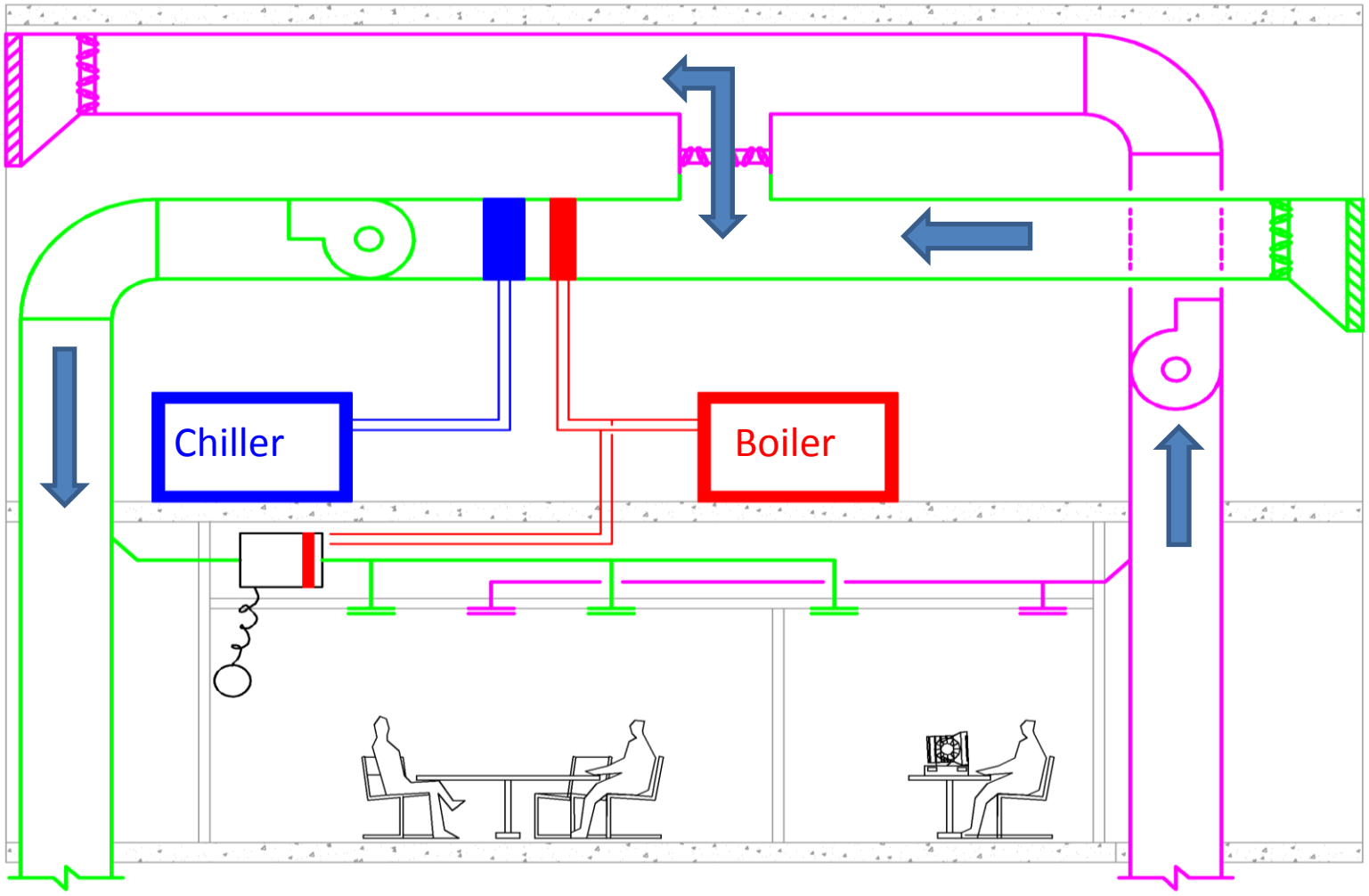
C&I BUILDING OVERVIEW



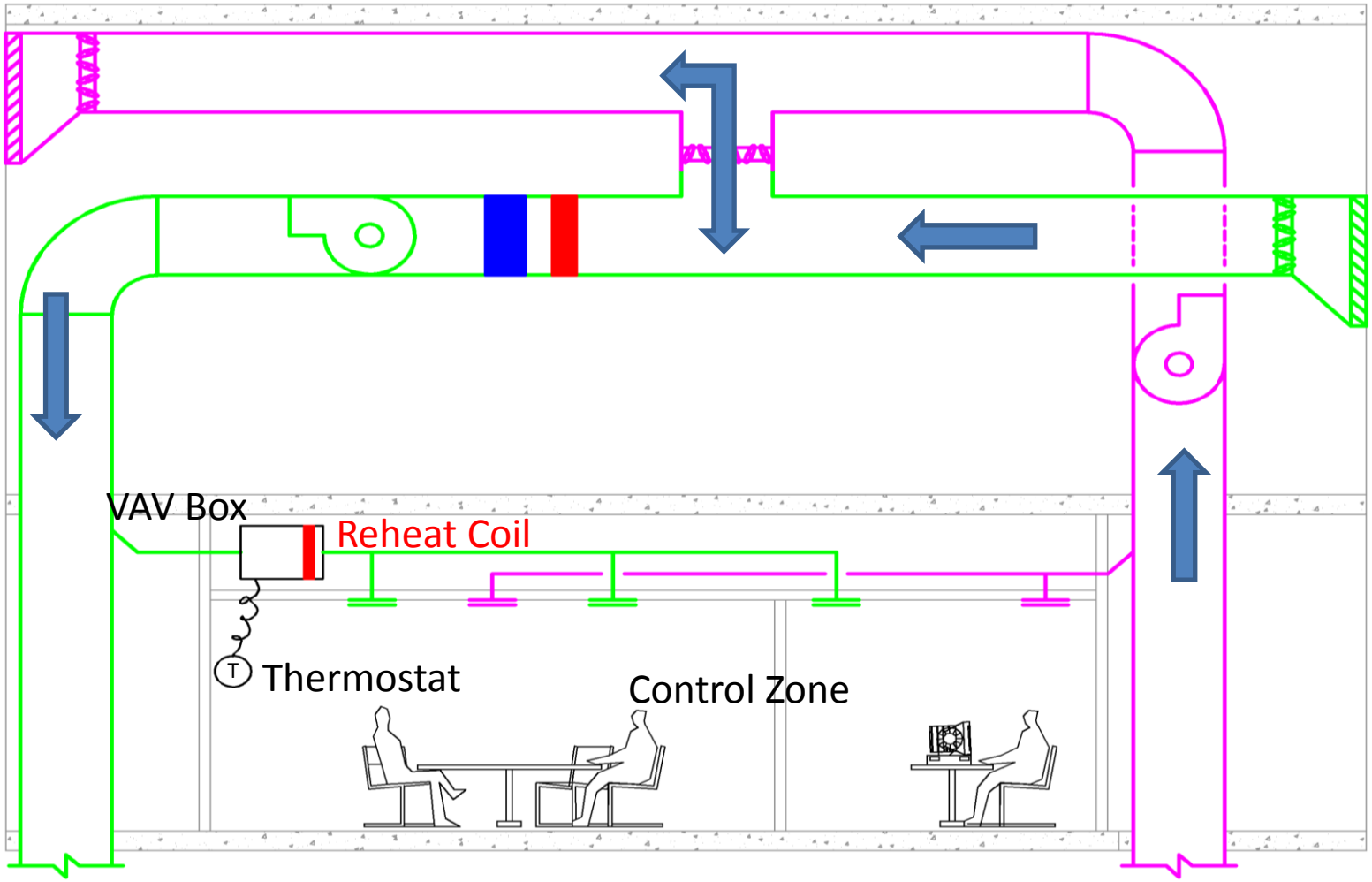
AIR HANDLER IN C&I BUILDING



HEATING AND COOLING



