COLUMBUS
INTERNATIONAL CODE COUNCIL 2017

The Top 10 Approach to Commercial Energy Code Compliance

Presenter: Shaunna Mozingo

Tuesday, September 12, 2017

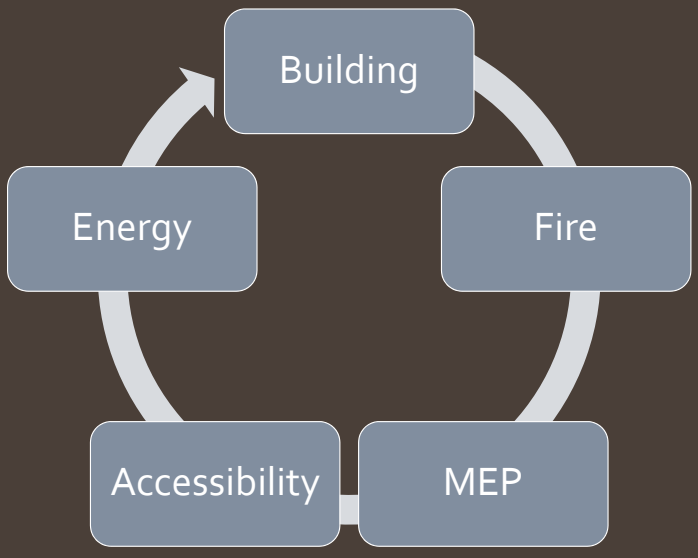
1:30 PM - 4:30 PM

ICC INTERNATIONAL CODE COUNCIL®

A Top 10 Approach to Energy Code Compliance

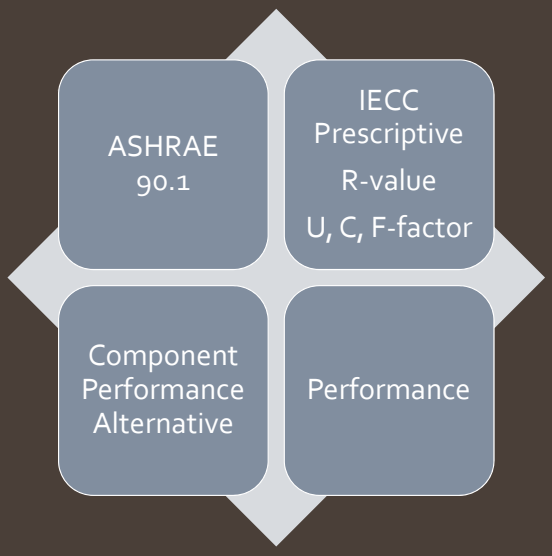
Colorado Energy Office and Colorado Code Consulting in association with Group 14 Engineering

