Thank you for attending Denver Community Planning and Development’s IECC training session. Below is contact information for the presenter should you have any questions. Thank you!

Shaunna Mozingo: sdmozingo@shaunnamozingo.com
Roger Hedrick: rhedrick@noresco.com | 303-459-7481
Other sections of the code to consider besides C405

- Administrative Provisions of Chapter 1
- Definitions – Chapter 2
- Envelope Provisions of C402
- Mechanical Provisions in C403
- Additional Efficiency Packages options of C406
- Commissioning in C408
- Appendix CA
C103.2: Must include air barrier and air sealing details on plans, including the location of the air barrier!

Chapter 1 – Administrative Provisions

• The new C103.6: Documentation
• Information to be provided to owner within 90 days of C.O.
• C103.6.1: record documents
• C103.6.2: compliance documents
• C103.6.3 Systems Operation Control!!!
• Many definitions to consider for Electric Power and lighting systems

• New:
  • Captive Key Override
  • Luminaire Light Level Controls
  • Electric Vehicle (EV)
  • Electric Vehicle Supply Equipment (EVSE)
  • Electric Vehicle Fast Charger
  • Electric Vehicle Load Management System
  • Electric Vehicle Capable Space
  • Electric Vehicle Ready Space
  • Electric Vehicle Supply Equipment (EVSE) Installed Space
Chapter 4: Commercial Energy Efficiency
Section C401.2 Application is replaced as follows:

C401.2 Application. Commercial building shall comply with the requirements of Appendix CA and one of the following:
Appendix CA Solar-ready zone—commercial is adopted with the following amendments:

APPENDIX CA
SOLAR-READY ZONE—COMMERCIAL

SECTION CA103
SOLAR-READY ZONE

Section CA103.6 Interconnection pathway is added as follows:

CA103.6 Interconnection pathway. The building shall be provided with conduit or piping from the solar-ready zone to the electrical service panel or service hot water system.

Section CA103.7 Electrical service reserved space is added as follows:

CA103.7 Electrical service reserved space. The main electrical service panel shall have a reserved space to allow for installation of a two-pole/three-pole circuit breaker or disconnect switch for future solar electric and a two-pole/three-pole circuit breaker or disconnect switch for future electrical energy storage system installation. These spaces shall be labeled “For Future Solar Electric.” and “For Future Energy Storage” respectively. The reserved spaces shall be positioned at the end of the panel that is opposite from the panel supply conductor connection.
Appendix CA and the following...

1. The requirements of compliance options a or c of Section 4.2.1.1 of ANSI/ASHRAE/IESNA 90.1 and sections C402.5 and C408, of the *International Energy Conservation Code*:
New buildings shall comply with either the provisions of

a. Section 5, “Building Envelope”; Section 6, “Heating, Ventilating, and Air Conditioning”; Section 7, “Service Water Heating”; Section 8, “Power”; Section 9, “Lighting”; and Section 10, “Other Equipment,” or

b. Section 11, “Purchased Energy Budget Method,” or

c. Appendix G, “Performance Rating Method.”
To use Option a, Must comply with 2 of the 3 following requirements:

- Envelope performance factor is ≤ 90% of the envelope performance factor of the base design
- Interior lighting power allowance is ≤ 75% of the lighting power allowance of the base design
- HVAC minimum efficiency requirement of proposed design is ≤ 90% of the HVAC minimum efficiency requirements of the base design.
ASHRAE 90.1, Section 4.2.1.1 Option c

For buildings complying with Appendix G of 90.1:

- Use method C401.2.c.1 or C401.2.c.2
- Replace 90.1 Section G1.2.1 Mandatory Provisions, with Section C401.2.c.3
- Include site energy, in kbtu/sf/yr, of the proposed design and baseline building design in the compliance documentation:

Appendix CA and the following...

2. The requirements of Sections C402 through C405 and C408. In addition, commercial buildings shall comply with Section C406 and tenant spaces shall comply with Section C406.1.1.
IECC Additional Efficiency Package Options
Section C406

• One additional efficiency feature must be selected to comply with the IECC

Enhanced lighting controls

Dedicated Outdoor Air System

More Efficient Lighting System

High Efficiency HVAC

Onsite Renewables

Solar Thermal/More Efficient SWH

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Appendix CA and the following...