DISTRIBUTION TO OCCUPANTS



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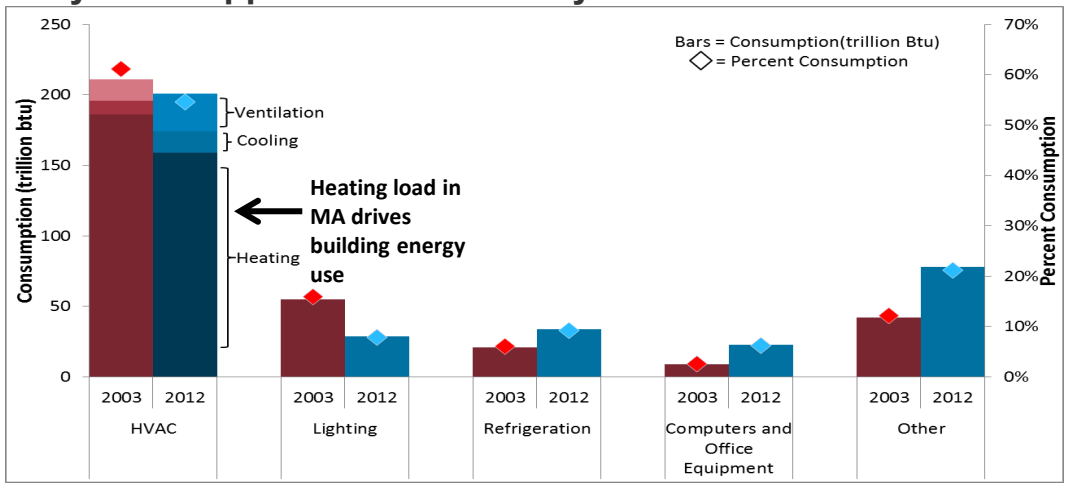
TAPPING HVAC SAVINGS WITH CONTROLS