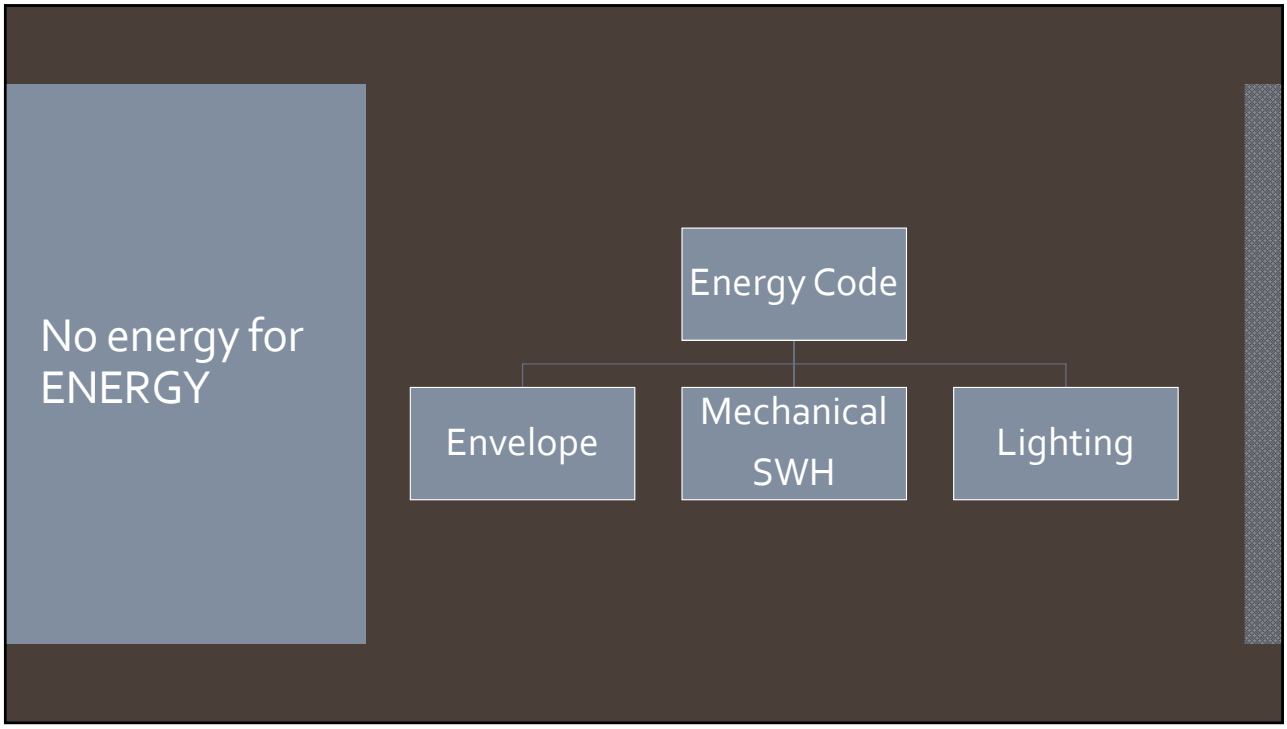
So much code, so little time

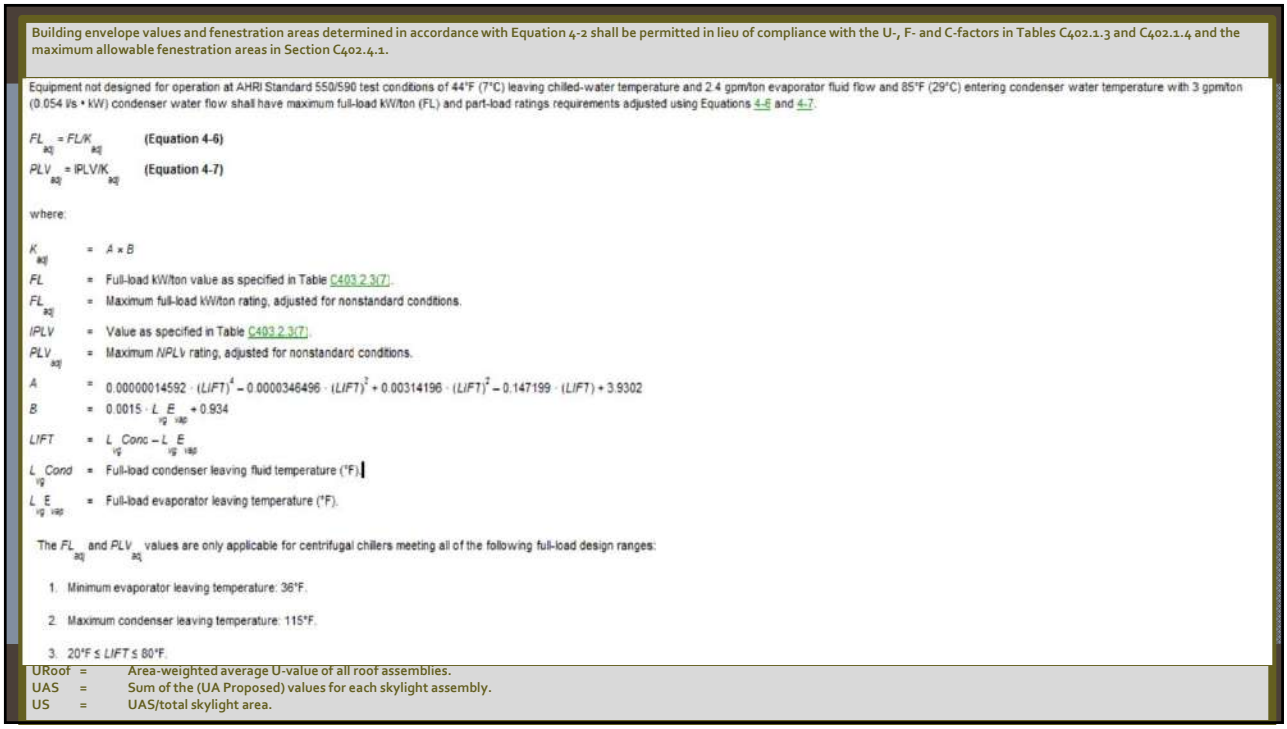


So much code, so little time

So many options







Building envelope values and fenestration areas determined in accordance with Equation 4-2 shall be permitted in lieu of compliance with the U-, F- and C-factors in Tables C402.1.3 and C402.1.4 and the maximum allowable fenestration areas in Section C402.4.1.

Equipment not designed for operation at AHRI Standard 550/590 test conditions of 44°F (7°C) leaving chilled-water temperature and 2.4 gpm/ton evaporator fluid flow and 85°F (29°C) entering condenser water temperature with 3 gpm/ton (0.054 l/s • kW) condenser water flow shall have maximum full-load kW/ton (FL) and part-load ratings requirements adjusted using Equations 4-6 and 4-7.

$FL_{adj} = FL/K_{adj}$ **(Equation 4-6)**

$PLV_{adj} = IPLV/K_{adj}$ **(Equation 4-7)**

where:

$K_{adj} = A \times B$

FL = Full-load kW/ton value as specified in Table C403.2.3(7).

FL_{adj} = Maximum full-load kW/ton rating, adjusted for nonstandard conditions.

$IPLV$ = Value as specified in Table C403.2.3(7).

PLV_{adj} = Maximum *NPLV* rating, adjusted for nonstandard conditions.

$A = 0.00000014592 \cdot (LIFT)^4 - 0.0000346496 \cdot (LIFT)^3 + 0.00314196 \cdot (LIFT)^2 - 0.147199 \cdot (LIFT) + 3.9302$

$B = 0.0015 \cdot L\_E_{vap} + 0.934$

$LIFT = L\_Conc_{vg} - L\_E_{vap}$

L_Cond_{vg} = Full-load condenser leaving fluid temperature (°F).

L_E_{vap} = Full-load evaporator leaving temperature (°F).

The FL_{adj} and PLV_{adj} values are only applicable for centrifugal chillers meeting all of the following full-load design ranges:

1. Minimum evaporator leaving temperature: 36°F.
2. Maximum condenser leaving temperature: 115°F.
3. 20°F ≤ *LIFT* ≤ 80°F.

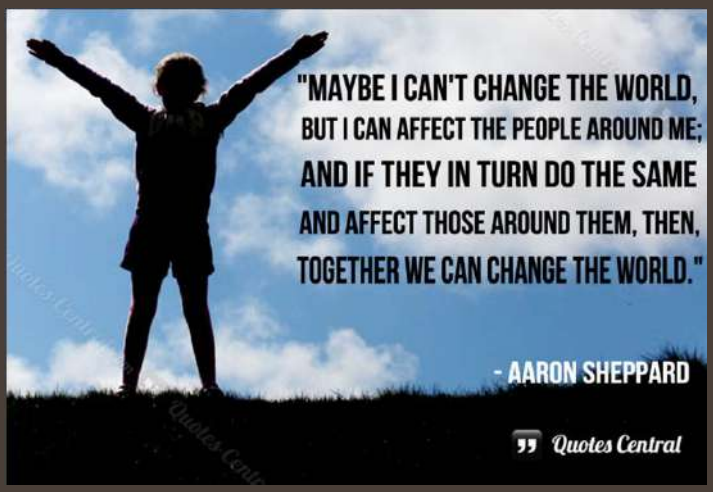
URoof = Area-weighted average U-value of all roof assemblies.
UAS = Sum of the (UA Proposed) values for each skylight assembly.
US = UAS/total skylight area.

What happens to a code book that you don't understand?

Leaving us with efficiency on paper only

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{total energy in}}$$

How do we affect change?



Keep it simple

WHO...

CEO COLORADO Energy Office

Group 14 ENGINEERING Inspiring better buildings.

COLORADO CODE CONSULTING LLC

Why did we do the study?

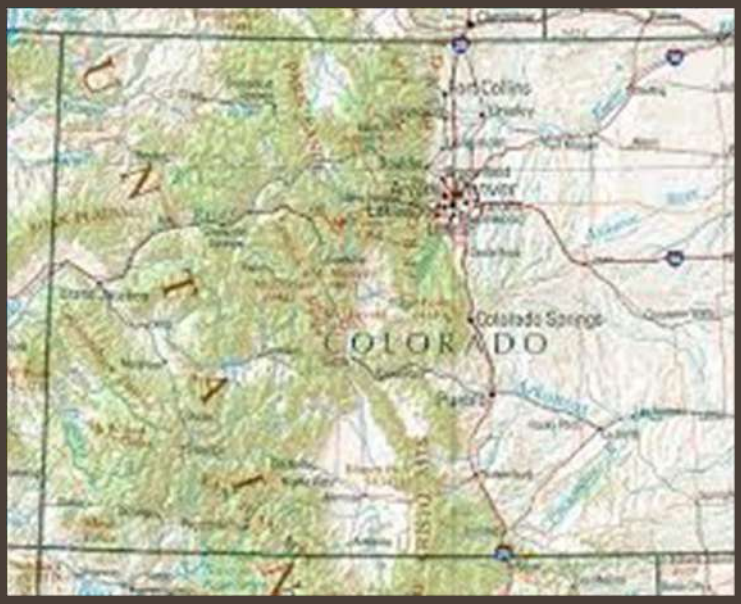
- A new way to meet ARRA Requirements
- To take a complex code and make it useable
- To give the code official an alternative way to do their job
- To actually get better efficiency in buildings and not just on paper
- Commercial buildings hadn't really been looked at this way

When did this take place…

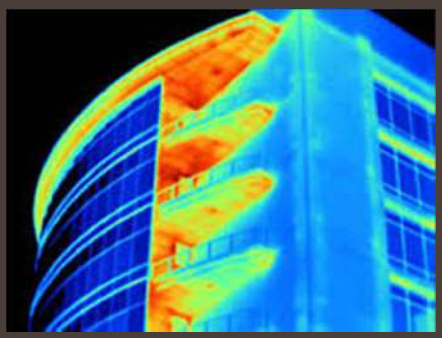
- **Methodology Phase**: November 2015-January 2016
  - Create methodology
  - Create data collection forms/spreadsheets
  - Research data on existing buildings to find energy usage
  - Determine which types of buildings to go into
- **Implementation Phase:** February 2016-May 2016
  - Plan review and inspections using data collection tools
- **Final Analysis Phase:** May 2016-June 2016
  - Entering all data into spreadsheets
  - Analyzing all data
  - Final reporting

Where…

44 buildings around the state

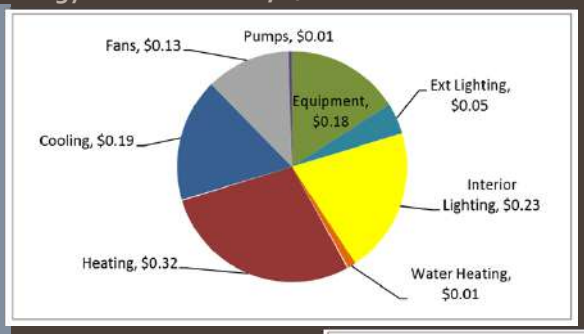


How are commercial buildings consuming energy?