3. The requirements of Sections C402.5, C403.2, C403.3 through C403.3.2, C403.4 through C403.4.2.3, C403.5.5, C403.7, C403.8.1 through C403.8.4, C403.10.1 through C403.10.3, C403.11, C403.12, C404, C405, C407 and C408. The building energy cost or site EUI shall be equal to or less than 76 percent of the standard reference design building.
COMcheck for Denver IECC Compliance Verification
Chapter 4: Building Thermal Envelope Requirements affecting lighting
Vertical Fenestration Requirement
Section C402.4.1 – Prescriptive (Max area)

Percentage of Vertical Fenestration Area to Gross Wall Area

- Allowed up to 30% maximum of above grade wall
- In Climate Zones 1-6, up to 40% maximum of above grade wall with daylighting controls
Skylight Fenestration Area
Section C402.4.1 and C402.4.1.2 Prescriptive

✓ Limited to ≤ 3% of Roof Area
✓ Up to 6% allowed if automatic daylighting controls installed in daylight zones under skylights Toplit daylight zones.
Minimum Skylight Fenestration Area
Section C402.4.2

• In certain types of enclosed spaces > 2,500 ft² in floor area directly under a roof with > 75% of ceiling area with ceiling height > 15 ft.
  • total daylight zone under skylights to not be < ½ the floor area and provide one of the following
    • Minimum of 3% of skylight area to daylight zone where all skylights have a VLT at least 0.40 OR
    • Provide a minimum skylight effective aperture of at least 1%

• Exceptions:
• Climate Zones 6-8
• Spaces with LPDs < 0.5 W/ft²
• Documented shaded spaces
• Daylight area under rooftop monitors is > 50% of floor area
• Spaces where total area minus area of daylight zones adjacent to vertical fenestration is < 2,500 ft² and lighting is controlled per C405.2.5 (Exterior Lighting Controls)
Lighting requirements coming from the C403 Mechanical Systems Sections
Walk-in Coolers, Freezers, Refrigerated Warehouse Coolers/Freezers (not site assembled or constructed)
Section C403.10.1 - Mandatory

• Shall comply with ALL of the following 1-11...
• #11: Lights in walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall either use light sources with an efficacy of not less than 40 lumens per watt, including ballast losses, or shall use light sources with an efficacy of not less than 40 lumens per watt, including ballast losses, in conjunction with a device that turns off the lights within 15 minutes when the space is not occupied.
Walk-in Coolers and Walk-in Freezers
Section C403.10.2 – Mandatory
(site assembled or constructed)

- Light sources shall have an efficacy of not less than 40 lumens per watt, including any ballast losses, or shall be provided with a device that automatically turns off the lights within 15 minutes of when the walk-in cooler or walk-in freezer was last occupied.
Site-assembled or site-constructed refrigerated display cases shall comply with the following:

• Lighting and glass doors controlled by one of the following:
  • Time switch controls to turn off lights during nonbusiness hours. Timed overrides for display case shall turn the lights on for up to 1 hour and automatically time out to turn the lights off
  • Motion sensor controls on each display case section that reduce lighting power by at least 50% within 3 minutes after the area within the sensor range is vacated
IECC Additional Efficiency Package Options
Section C406

- **TWO** or more additional efficiency features **must be selected**

Enhanced lighting controls

Dedicated Outdoor Air System

- **10% more efficient**

High Efficiency HVAC

- **30% more efficient**

More Efficient Lighting System

Solar Thermal/More Efficient SWH

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- **Total UA x 115%**

Onsite Renewables

Reduced air infiltration
C406.1.1 Tenant Spaces

Tenant spaces where the area of work is 10,000 sq ft or more shall comply with one:

- C406.2 More efficient HVAC equipment performance
- C406.3 Reduced lighting power (as amended)
- C406.4 Enhanced digital lighting controls
- C406.6 Dedicated outdoor air system
- C406.7 Reduced energy use in service water heating

Alternatively, tenant spaces shall comply with C406.5 (on-site renewables) where the entire building complies.
C408 Maintenance Information and System Commissioning

Required for mechanical, Service Water Heating and Lighting controls per C401.2

C408.3 FUNCTIONAL TESTING OF LIGHTING CONTROLS

Procedures for testing:
- Occupancy sensors
- Time switch controls
- Daylight responsive controls