Jennifer Chiodo, PE

September 21, 2016

IMPORTANCE OF HVAC AS A RESOURCE

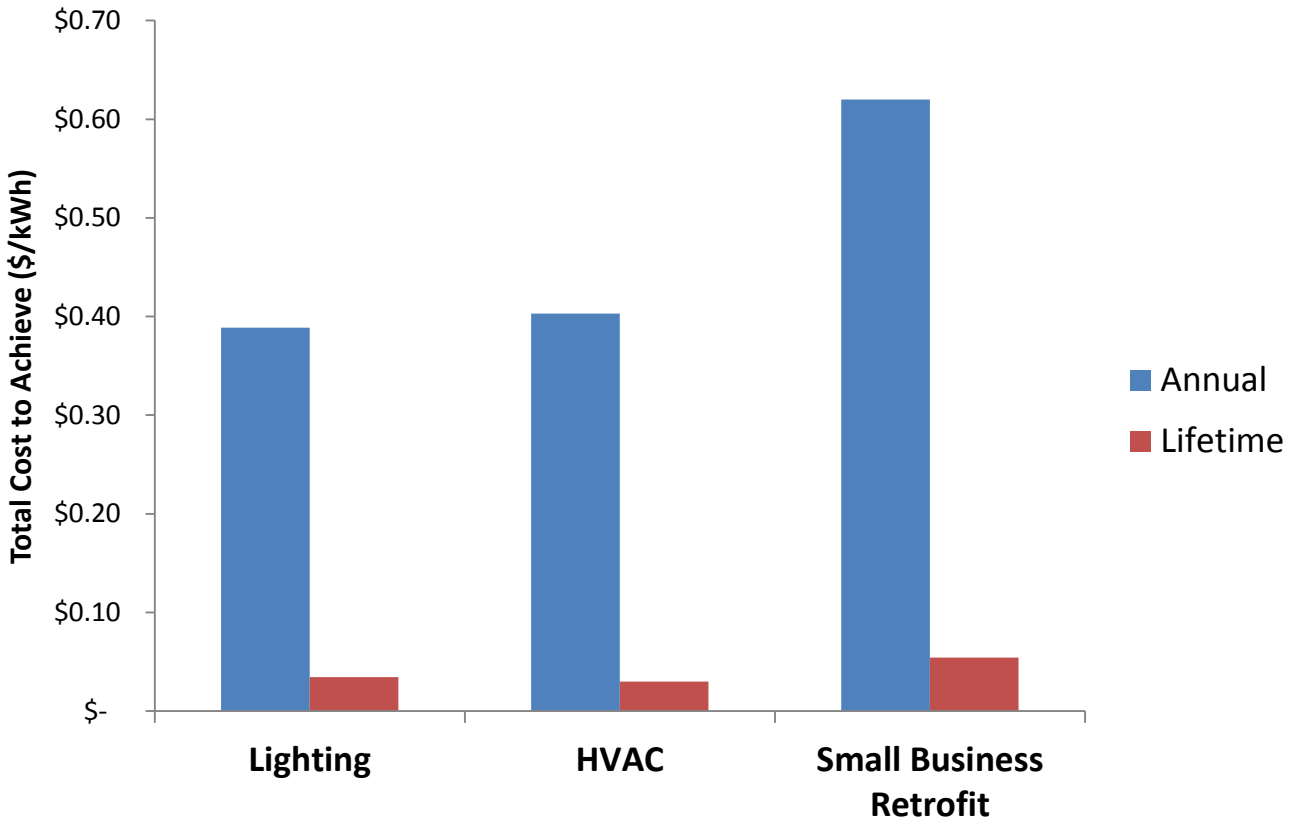
- **Largest commercial building energy use with untapped potential**
  - PA HVAC savings flat from 2012-2014 then dropped 26% in 2015
  - HVAC savings as percent of sector savings is consistently declining (21% in 2012 down to 11% in 2015)
  - PAs with higher HVAC savings rates also had higher overall savings rates
- **Integrated systems approach is necessary**