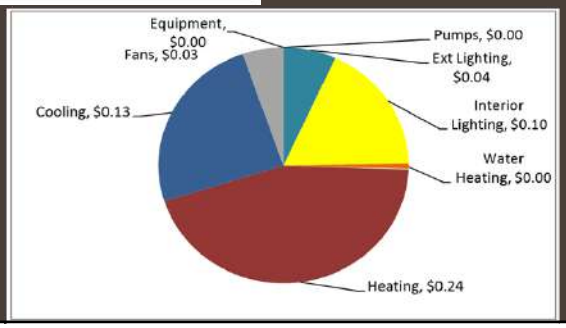


Example: EDUCATION

Energy Use Breakdown, $/SF



Energy Savings Breakdown, $/SF



Energy Cost Savings VS Difficulty in Verification & Enforcement

	Easy to Verify	Difficult to Verify
High Energy Savings	I	II
Low Energy Savings	III	IV

Recommended Educational Building Energy Conservation Measures

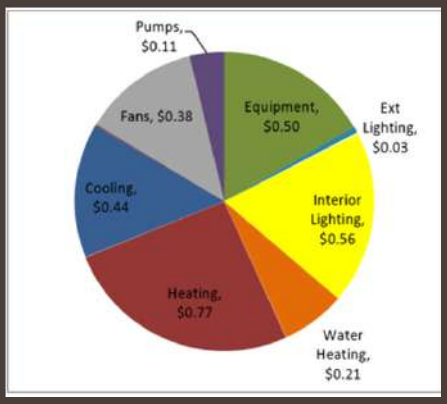
Measure	Measure Category	Measure Notes
Vertical Fenestration	I	Relatively high window-to-wall ratios can make stricter U-Factor and SHGC requirements for vertical glazing relatively cost effective. Glazing requirements are relatively easy to enforce through submittal reviews.
HVAC Equipment Cooling Efficiency	I	Cooling is the second highest source of energy cost savings seen in educational buildings. While cooling savings include lighting and envelope measures, equipment efficiency can make a significant difference.
Installed Lighting	I	Strict lighting allowances have a high impact on nearly all building types, and can be verified through design and submittal reviews.
Lighting Controls	II	Classrooms are occupied intermittently. Common areas are typically naturally lit. Educators often prefer reduced lighting "scenes" to help with projectors, screens etc. Lighting control systems can have a large impact in schools and are typically desired anyway, but since lighting controls have to be programmed during construction, they do require on site-testing or even data logging to verify they are installed correctly.
HVAC Ventilation	II	Classrooms, gyms, and auditoriums have high peak occupant densities requiring ventilation rates that significantly exceed pressurization requirements. Occupancy also tends to vary significantly (a lecture hall or cafeteria may be nearly empty most of the day). Depending on the building and HVAC design, air-side energy recovery or demand-based ventilation setback on the HVAC system can have a significant impact on heating costs, the largest source of savings in educational buildings. Unfortunately energy recovery and especially

Recommended Educational Building Energy Conservation Measures

Measure	Measure Category	Measure Description
Service Hot Water Equipment	III	Service hot water equipment is easy to verify through submittal reviews, but service water heating costs are so low in educational buildings there is little impact.
Wall and Roof Insulation	II	While educational buildings tend to have a high ratio of exterior wall area to interior space, glazing improvements, lighting controls and energy recovery are far more cost effective energy conservation measures.
Service Hot Water Controls	IV	Controls to reduce service water heating energy use would require functional testing to verify and save very little.

Healthcare

Energy Use Breakdown, $/SF



Energy Savings Breakdown, $/SF

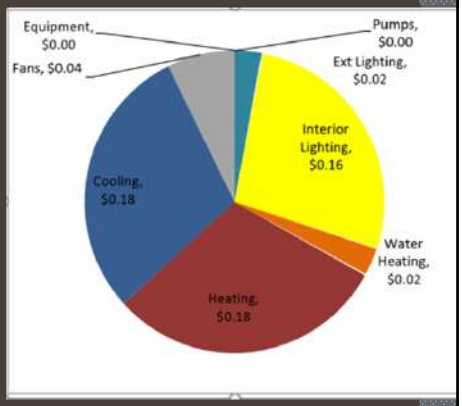
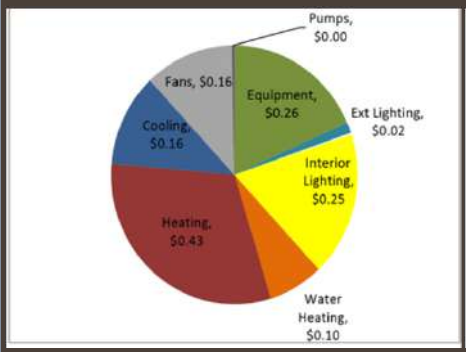


Table 3 – Recommended Healthcare Energy Conservation Measures

Measure	Measure Category	Measure Notes
HVAC Equipment Heating Efficiency	I	Even though medical buildings are cooling dominated, the high air change requirements result in a significant amount of reheat energy. Efficient equipment to provide the reheat energy typically results in significant savings.
HVAC Equipment Cooling Efficiency	I	High ventilation requirements, internal gains and large core spaces result in significant year-round cooling requirements. Efficient cooling equipment typically results in significant savings.
Installed Lighting	I	Strict lighting allowances have a high impact on nearly all building types, and can be verified through design and submittal reviews. Meeting specialized lighting needs in medical buildings with LEDs can dramatically reduce energy use.
HVAC Ventilation	II	Hospitals are typically 24-hour buildings and have high ventilation requirements. Energy recovery results in significant energy savings, but sequences should be verified post construction.
HVAC Ventilation	II	High efficiency air distribution systems, which could include either oversized ductwork or efficient fan wall systems, can result in significant energy savings, but final fan power must be verified following the test, adjust and balance (TAB) process. If fan power limitations are written into an energy code, it is unclear how it would be enforced if required fan power ends up being higher than the design fan power.
HVAC Controls	II	High air change requirements with multizone systems (VAVs) typically result in very high reheat loads. Mandating demand-based discharge air reset controls can significantly reduce heating energy use, but requires functional testing and trend analysis to verify and fine tune. Duct static pressure reset sequences are also critical to reducing fan energy use in large, central air handling systems frequently used in hospitals.
Free Cooling	II	Hospitals have a relatively high amount of core space, resulting in year-round cooling requirements. Air-side or water-side "free" cooling systems (economizers) can significantly reduce cold weather energy use and should be encouraged. Economizers typically require seasonal functional testing to verify that they are operating correctly.
Lighting Occupancy Controls	II	Higher space-by-space lighting requirements and intermittent use of many small rooms make occupancy or vacancy lighting sensors impactful in hospitals. Occupancy sensors should be functionally tested to verify the sensors are programmed per the design.
Service Hot Water Equipment	III	Service hot water equipment is easy to verify through submittal reviews, and service hot water requirements are higher in hospital buildings. Energy savings would be small relative to other measures, but inexpensive to implement.
Vertical Fenestration	III	Heating and cooling loads in hospitals are driven by air change requirements and internal gains, so glass selection plays less of a role, but low SHGC glass can still reduce cooling.