- Exception:
  - New lighting systems are exempt from functional testing requirements in buildings where installed lighting load is less than 20KWW and the area of work is less than 10,000 sq ft.
<table>
<thead>
<tr>
<th>Project Information</th>
<th>Project Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Project Address:</td>
</tr>
<tr>
<td></td>
<td>Registered design professional or approved agency who completed commissioning:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Commissioning Plan (Section C408.2.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commissioning Plan was used during construction and includes all items required by Section C408.2.1: (owner or owner representative to initial here)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Systems Adjusting and Balancing (Section C408.2.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems Adjusting and Balancing has been completed</td>
</tr>
<tr>
<td>• Air and water flow rates have been measured and adjusted to deliver final flow rates within the tolerances provided in the produce specifications.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Functional Testing (Sections C408.2.3 and C408.3.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC Equipment Functional Testing has been executed. If applicable, deferred and/or follow-up testing is scheduled to be provided on:</td>
</tr>
<tr>
<td>HVAC Controls Functional Testing has been executed. If applicable, deferred and/or follow-up testing is scheduled to be provided on:</td>
</tr>
<tr>
<td>Economizers Functional Testing has been executed. If applicable, deferred and/or follow-up testing is scheduled to be provided on:</td>
</tr>
<tr>
<td>Lighting Controls Functional Testing has been executed. If applicable, deferred and/or follow-up testing is scheduled to be provided on:</td>
</tr>
<tr>
<td>Service Water Heating System Functional Testing has been executed. If applicable, deferred and/or follow-up testing is scheduled to be provided on:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supporting Documents (Sections C408.1.3.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manuals, record documents and training have been completed or are scheduled</td>
</tr>
<tr>
<td>• System documentation has been provided to the owner or scheduled to be delivered to the owner on:</td>
</tr>
<tr>
<td>• Record documents have been submitted to owner or scheduled to be delivered to the owner on:</td>
</tr>
<tr>
<td>• Training has been completed or scheduled to be completed on:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preliminary Commissioning Report (Section C408.2.4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary Commissioning Report submitted to Owner and includes all items required by Section C408.2.4 as amended: (owner or owner representative to initial here)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>I hereby certify that the commissioning provider has provided me with evidence of mechanical, service water heating and lighting systems commissioning in accordance with the 2018 IECC as amended.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signature of Building Owner or Owner’s Representative</th>
<th>Date</th>
</tr>
</thead>
</table>

**FIGURE 408.2.4**

**COMMISSIONING COMPLIANCE CHECKLIST**
Power and Lighting Systems

That affect the envelope design
Lighting Commercial Provisions
Section C405.1, C405.2

C405.1.1
No less than 90% of the permanently installed luminaires provided with lamps or light sources in dwelling units and sleeping units shall be provided by lamps with an efficacy of not less than 65 lm/W.
Lighting Controls

Section C405.2 - Mandatory

- Lighting systems required to be provided with controls as specified for:
  - Occupant sensor controls – C405.2.1
  - Time-switch controls – C405.2.2
  - Daylight-responsive controls – C405.2.3
  - Specific application controls – C405.2.4
  - Manual Controls – C405.2.5
  - Exterior lighting controls – C405.2.6
  - Parking Garage Lighting Control – C405.2.7
  - Lighting for Plant Growth and Maintenance C405.3.3

- Exemptions:
  - Security or emergency areas that must be continuously lighted
  - Interior exit stairways, interior exit ramps and exit passageways

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C405.2

- Adds a definition for Luminaire Light Level Controls
- Adds the option to use luminaire light level controls in lieu of some of the other mandatory controls such as occupancy sensors and time switches.
C405.2.1.1 and C405.2.1.3

- Revises the list of spaces that require occupant sensor control to add open plan office areas to the requirement. The controls will switch off small groups of workstations while maintaining a minimum background illumination in the overall area.