CBECS New England, Major Fuel Consumption (Btu) by End Use

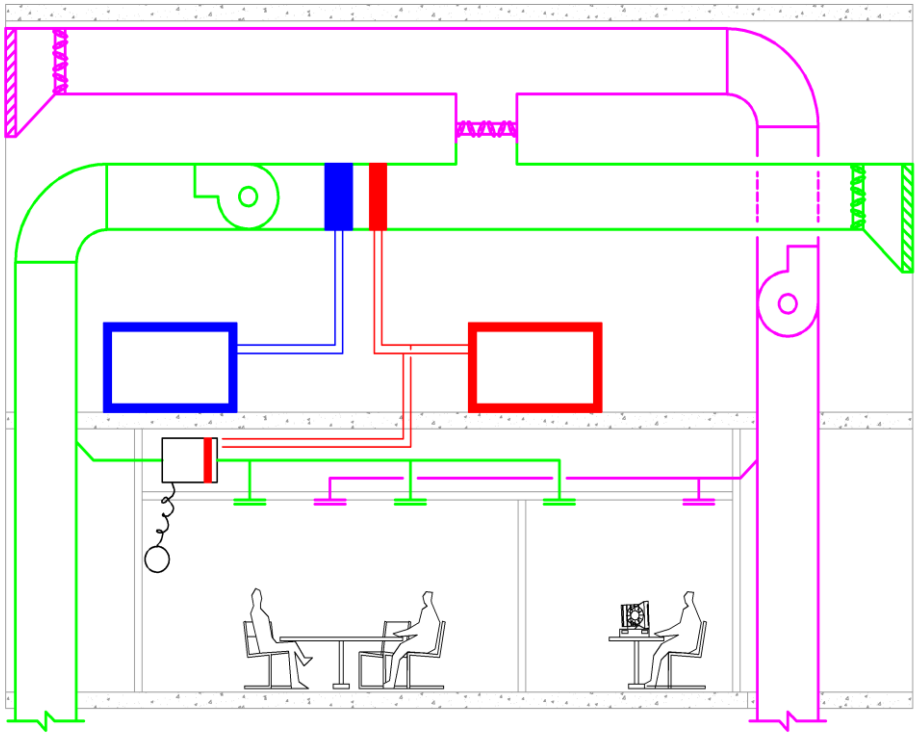
2014 ELECTRIC COST TO ACHIEVE

- **HVAC *and* lighting: lifetime cost to achieve = $0.03/kWh**



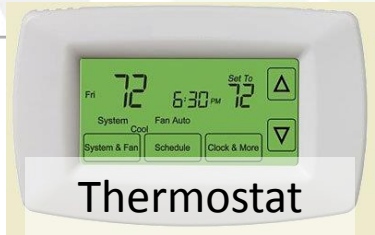
HVAC CONTROLS OPERATE THE MANY MOVING PARTS OF HVAC SYSTEMS

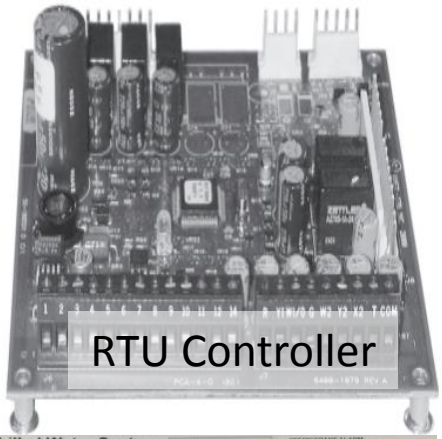
- **Turn equipment on and off**
- **Open/close dampers and valves**
- **Optimize systems**
  - Based on weather and load
- **Better controls:**
  - Increase comfort and productivity
  - Eliminate energy waste
  - Reduce peak demand
  - Decrease maintenance needs

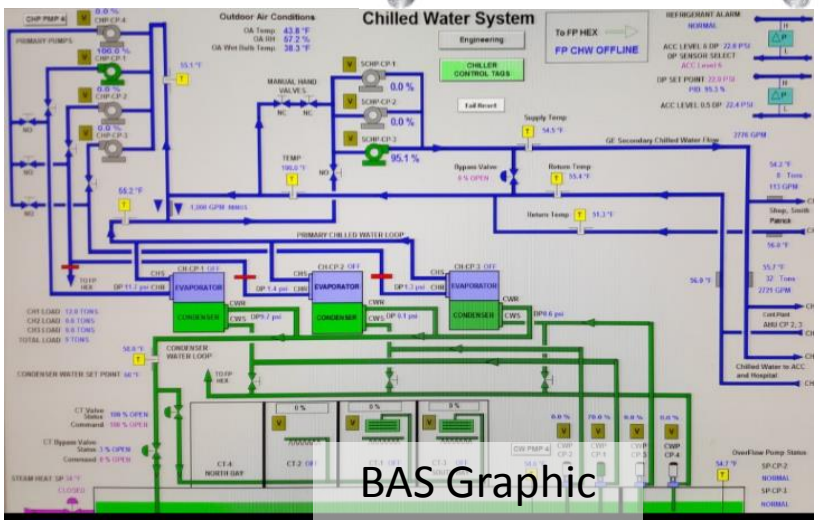


BUILDING HVAC CONTROLS - OVERVIEW

- **Stand-alone controls - limit opportunities**
  - Typical in small buildings, common in midsized
- **Building Automation Systems (BAS) increase ops**
  - Typical in larger buildings and increasing in midsized
    - Pneumatic/electric and electronic
    - Electronic offer integration and EMIS capability
- **Energy Management Information Systems (EMIS)**
  - Uncommon – most buildings operate "blind"
  - Analyze BAS data
  - Flag performance issues
  - Integration capable
    - Lighting, HVAC, elevators, etc







HVAC CONTROLS ➡ ENERGY EFFICIENCY

- **New wireless BAS for smaller buildings**
- **Retrofit legacy BAS**
  - Who uses a 15 year old computer?
- **Energy Management Information Systems (EMIS)**
  - Creates a dynamic feedback loop driving improved and maintained efficiency over time
- **Fully integrated building controls optimize HVAC, lighting and other systems**
  - Human-centric building operations
- **Improved HVAC control typically reduces peak demand**

HVAC Controls 10 – 30+% bill savings

HVAC CONTROLS - MARKET ACTORS

- **Building operator**
  - Day-to-day interactions with the systems and their issues
- **Engineering design firms**
  - Specify control systems and sequences of operations for new buildings and new systems
- **Controls Contractors**
  - Provide proprietary systems with custom programs & services
- **Commissioning providers**
  - Ensure controls are installed and operating correctly
- **PAs**
  - Work to influence the market to improve building controls

HVAC CONTROL STRATEGIES

1. **Shut equipment off**
   - Big savings by controlling equipment off during unoccupied periods
2. **Occupancy based control**
   - Integrated sensors enable increased temperature range, decreased ventilation rate and lights off when space is unoccupied during business hours
3. **Optimize systems: fans, chillers, boilers, pumps and terminal equipment**
   - Dynamic control responds to current occupant and building needs
   - ASHRAE Guideline 36 – High Performance Sequences of Operations for HVAC Systems

OPPORTUNITIES TO ADVANCE SAVINGS THROUGH HVAC CONTROLS

- **Recognize and support optimized sequences of operations**
  - Development and training on best practices
  - Apply to new construction and retrofit
- **Continue to advance commissioning services for new and existing buildings**
  - Provide training to ensure providers understand EE and system optimization
- **Support continuous improvement through EMIS feedback**
  - Third party providers
  - DOE Smart Energy Analytics Campaign (smart-energy-analytics.org)
  - Support open-source control systems
  - Accelerate fully integrated controls with feedback loops

DANA FARBER EMIS PROJECT

- **Third party Energy Management Information System (EMIS) with continuous monitoring & feedback (2011-present)**
  - Real-time feedback regarding building operational issues