HOTELS AND HOSPITALITY

Energy Use Breakdown, $/SF



Energy Savings Breakdown, $/SF

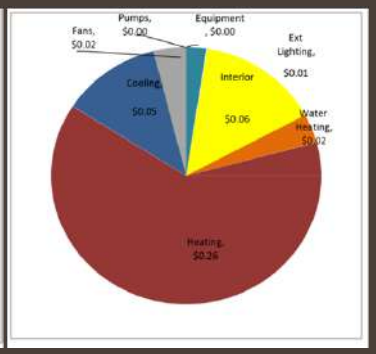
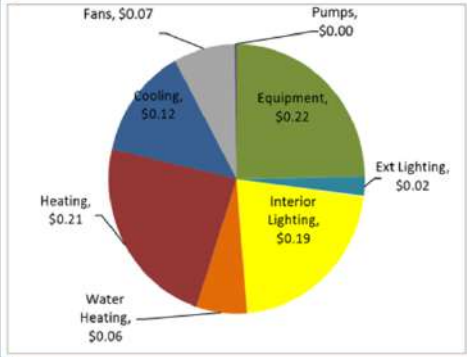


Table 5 – Recommended Hotel Energy Conservation Measures

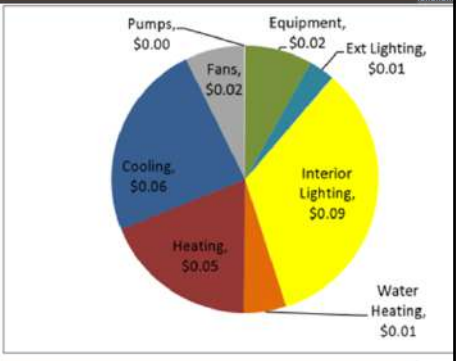
Measure	Measure Category	Measure Notes
Installed Lighting	I	Strict lighting allowances have a high impact on nearly all building types, and can be verified through design and submittal reviews. It is important that lighting requirements apply to portable lighting installed in the guest rooms in addition to hardwired lighting.
Vertical Fenestration: Glazing Area	I	Reducing the window-to-wall area ratio can have a significant impact on reducing total loads on hotel buildings. In-unit HVAC systems tend to be small and less efficient, so reducing the loads in the space in the first place is an easy way to conserve energy.
HVAC Ventilation – Energy Recovery	II	Guest rooms are required to have continuous mechanical ventilation, 24 hours per day. This makes energy recovery on the guest room ventilation cost effective. It is common for hotels to have electric heat pump or fan coils in the guest rooms. Splitting the ventilation system from the guest room conditioning unit provides an opportunity for heat recovery and often reduces electric heating.
Guest Room Occupancy Controls	II	Occupancy rates vary by hotel but are typically around 60%. Occupancy controls that lock out lighting, increase the guest room temperature deadband or set back ventilation rates ensure empty guest rooms don't waste energy.
High Efficiency Service Water Heaters	III	Hotels generally have central water heaters. While the savings potential from high efficiency water heaters isn't great, they are relatively inexpensive to install and easy to verify.

HIGH RISE MULTIFAMILY

Energy Use Breakdown, $/SF



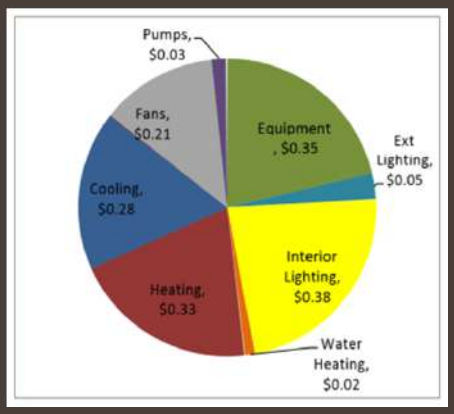
Energy Savings Breakdown, $/SF



Measure	Measure Category	Measure Notes
Installed Lighting	I	Strict lighting allowances have a high impact on nearly all building types, and can be verified through design and submittal reviews. Hardwired lighting in multifamily units usually uses less than what the resident would install themselves. Encouraging hardwired lighting in multifamily units can reduce lighting energy use.
Vertical Fenestration: Glazing Area	I	Reducing the window-to-wall area ratio can have a significant impact on reducing total loads on multifamily buildings. In-unit HVAC systems tend to be small and less efficient, so reducing the loads in the space in the first place is often the easiest way to conserve energy.
Vertical Fenestration: Performance	III	Insulating glass has become standard practice in multifamily. Low SHGC glass can reduce cooling loads, but due to low internal gains can increase heating energy use, offsetting the savings from low-SHGC glass.
HVAC Equipment Cooling Efficiency	III	Cooling is the second highest source of energy cost savings in multifamily. This is primarily from reduced lighting. Because total cooling costs are low, and there are many small systems that need to be upgraded to improve efficiency, improved unitary cooling efficiency is often not cost effective.
Corridor Ventilation	II	Corridors in multifamily buildings need to be conditioned and pressurized 24 hours per day. Keeping the minimum ventilation rate as low as possible while still keeping the corridors pressurized can reduce heating energy use. Examples include nighttime airflow setback or small fan coils conditioning the corridors. Ventilation airflow reduction strategies require functional testing to verify.
Service Hot Water Equipment (Central)	III	Domestic water heating costs are low in multifamily, but if central domestic water heaters are used, high efficiency water heaters are often cost effective. If the central domestic hot water heater is used for both space heating and potable water heating, condensing water heaters are recommended anyway due to lower return water temperatures and condensation issues.

OFFICE

Energy Use Breakdown, $/SF



Energy Savings Breakdown, $/SF

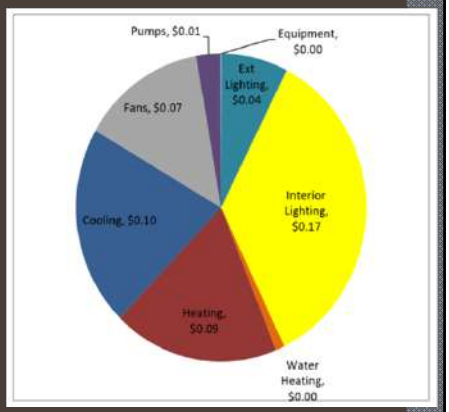


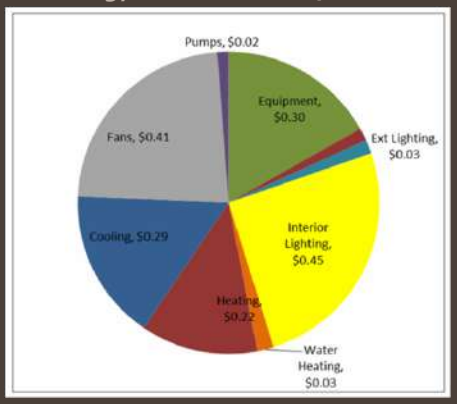
Table 9 – Recommended Office Energy Conservation Measures

Measure	Measure Category	Measure Notes
Installed Lighting	I	Strict lighting allowances have a high impact on nearly all building types, and can be verified through design and submittal reviews. Reduced area lighting supplemented with daylighting and task lights is the simplest and most effective way to conserve energy in offices.
Glazing Performance	I	Offices tend to be cooling dominated and have high window-to-wall area ratios. Reducing maximum allowed solar heat gain requirements would be easy to verify through submittal reviews and effective at reducing cooling energy use.
Lighting Occupancy Controls	II	Offices typically have a significant amount of area devoted to intermittently occupied spaces such as conference rooms, huddle spaces, break rooms and private offices. Motion sensors have been required in some of these spaces for several years, but additional requirements, such as vacancy sensors in perimeter private offices would likely increase savings. Lighting controls would require testing to verify.
Lighting Daylight Controls	II	The open plans and high window-to wall ratios make offices good candidates for automatic daylight dimming. Daylight dimming controls require tuning during construction and need to be verified through testing or trending.