C405.2.1.1

- Reduces the amount of time for occupant sensor shut-off from 30 minutes to 20 minutes.
Specific Application Controls
Section C405.2.4

• **These types to be controlled by dedicated, independent control**
  • Display and accent lighting
  • Display case lighting
  • Nonvisual applications, plant growth and food warming
  • Equipment for sale or educational demonstrations

• **Hotel and motel sleeping units and guest suites**
  • *Master control device capable of automatically switching off all installed luminaires and switched receptacles within 20 minutes of occupants leaving the room*
  • **Exceptions:** lighting and switch receptacles controlled by *card key controls*
Must provide controls that shut lights off when daylight is present

Or

Reduce lighting by at least 30% from
  - Midnight to 6am
  - 1 hour after C.O.B. to 1 hour before business opening
  - 15 minutes of non-activity

OR

Exterior time-switch control

Exception: Lighting for covered vehicle entrances and exits from buildings where required for eye adaptation.
C405.2.7 Parking Garage Lighting Control

- **Not required when total interior lighting power density is less than** .08 watts/sq ft.
  - Must have Automatic time-switch shutoff
  - Lighting power of each luminaire reduced by at least 60% when no activity detected within a lighting zone for 20 minutes
  - Lighting zones no greater than 3600 sq ft
  - Separately control lighting for eye adaptation at entrances and exits. Control must reduce lighting by 50% from sunset to sunrise
  - Reduce power to luminaires within 20 ft of perimeter wall openings or fenestration by 50% in response to daylight.
    - Exceptions exist for low fenestration to wall ratios, size of openings or penetrations, and obstructions restricting daylight entrance.
Two methods to determine allowance:

- **Building Area Method**
  - Floor area for each building area type \( \times \) value for the area
  - “area” defined as all contiguous spaces that accommodate or are associated with a single building area type as per the table
  - When used for an entire building, each building area type to be treated as a separate area

- **Space-by-Space Method**
  - Floor area of each space \( \times \) value for the area
  - Then sum the allowances for all the spaces
  - Tradeoffs among spaces are allowed
• Building Area
• Method

**Table C405.3.2(1)**

<table>
<thead>
<tr>
<th>Building Area Type</th>
<th>LPD (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive facility</td>
<td>0.74</td>
</tr>
<tr>
<td>Convention center</td>
<td>0.74</td>
</tr>
<tr>
<td>Courthouse</td>
<td>0.80</td>
</tr>
<tr>
<td>Dining: bar/lounge/leisure</td>
<td>0.69</td>
</tr>
<tr>
<td>Dining: cafeteria/fast-food</td>
<td>0.79</td>
</tr>
<tr>
<td>Dining: family</td>
<td>0.78</td>
</tr>
<tr>
<td>Dormitory**</td>
<td>0.61</td>
</tr>
<tr>
<td>Exercise center</td>
<td>0.65</td>
</tr>
<tr>
<td>Fire station*</td>
<td>0.55</td>
</tr>
<tr>
<td>Gymnasium</td>
<td>0.66</td>
</tr>
<tr>
<td>Health care clinic</td>
<td>0.82</td>
</tr>
<tr>
<td>Hospital</td>
<td>1.00</td>
</tr>
<tr>
<td>Hotel/Motel*</td>
<td>0.72</td>
</tr>
<tr>
<td>Library</td>
<td>0.78</td>
</tr>
<tr>
<td>Manufacturing facility</td>
<td>0.99</td>
</tr>
<tr>
<td>Motion picture theater</td>
<td>0.80</td>
</tr>
<tr>
<td>Multiple family*</td>
<td>0.61</td>
</tr>
<tr>
<td>Museum</td>
<td>1.06</td>
</tr>
<tr>
<td>Office</td>
<td>0.79</td>
</tr>
<tr>
<td>Parking garage</td>
<td>0.15</td>
</tr>
<tr>
<td>Restaurant*</td>
<td>0.73</td>
</tr>
<tr>
<td>Performing arts theater</td>
<td>1.13</td>
</tr>
<tr>
<td>Police station</td>
<td>0.80</td>
</tr>
<tr>
<td>Post office</td>
<td>0.06</td>
</tr>
<tr>
<td>Religious building</td>
<td>0.94</td>
</tr>
<tr>
<td>Retail</td>
<td>1.06</td>
</tr>
<tr>
<td>School/university</td>
<td>0.80</td>
</tr>
<tr>
<td>Sports arena</td>
<td>0.67</td>
</tr>
<tr>
<td>Town hall</td>
<td>0.80</td>
</tr>
<tr>
<td>Transportation</td>
<td>0.61</td>
</tr>
<tr>
<td>Wardroom</td>
<td>0.61</td>
</tr>
<tr>
<td>Workshop</td>
<td>0.00</td>
</tr>
</tbody>
</table>

*Where sleeping units are excluded from lighting power calculations by application of Section R405.1, neither the area of the sleeping units nor the average of lighting in the sleeping units is counted.