HVAC Points	12,000
HVAC Equipment Units Monitored	750
Energy Cost Savings Identified	$760,000
Energy Cost Savings Implemented	$718,000

MEASURES, COSTS AND BENEFITS

- **Cost ~ $120,000**
  - Programming ($30k)
  - Monitoring ($50k)
  - Implementation ($40k)

- **Non energy benefits**
  - Increased comfort
  - Reduced maintenance

Item	Description	Savings
1	AHU and heat recovery system scheduling	$62,000
2	Temperature sensor calibration adjustment	$74,000
3	Correct simultaneous heating and cooling	$509,000
4	Address economizer operational issues	$70,000
5	Other control tuning	$3,000
Total		$718,000

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THE FUTURE OF INTERIOR LIGHTING FOR COMMERCIAL AND INDUSTRIAL MARKETS

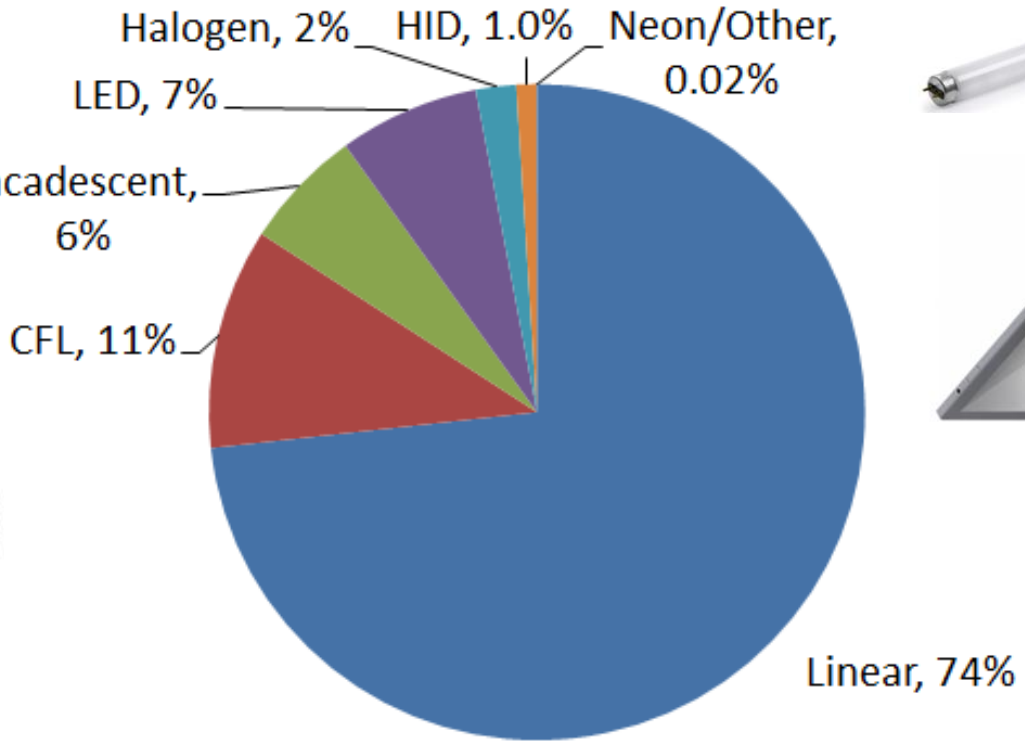
George Lawrence

September 21, 2016

LIGHTING REMAINS AN EFFICIENCY RESOURCE

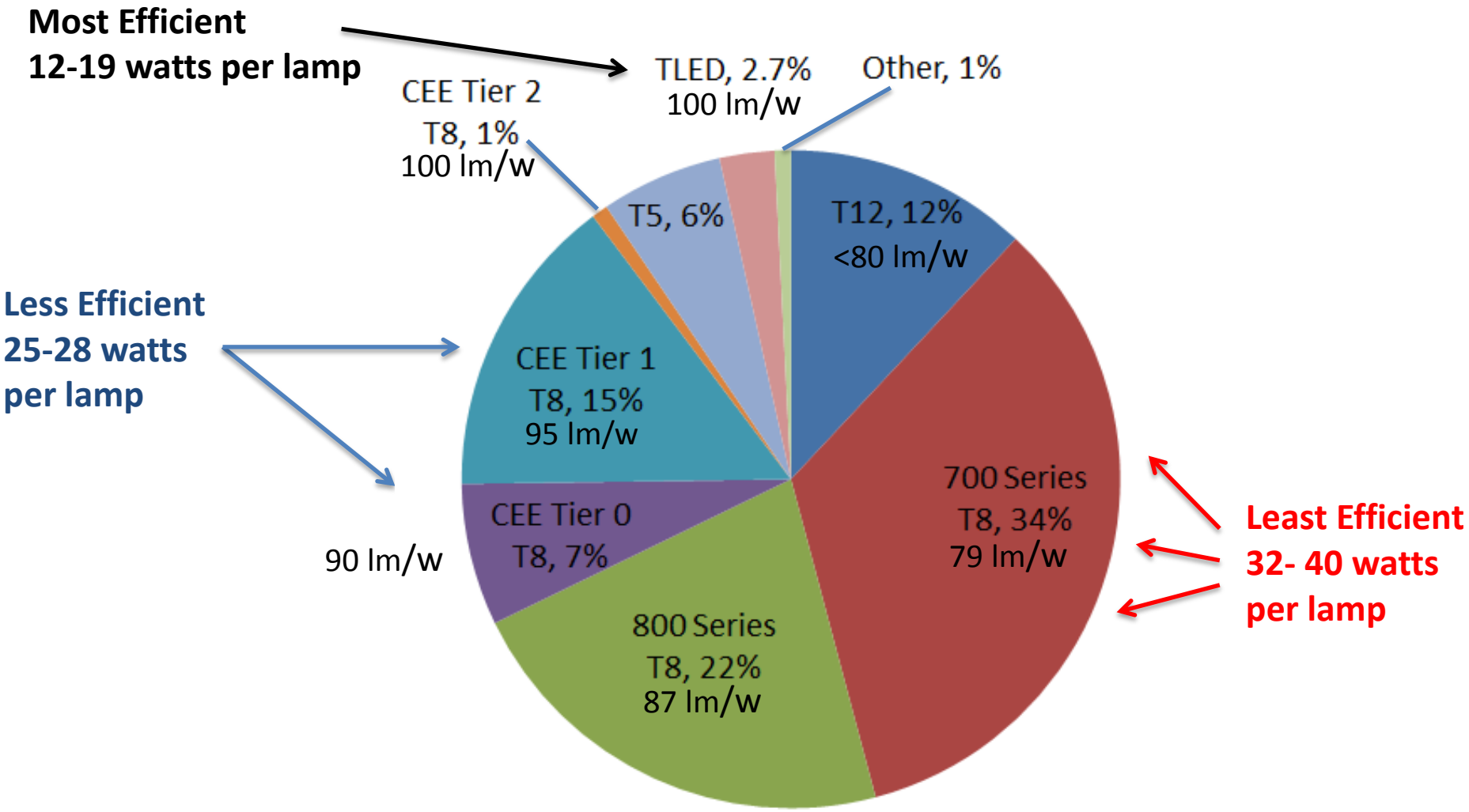
- Lighting energy use has declined from 38% to 17% of commercial building load over the past 15 years
- LED efficiency and control capabilities provide a significant opportunity to cut lighting consumption by another 50%
- Overview of the current technology and where savings are expected