Measure	Measure Category	Measure Notes
HVAC Demand Based Reset	II	Cyclical occupancy and variable heating and cooling loads mean airflow requirements vary significantly in offices. Duct static pressure reset sequences can conserve fan energy when airflow requirements are low, typically in cool or mild weather. Duct static reset sequences require functional testing to verify. A wide temperature reset sequence reduces reheat and fan energy, but also requires testing and tending to verify.

RETAIL

Energy Use Breakdown, $/SF



Energy Savings Breakdown, $/SF

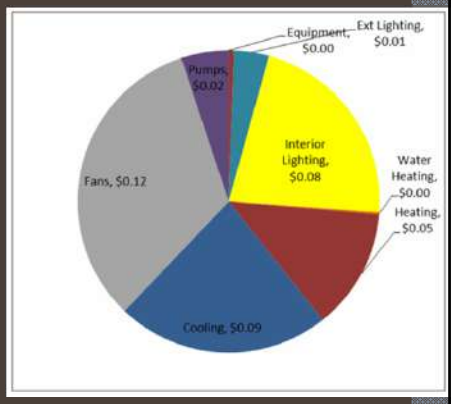


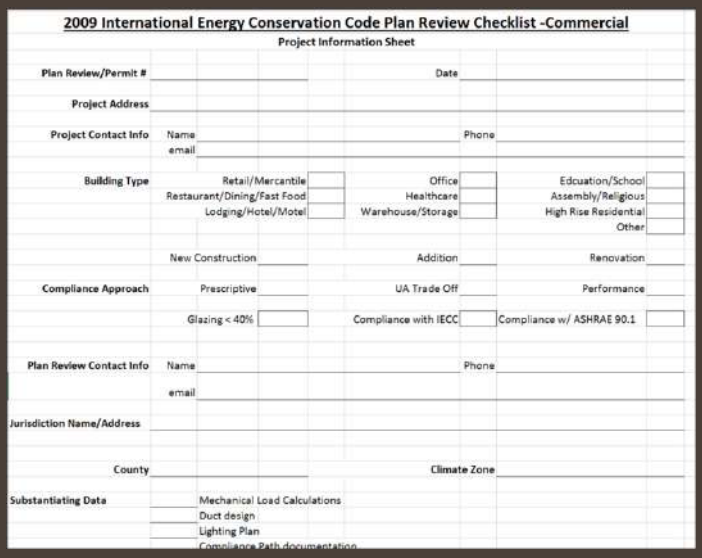
Table 11 – Recommended Retail Energy Conservation Measures

Measure	Measure Category	Measure Notes
Installed Lighting	I	Strict lighting allowances have a high impact on nearly all building types, and can be verified through design and submittal reviews. Reduced area lighting supplemented with daylighting and task lights is the simplest and most effective way to conserve energy in retail.
Lighting Occupancy Controls	II	Retail typically has intermittently occupied spaces such as conference rooms, active storage, break rooms and private offices. Motion sensors, such as requiring vacancy sensors in back-of-house spaces, would likely increase savings. Lighting controls require testing to verify.
Lighting Daylight Controls	II	The open plans make retail good candidates for automatic daylight dimming. Daylight dimming controls require tuning during construction and need to be verified through testing or trending.
HVAC Ventilation	II	High efficiency air distributions systems, which could include either oversized ductwork or efficient fan wall systems can result in significant energy savings, but final fan power must be verified following the test, adjust and balance (TAB) process. If fan power limitations are written into an energy code, it is unclear how it would be enforced if required fan power ends up being higher than the design fan power.
HVAC Demand Based Reset	II	Cyclical occupancy and variable heating and cooling loads mean airflow requirements vary significantly in retail. Duct static pressure reset sequences can conserve fan energy when airflow requirements are low, typically in cool or mild weather. Duct static reset sequences require functional testing to verify. A wide temperature reset sequence reduces reheat and fan energy, but also requires testing and tending to verify.
HVAC Equipment Cooling Efficiency	II	Cooling is the fourth highest source of energy cost savings seen in retail buildings. While cooling savings include lighting and envelope measures, equipment efficiency can make a significant difference.

The Study

Measure	Education / Public	Healthcare	Hotels and Hospitality	Multifamily	Office	Retail
Insulating Glazing	X	X	X	X	X	
Glazing Solar Heat Gain Coefficient		X	X		X	
Increase Exterior Envelope Requirements						
Reduce Installed Lighting Allowances	X	X	X	X	X	X
Lighting Controls Requirements	X	X	X		X	X
HVAC: Increased Equipment Efficiency	X	X			X	X
HVAC: Controls Requirements	X	X	X		X	X
HVAC Ventilation Controls	X			X		X
HVAC Energy Recovery	X	X	X			
Increased Service Hot Water Efficiency		X	X	X		

The Checklist



2009 International Energy Conservation Code Plan Review Checklist -Commercial

Project Information Sheet

Plan Review/Permit # _____ Date _____

Project Address _____

Project Contact Info Name _____ Phone _____

email _____

Building Type
Retail/Mercantile ☐ Office ☐ Education/School ☐
Restaurant/Dining/Fast Food ☐ Healthcare ☐ Assembly/Religious ☐
Lodging/Hotel/Motel ☐ Warehouse/Storage ☐ High Rise Residential ☐
Other ☐

New Construction ☐ Addition ☐ Renovation ☐

Compliance Approach
Prescriptive ☐ UA Trade Off ☐ Performance ☐
Glazing < 40% ☐ Compliance with IECC ☐ Compliance w/ ASHRAE 90.1 ☐

Plan Review Contact Info Name _____ Phone _____

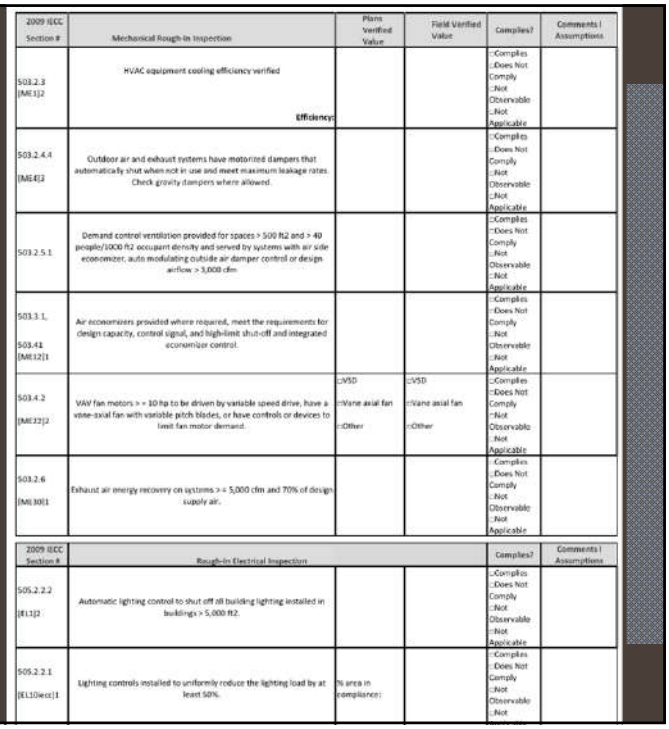
email _____

Jurisdiction Name/Address _____

County _____ Climate Zone _____

Substantiating Data
☐ Mechanical Load Calculations
☐ Duct design
☐ Lighting Plan
☐ Compliance Path documentation