**a** Where sleeping units are excluded from lighting power calculations by application of Section R405.1, neither the area of the sleeping units nor the average of lighting in the sleeping units is counted.

**b** Where sleeping units are excluded from lighting power calculations by application of Section R405.1, neither the area of the sleeping units nor the average of lighting in the sleeping units is counted.

**c** Dwelling units are excluded. Neither the area of the dwelling units nor the average of lighting in the dwelling units is counted.
**Space-By-Space Method**

Table C405.3.2(2)
C405.3.3 Lighting for plant growth and maintenance
Lighting for plant growth and Maintenance

- Non-LED lighting using replaceable lamps must have electronic ballasts
- All luminaires shall be listed by OSHA Nationally Recognized Testing Labs (NRTL) OR field certified by on OSHA NRTL to appropriate standard
- At least 80% of total Watts of lighting for the areas used for plant growth and maintenance (canopies) must have lighting with photosynthetic photon efficacy of at least 1.6Umol/J (luminaires), or 1.9Umol/J (lamps).
Indoor agriculture facilities = 3 options

1. LED luminaires listed in the Design Lights Consortium’s Horticultural Qualified Products List (QPL) comply.

2. High efficient double-ended high-pressure sodium (HPS) lamps used with any reflector/ballast combination complies.
   - 3rd party verification required
   - Efficacy must be generated by facility accredited to ANSI/IES LM-51.

3. Other lamps and luminaires not previously mentioned must have 3rd party verification showing lamps or luminaires photosynthetic photon efficacy generated by an ANSI/ASABE S642, ANSI/IES LM-79 or ANSI/IES LM-51 accredited facility.
The total exterior connected lighting power shall be the total maximum rated wattage of all lighting that is powered through the energy service for the building.

15 EXCEPTIONS!!!

1. Pick an exterior lighting zone from Table C405.4.2(1)

2. Add base allowance from Table C405.4.2(2) + individual allowances for areas to be illuminated from Tables C405.4.2 (2) and (3)

Not called “Tradeable” or “Non-Tradeable” anymore.

3. Add it all up and stay under the allowed watts

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## Exterior Lighting Zones
*Section C405.4.2(1)*

Power allowances are listed by lighting zone

<table>
<thead>
<tr>
<th>Lighting Zone</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Developed areas of national parks, state parks, forest land, and rural areas</td>
</tr>
<tr>
<td>2</td>
<td>Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas</td>
</tr>
<tr>
<td>3</td>
<td>All other areas no classified as lighting zone 1, 2 or 4</td>
</tr>
<tr>
<td>4</td>
<td>High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority</td>
</tr>
</tbody>
</table>
What areas are covered under exterior lighting allowances?

✔ Tradable surfaces **Exterior lighting power allowance**

Common exterior lighted needs that can be traded for other needs

- For example, wattage allowed for parking lot lighting can be “traded” and used for canopy lighting

✔ Nontradable surfaces **Additional exterior lighting power**

Less common exterior lighted needs that **cannot** be traded for other needs

- These applications have more specific security or task illuminance needs
## Exterior Lighting Zones

### Section C405.4.2(2)

Allowances include a base allowance plus tradeable allowance.

<table>
<thead>
<tr>
<th>TABLE C405.4.2(2) LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lighting Zones</strong></td>
</tr>
<tr>
<td>Zone 1</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td><strong>Base Site Allowance</strong></td>
</tr>
<tr>
<td><strong>Uncovered Parking Areas</strong></td>
</tr>
<tr>
<td>Parking areas and drives</td>
</tr>
<tr>
<td><strong>Building Grounds</strong></td>
</tr>
<tr>
<td>Walkways and ramps less than 10 feet wide</td>
</tr>
<tr>
<td>Walkways and ramps 10 feet wide or greater, plaza areas, special feature areas</td>
</tr>
<tr>
<td><strong>Dining areas</strong></td>
</tr>
<tr>
<td><strong>Stairways</strong></td>
</tr>
<tr>
<td><strong>Pedestrian tunnels</strong></td>
</tr>
<tr>
<td><strong>Landscaping</strong></td>
</tr>
<tr>
<td><strong>Building Entrances and Exits</strong></td>
</tr>
<tr>
<td>Pedestrian and vehicular entrances and exits</td>
</tr>
<tr>
<td>Entry canopies</td>
</tr>
<tr>
<td>Loading docks</td>
</tr>
<tr>
<td><strong>Sales Canopies</strong></td>
</tr>
<tr>
<td>Free-standing and attached</td>
</tr>
<tr>
<td><strong>Outdoor Sales</strong></td>
</tr>
<tr>
<td>Open areas (including vehicle sales lots)</td>
</tr>
<tr>
<td>Street frontage for vehicle sales lots in addition to “open area” allowance</td>
</tr>
</tbody>
</table>