74% OF INTERIOR C&I LAMPS ARE LINEAR



Source: Figure 3-5, MA C&I Onsite Assessment Final

THERE IS A LOT OF POTENTIAL IN C&I LINEAR LIGHTING



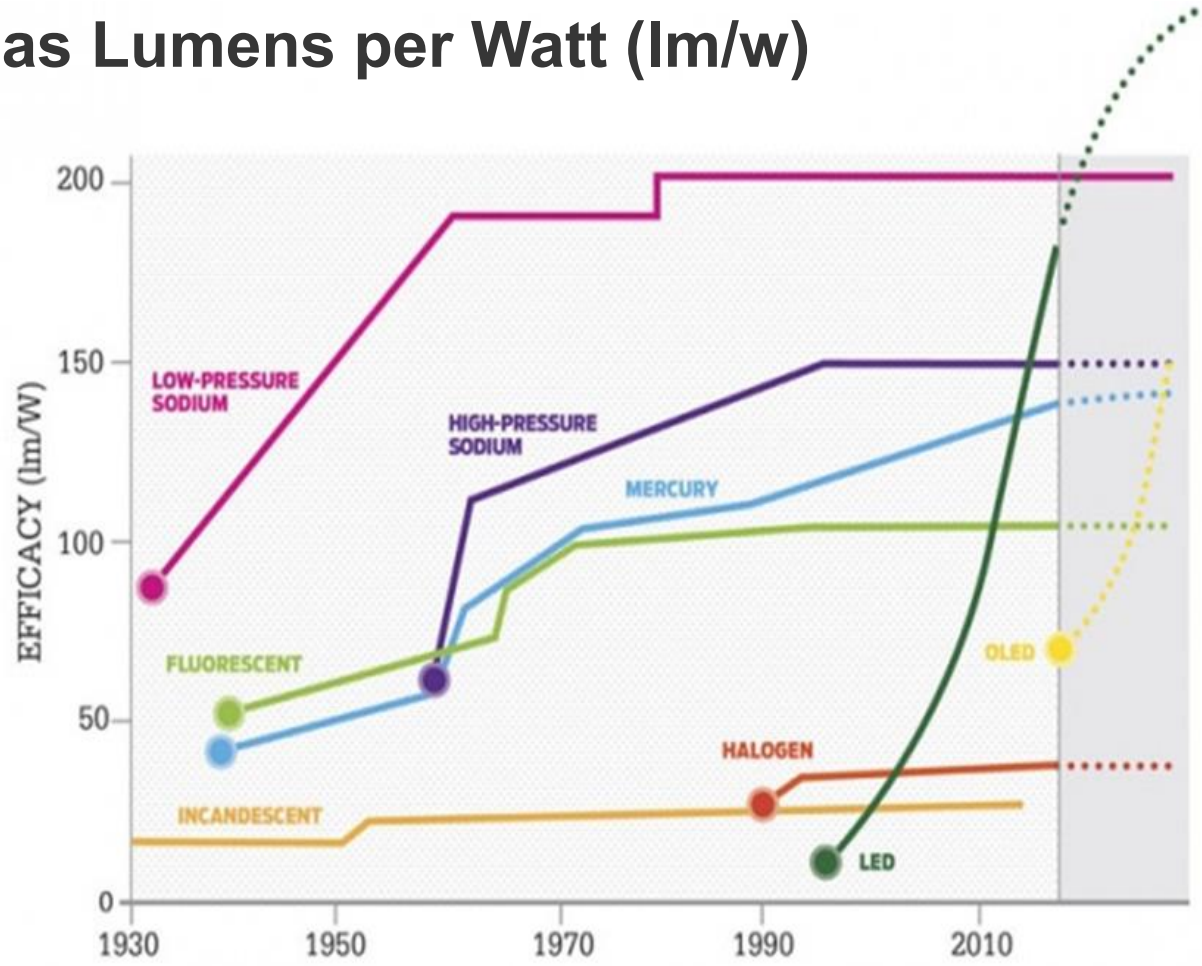
Percent of Linear Market by Lamp Count
Source: MA C&I Onsite Report - Final