COMPLIANCE CHECKLIST



2009 IECC Section #	Mechanical Rough-In Inspection	Plans Verified Value	Field Verified Value	Complies?	Comments / Assumptions
503.2.3 [ME1]2	HVAC equipment cooling efficiency verified Efficiency:			□Complies □Does Not Comply □Not Observable □Not Applicable	
503.2.4.4 [ME4]3	Outdoor air and exhaust systems have motorized dampers that automatically shut when not in use and meet maximum leakage rates. Check gravity dampers where allowed.			□Complies □Does Not Comply □Not Observable □Not Applicable	
503.2.5.1	Demand control ventilation provided for spaces > 500 ft2 and > 40 people/1000 ft2 occupant density and served by systems with air side economizer, auto modulating outside air damper control or design airflow > 3,000 cfm			□Complies □Does Not Comply □Not Observable □Not Applicable	
503.3.1, 503.41 [ME12]1	Air economizers provided where required, meet the requirements for design capacity, control signal, and high-limit shut-off and integrated economizer control.			□Complies □Does Not Comply □Not Observable □Not Applicable	
503.4.2 [ME22]2	VAV fan motors >= 10 hp to be driven by variable speed drive, have a vane-axial fan with variable pitch blades, or have controls or devices to limit fan motor demand.	□VSD □Vane axial fan □Other	□VSD □Vane axial fan □Other	□Complies □Does Not Comply □Not Observable □Not Applicable	
503.2.6 [ME30]1	Exhaust air energy recovery on systems >= 5,000 cfm and 70% of design supply air.			□Complies □Does Not Comply □Not Observable □Not Applicable	
2009 IECC Section #	Rough-In Electrical Inspection			Complies?	Comments / Assumptions
505.2.2.2 [EL1]2	Automatic lighting control to shut off all building lighting installed in buildings > 5,000 ft2.			□Complies □Does Not Comply □Not Observable □Not Applicable	
505.2.2.1 [EL10ecc]1	Lighting controls installed to uniformly reduce the lighting load by at least 50%.	% area in compliance:		□Complies □Does Not Comply □Not Observable □Not	

How…

Group 14 Verifications

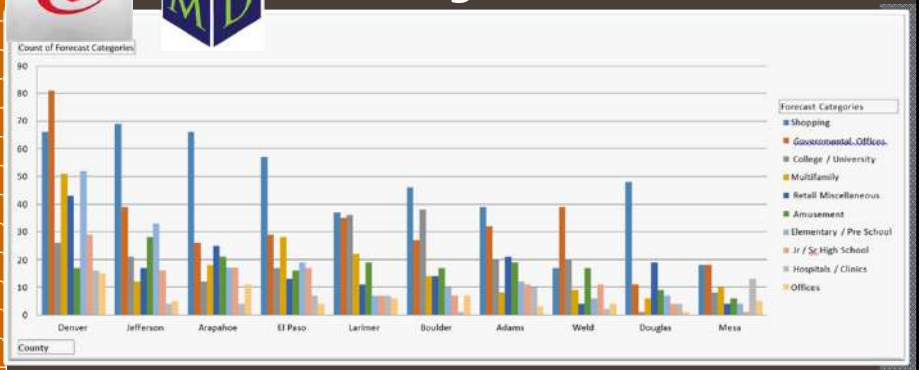
- Performance based compliance to ASHRAE 90.1
- Xcel's EDA Program

Colorado Code Consulting Verifications

- Invitation to participate
- Schedule times to verify each project
- Perform Plan Review
- Perform Inspections

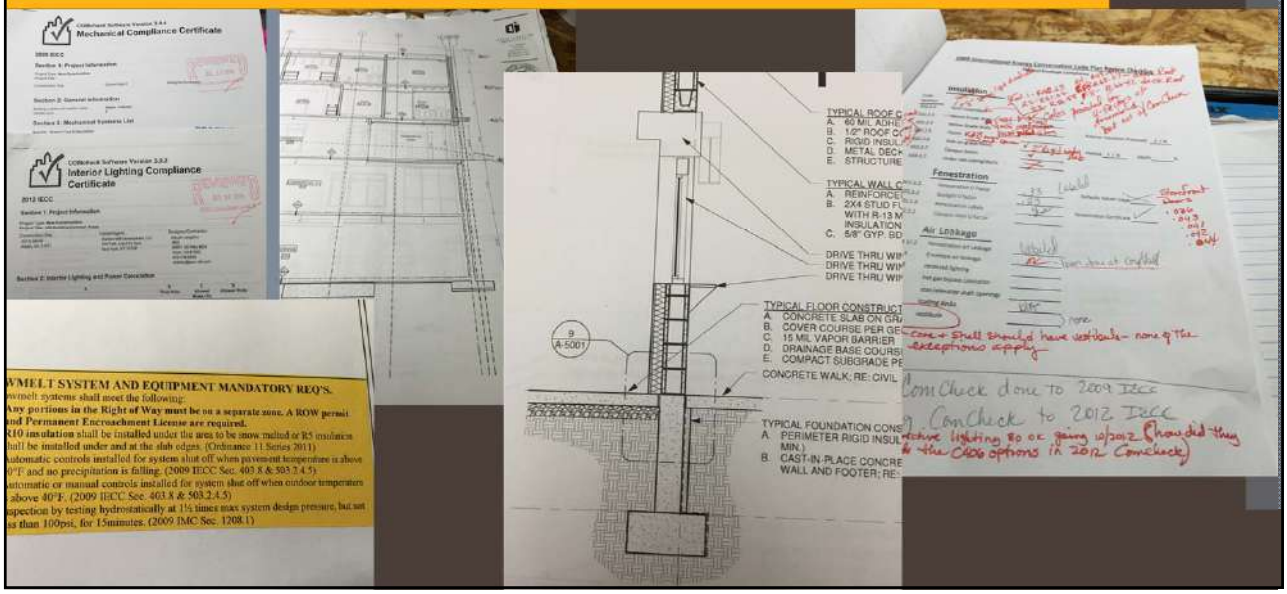
Shopping	1527
Governmental Offices	1307
College / University	821
Elementary / Pre School	748
Amusement	671
Retail Miscellaneous	622
Jr / Sr High School	520
Multifamily	519
Hospitals / Clinics	299
Offices	273
Warehouses	237
Fire and Police Stations	223
Libraries / Museums	177
Military	175
Transportation Terminals	166
Religious	166
Hotels / Motels	149
Medical Misc.	130
Nursing Homes/Assisted Living	91
Courthouse	83
Special / Vocational	68
Industrial Labs / Labs / School Labs	48
Sports Arenas / Convention Centers	37
Manufacturing	30
Grand Total	9087