*For SI: 1 ft² = 929.06 mm², 1 watt per square foot = W/0.0929 m², W = watts.*

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# Exterior Lighting Zones

*Section C405.4.2(2)*

<table>
<thead>
<tr>
<th>Lighting Zone 8</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building facades</td>
<td>No allowance</td>
<td>0.075 W/ft² of gross above-grade wall area</td>
<td>0.113 W/ft² of gross above-grade wall area</td>
<td>0.15 W/ft² of gross above-grade wall area</td>
</tr>
<tr>
<td>Automated teller machines (ATM) and night depositories</td>
<td></td>
<td></td>
<td></td>
<td>135 W per location plus 45 W per additional ATM per location</td>
</tr>
<tr>
<td>Uncovered entrances and gatehouse inspection stations at guarded facilities</td>
<td></td>
<td></td>
<td></td>
<td>0.5 W/ft² of area</td>
</tr>
<tr>
<td>Uncovered loading areas for law enforcement, fire, ambulance and other emergency service vehicles</td>
<td></td>
<td></td>
<td></td>
<td>0.35 W/ft² of area</td>
</tr>
<tr>
<td>Drive-up windows and doors</td>
<td></td>
<td></td>
<td></td>
<td>200 W per drive through</td>
</tr>
<tr>
<td>Parking near 24-hour retail entrances</td>
<td></td>
<td></td>
<td></td>
<td>400 W per main entry</td>
</tr>
</tbody>
</table>

For SI: 1 watt per square foot = W/0.0929 m².  
W = watts.

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• Building shall be provided with EV charging in accordance with this section and NEC.
• If no increase in building size or a level 3 alteration, only new parking spaces are subject to the requirement.
C405.10. Electric Vehicle (EV) charging for new construction and Level 3 Alterations.

C405.10.1. Group R occupancies

• Group-R occupancies with three or more dwelling units and/or sleeping units shall be provided with electric vehicle charging in accordance with Table C405.10.1. Calculations for the number of spaces shall be rounded up to the nearest whole number.

• All EVSE installed, EV ready and EV capable spaces are to be included in calculation for number of minimum vehicle spaces required

• AS provided by the applicable article of the Denver Zoning Code.
C405.10. Electric Vehicle (EV) charging for new construction and Level 3 Alterations.

C405.10.2. Group A,B,E,I, M and S-2 Occupancies (including parking garages under S-2 Occupancies)

- Provided with electric vehicle charging in accordance with Table C405.10.2
- Calculations for number of spaces shall be rounded up to nearest whole number
- All EVSE installed, EV ready and EV capable spaces are to bin included in calculation for number of minimum spaces required
- As provided by applicable article of Denver Zoning Code

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C405.10.3 Identification

• Circuit breakers or circuit breaker spaces reserved for the EV capable spaces, EV ready spaces, and EVSE installed spaces shall be clearly identified in panelboard directory

• Conduit for EV capable spaces shall be clearly identified at both panelboard and termination point at parking space

Exception:
• Alterations to one- and two-family dwellings
C405.10.4 Accessible parking

Where new EVSE installed spaces and/or new EV ready spaces and new accessible parking are both provided, parking facilities shall be designed so that at least one accessible parking space is EV ready or EVSE installed.
<table>
<thead>
<tr>
<th>NUMBER OF EV READY SPACES</th>
<th>NUMBER OF EV CAPABLE SPACES</th>
<th>NUMBER OF EVSE INSTALLED SPACES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Space</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>2 to 9 spaces</td>
<td>1</td>
<td>20% of spaces</td>
</tr>
<tr>
<td>10 or more spaces</td>
<td>15% of spaces</td>
<td>Remainder of spaces</td>
</tr>
</tbody>
</table>

© 2020 Mozingo Code Group LLC
### EV SPACES IN GROUP A, B, E, I, M and S-2 OCCUPANCIES

<table>
<thead>
<tr>
<th></th>
<th>NUMBER OF EV READY SPACES</th>
<th>NUMBER OF EV CAPABLE SPACES</th>
<th>NUMBER OF EVSE INSTALLED SPACES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Space</td>
<td>1</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>2 to 9 spaces</td>
<td>1</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>10 or more spaces</td>
<td>10% of spaces</td>
<td>10% of spaces</td>
<td>5% of spaces</td>
</tr>
</tbody>
</table>
C405.9 Voltage drop in feeders and branch circuits

- The total voltage drop across the combination of feeders and branch circuits shall not exceed 5 percent.
THANK YOU!!!