LED EFFICACY KEEP INCREASING

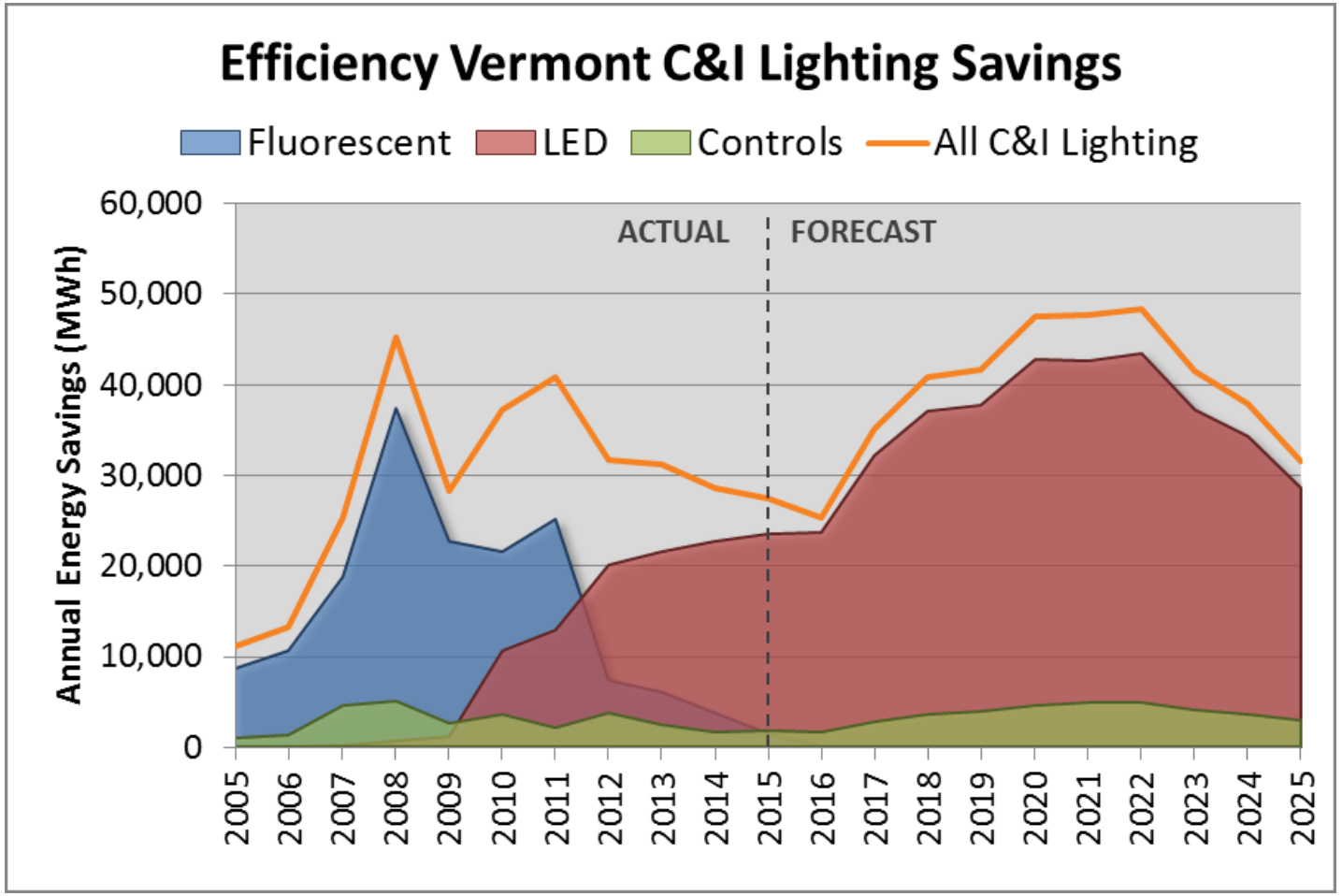
- **Efficacy is defined as Lumens per Watt (lm/w)**

- **TLEDs lead all LED technologies in lamp efficacy**
  - Mean of 113 lm/w,
  - Best is 190 lm/w
  - Mean for an installed TLED is 91

- **LED fixtures**
  - Mean for a LED fixture is 98 lm/w



C&I LIGHTING SAVINGS POTENTIAL



US GSA CASE STUDY - OFFICES

- **United States General Services Administration Projects**
  - Two federal buildings with open office spaces were retrofitted (13,000 to 22,000 SF)

- **LED fixtures with integrated controls reduced lighting energy by 69%**
  - LEDs reduced energy by 41%
  - Controls reduced energy by 28%
    - LEDs were “tuned” (dimmed) to medium setting
    - Automatically adjust for occupancy and daylight
    - 1 hr to commission 300 fixtures