Selecting the Jurisdictions

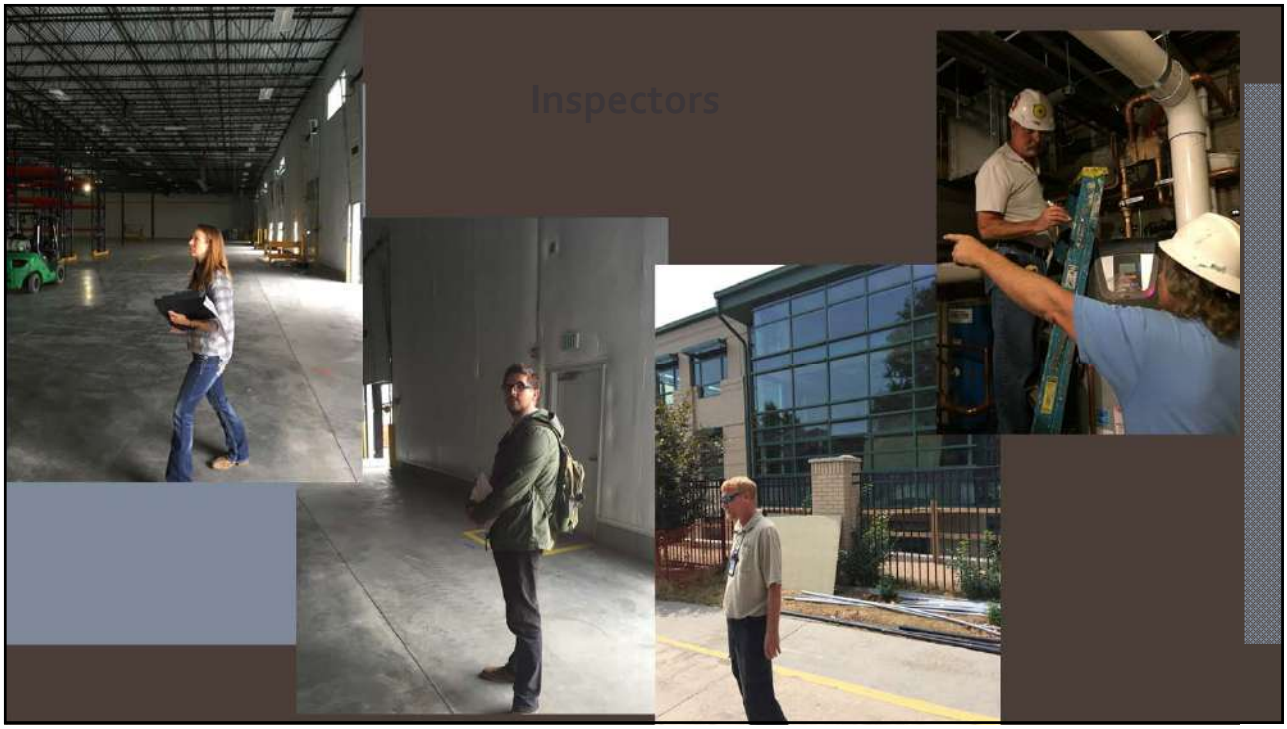


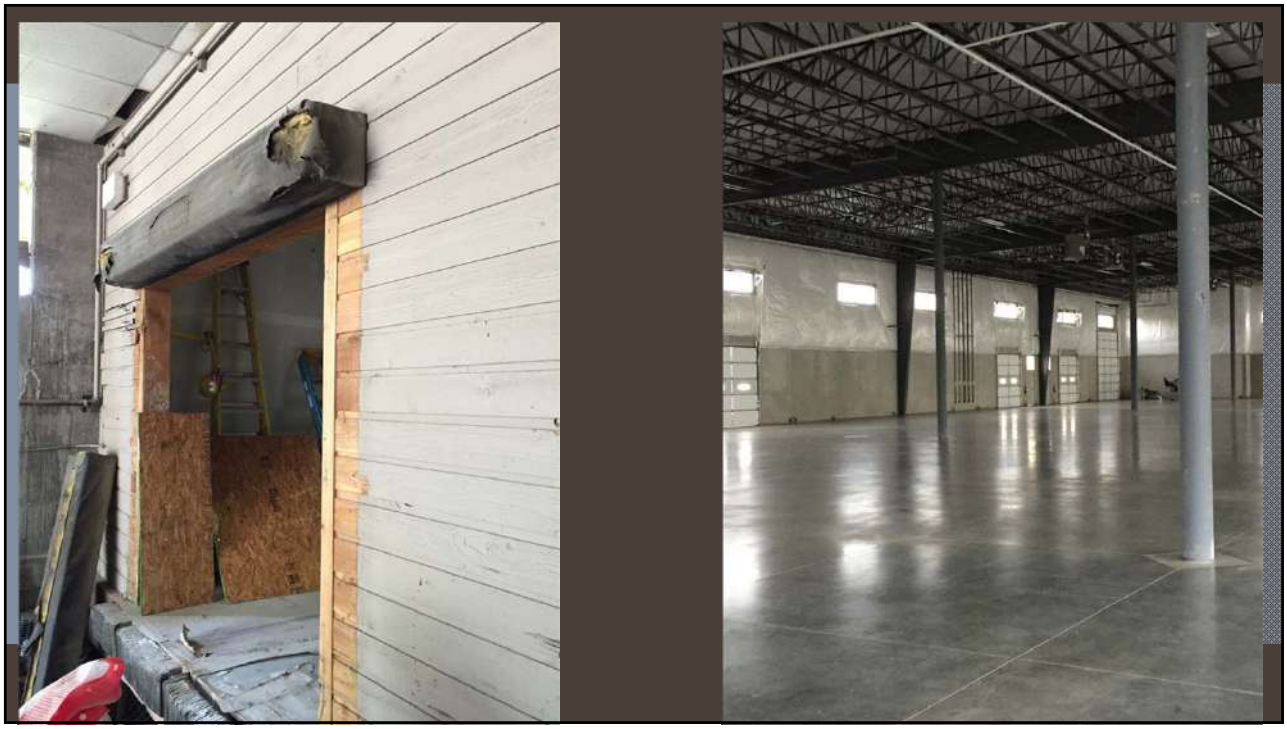
Count of New or Renovation	Column Labels	No. of New to Survey		No. of Renovated to Survey		Total No. to Survey
Row Labels	New	(of 44)	Renovation	(of 44)	Grand Total	(of 44)
Denver	5.38%	2.4	14.54%	6.4	19.92%	8.8
El Paso	3.78%	1.7	8.45%	3.7	12.22%	5.4
Arapahoe	3.95%	1.7	7.58%	3.3	11.53%	5.1
Jefferson	2.59%	1.1	8.22%	3.6	10.81%	4.8
Larimer	3.17%	1.4	7.12%	3.1	10.29%	4.5
Boulder	2.29%	1.0	7.72%	3.4	10.02%	4.4
Adams	2.83%	1.2	5.40%	2.4	8.23%	3.6
Mesa	1.71%	0.8	4.03%	1.8	5.74%	2.5
Weld	1.78%	0.8	3.90%	1.7	5.69%	2.5
Douglas	2.09%	0.9	3.45%	1.5	5.55%	2.4
Grand Total	**29.57%**	**13.0**	**70.43%**	**31.0**	**100.00%**	**44.0**