By His Grace, In His Honor, For His Glory!

Presented by:

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President
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THIS TRAINING IS PROVIDED BY THE COLORADO ENERGY OFFICE WITH TRAINING MATERIALS CREATED BY NORESCO.
Roger Hedrick
BEMP, LEED AP
Principal Engineer, Codes and Standards, Sustainability Services

- Author of the User’s Manual for ASHRAE 90.1-2016 and 2019
- Author of the User’s Manual for ASHRAE 62.1-2013, 2016, and 2019
- 40 years of experience in energy modeling
AGENDA

• Mandatory Requirements

• IECC Performance Path
  – Proposed Model
  – Baseline Model

• 90.1 Performance Path
  – Proposed Model
  – Baseline Model
The Energy Code requires compliance with:
- Mandatory Provisions and
- Prescriptive Requirements

Or
- Mandatory Provisions and
- Performance Path

The Performance Path can be either:
- IECC C407, or
- ASHRAE Standard 90.1 Performance Rating Method (Appendix G)

Mandatory Provisions are IECC or 90.1, respectively

IECC and 90.1 requirements are modified by Denver amendments
MANDATORY PROVISIONS – IECC

Building Envelope
   C402.5 – Air Leakage - Thermal Envelope
   Building Mechanical Systems
   C403.2 – System design
   C403.3 – Heating and cooling equipment efficiencies
   C403.3.1 – Equipment sizing
   C403.3.2 – Equipment performance requirements
   C403.3.2.1 – Water cooled centrifugal chilling packages
   C403.3.2.2 – Positive displacement (air- and water-cooled) chilling packages
   C403.4 – Heating and cooling system controls
   C403.4.1 – Thermostatic controls
   C403.4.1.1 – Heat pump supplementary heat
   C403.4.1.2 – Deadband
   C403.4.1.3 – Setpoint overlap restriction
   C403.4.1.4 – Heated or cooled vestibules
   C403.4.1.5 – Hot water boiler outdoor temperature setback control
   C403.4.2 – Off-hours controls
   C403.4.2.1 – Thermostatic setback
   C403.4.2.2 – Automatic setback and shutdown
   C403.4.2.3 – Automatic Start
   C403.5.5 – Economizer fault detection and diagnostics
   C403.7 – Ventilation and exhaust systems
   C403.7.1 – Demand control ventilation
   C403.7.2 – Enclosed parking garage ventilation controls
   C403.7.3 – Ventilation air heating control
   C403.7.4 – Energy recovery ventilation systems
   C403.7.5 – Kitchen exhaust systems
   C403.7.6 – Automatic control of HVAC systems serving guestrooms
   C403.7.6.1 – Temperature setpoint controls
   C403.7.6.2 – Ventilation controls
   C403.8.1 – Allowable fan horsepower
   C403.8.2 – Motor nameplate horsepower
   C403.8.3 – Fan efficiency
   C403.8.4 – Fractional hPfan motors
   C403.10.1 – Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers
   C403.10.2 – Walk-in coolers and walk-in freezers
   C403.10.2.1 – Performance standards

   C403.10.3 – Refrigerated display cases
   C403.11 – Construction of HVAC system elements
   C403.11.1 – Duct and plenum insulation and sealing
   C403.11.2 – Duct construction
   C403.11.2.1 – Low-pressure duct systems
   C403.11.2.2 – Medium-pressure duct systems
   C403.11.2.3 – High-pressure duct systems
   C403.11.3 – Piping, insulation
   C403.11.3.1 – Protection of piping insulation
   C403.11.3.2 – Mechanical systems located outside of the building thermal envelope
   C403.11.3.1 – Heating outside a building
   C403.11.3.2 – Snow- and ice-melt system controls
   C403.11.3.3 – Freeze protection system controls