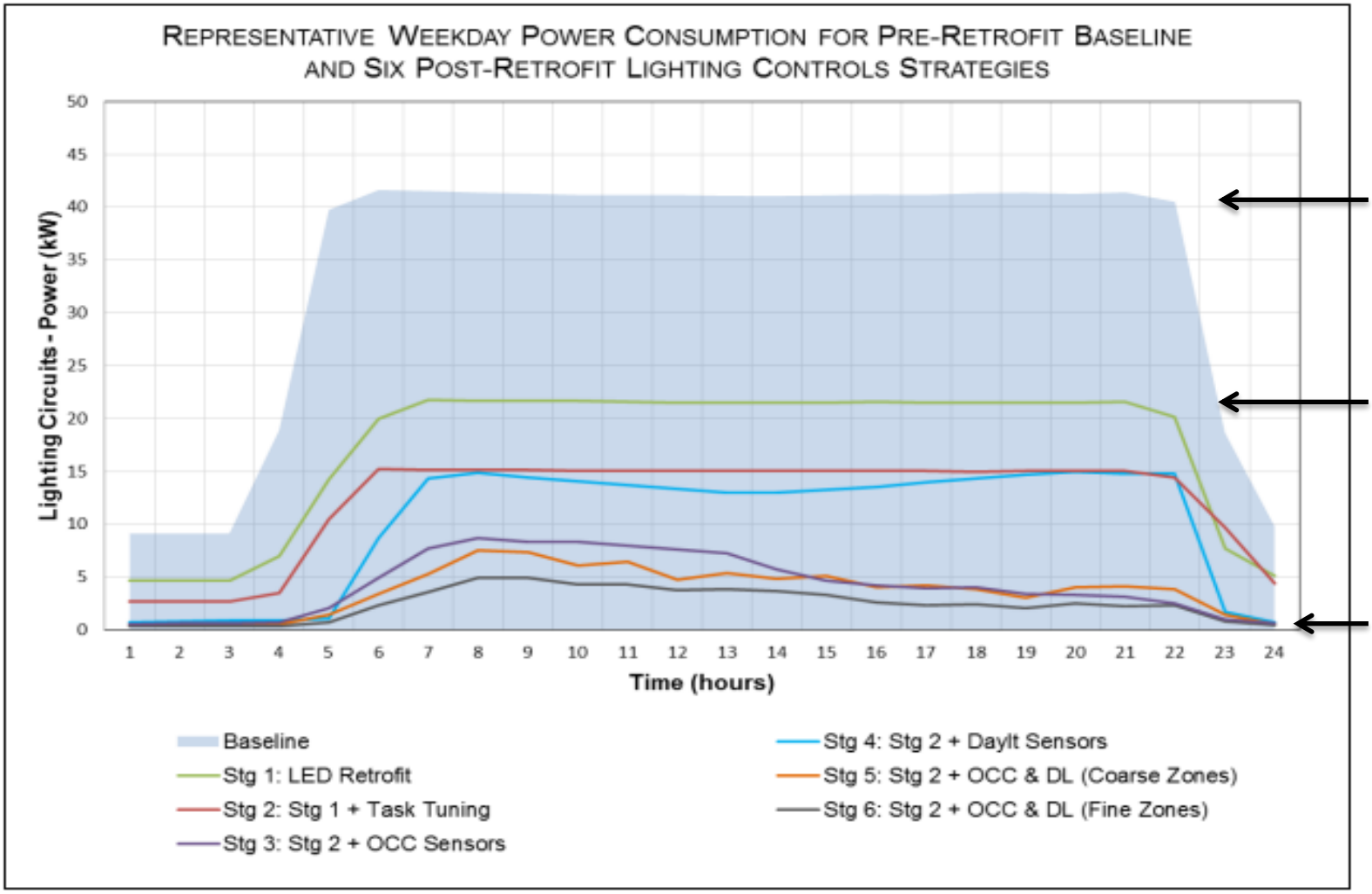
- **Surveys showed increases in occupant satisfaction**
- **GSA estimates 50% ROI for retrofit, and 400% for NC**

ATLAS BOX CASE STUDY - WAREHOUSE

- Headquarters in Sutton Massachusetts
- New 190k SF expansion completed in 2012
- LED fixtures with integrated controls reduced lighting energy by 75%
  - Annual energy savings 958,000 kWh
  - Simple payback of 1.7 yrs
  - Peak demand savings of 148 kW

- The lighting software system:
  - Controls the lights (occupancy, dimming, daylighting)
  - Monitors production equipment performance
  - Real-time energy monitoring of lighting and production equipment

PACIFIC GAS AND ELECTRIC CASE STUDY - WAREHOUSE



Baseline Metal Halide

LED with No Controls 50% Savings

LED with Optimized Controls 93% Savings

HOW TO ADVANCE LIGHTING SAVINGS IN THE FUTURE

- **Maximize savings and demand reductions through comprehensive projects with integrated controls**
- **Develop Market Intelligence**
  - Identify and address market barriers
  - Use non-energy benefits to help sell projects
    - Increased building asset value, improved light quality and occupant productivity gains
- **Explore use of dimming for demand management and response**
- **Monitor and adapt to changing baselines**
  - Screw-ins will be baseline in 2020 if not sooner
  - Linear – LEDs becoming baseline for new construction
  - Stop incentivizing fluorescents- (planned for Jan. 1, 2017)
- **Assess and expand upstream offerings (PAs are doing)**

CONCLUSIONS

HVAC + LED Lighting + Controls
=
Significant cost effective savings