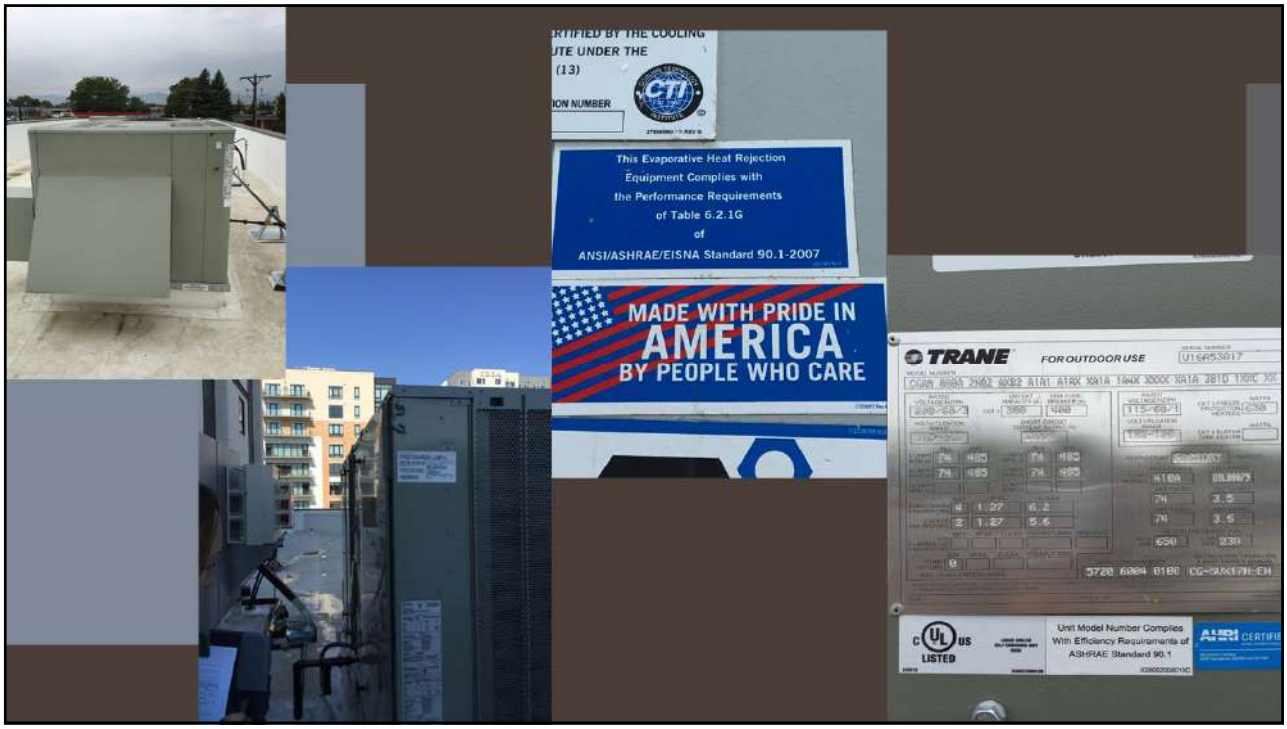
Plan Review



Inspections to the new checklist







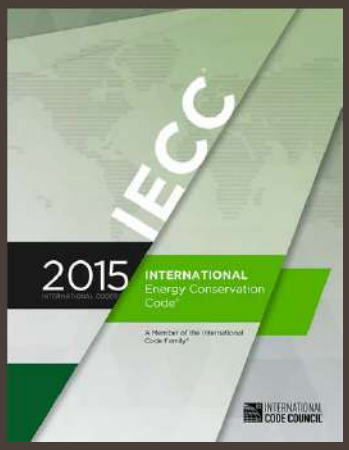
Road Blocks

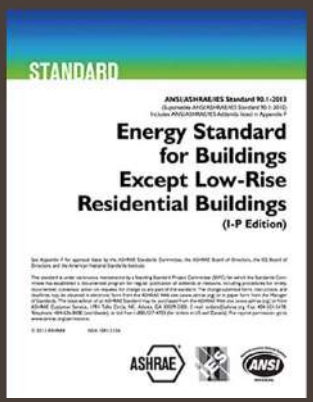
- Scheduling
- Code interpretations
- Phases of construction
- Design vs real life
- Multi-family (commercial vs residential)
- Plan review styles and requirements
- Time on the job site
- Oops, not ready yet
- Entering data into the methodology spreadsheets

What do we do with the data?

- Determine energy saved due to code compliance
- Determine energy left on the table for non or partial compliance
- Determine education needs for designers, contractors and code officials
- Determine needs for future code proposals
- Give the code's end-user a simplified approach to code compliance that focuses on the biggest impacts
- Give tools for the job in the form of checklists, education, resources
- Have a replicable program that we can compare future buildings to for years to come

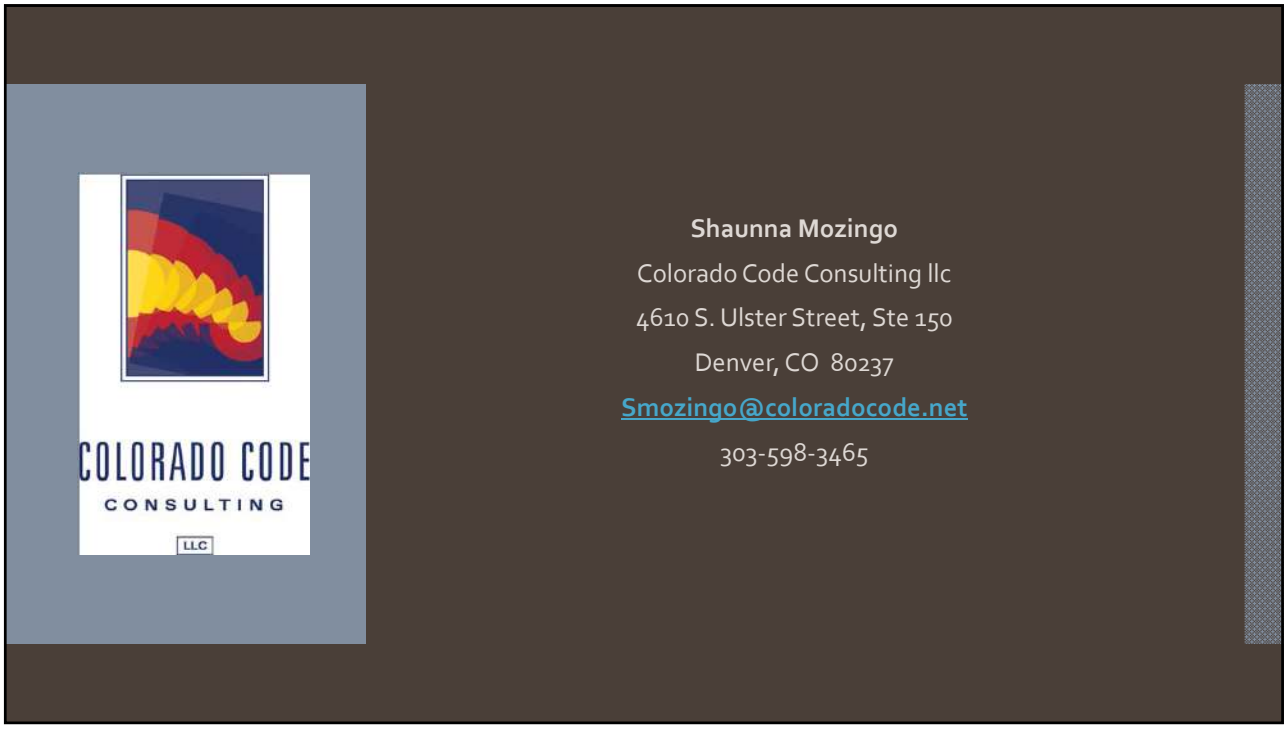
What about the rest of the code?





A foot in the door to full code compliance

This approach: One small step for man…



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