Service Water Heating
   C404 – Service Water Heating
   C404.1 – General
   C404.2 – Service water-heating equipment performance
   C404.2.1 – High input service water-heating systems
   C404.3 – Heat traps for hot water storage tanks
   C404.4 – Insulation of piping
   C404.5 – Heated water supply piping
   C404.5.1 – Maximum allowable pipe length method
   C404.5.2 – Maximum allowable pipe volume method
   C404.5.2.1 – Water volume determination
   C404.6 – Heated-water circulating and temperature maintenance systems
   C404.6.1 – Circulation systems
   C404.6.2 – Heat trace systems
   C404.6.3 – Controls for hot water storage
   C404.7 – Demand recirculation controls
   C404.8 – Drain water heat recovery units
   C404.9 – Energy consumption of pools and permanent spas
   C404.9.1 – Pools
   C404.9.2 – Time switches
   C404.9.3 – Covers
   C404.10 – Energy consumption of portable spas

Electrical Power and Lighting Systems
   C405 – Electrical Power and Lighting Systems
   C405.1 – General
   C405.2 – Lighting controls
   C405.21 – Occupant sensor controls
   C405.21.1 – Occupant sensor control function
   C405.21.2 – Occupant sensor control function in warehouses
   C405.21.3 – Occupant sensor control function in open plan offices areas
   C405.22 – Time-switch controls
   C405.22.1 – Time-switch control function
   C405.22.2 – Light-reduction controls
   C405.23 – Daylight-responsive control function
   C405.23.1 – Daylight-responsive control function
   C405.23.2 – Sidelit zone
   C405.23.3 – Toplit zone
   C405.24 – Specific application controls
   C405.25 – Manual controls
   C405.26 – Exterior lighting controls
   C405.26.1 – Daylight shutoff
   C405.26.2 – Decorative lighting shutoff
   C405.26.3 – Lighting setback
   C405.26.4 – Exterior time-switch control function
   C405.3 – Interior lighting power requirements
   C405.3.1 – Total connected interior lighting power
   C405.3.2 – Interior lighting power allowance
   C405.3.2.1 – Building area method
   C405.3.2.2 – Space-by-space method
   C405.3.2.2.1 – Additional interior lighting power
   C405.4 – Exterior lighting power requirements
   C405.4.1 – Total connected exterior building exterior lighting power
   C405.4.2 – Exterior lighting power allowance
   C405.4.2.1 – Additional exterior lighting power
   C405.4.3 – Gas lighting
   C405.5 – Dwelling electrical meter
   C405.6 – Electrical transformers
   C405.7 – Electric motors
   C405.8 – Vertical and horizontal transportation systems
   C405.8.1 – Elevator cabs
   C405.8.2 – Escalators and moving walks
   C405.8.2.1 – Regenerative drive
   C405.9 – Voltage drop in feeders and branch circuits
ELECTRICAL AND LIGHTING MANDATORY PROVISIONS
Electrical Power and Lighting Systems
- C405 – Electrical Power and Lighting Systems
  - C405.1 – General
  - C405.2 – Lighting controls
  - C405.21 – Occupant sensor controls
  - C405.211 – Occupant sensor control function
  - C405.212 – Occupant sensor control function in warehouses
  - C405.213 – Occupant sensor control function in open plan office areas
  - C405.22 – Time-switch controls
  - C405.221 – Time-switch control function
  - C405.222 – Light-reduction controls
  - C405.23 – Daylight-responsive controls
  - C405.231 – Daylight-responsive control function
  - C405.232 – Sidelite zones
  - C405.233 – Toplight zones
  - C405.24 – Specific application controls
  - C405.25 – Manual controls
  - C405.26 – Exterior lighting controls
  - C405.26.1 – Daylight switch
  - C405.26.2 – Decorative lighting, switch
  - C405.26.3 – Lighting setback
  - C405.26.4 – Exterior time-switch control function
  - C405.3 – Interior lighting power requirements
  - C405.31 – Total connected interior lighting power
  - C405.32 – Interior lighting power allowance
  - C405.321 – Building area method
  - C405.322 – Space-by-space method
  - C405.322.1 – Additional interior lighting power
  - C405.4 – Exterior lighting power requirements
  - C405.41 – Total connected exterior building exterior lighting power
  - C405.42 – Exterior lighting power allowance
  - C405.421 – Additional exterior lighting power
  - C405.43 – Gas lighting
  - C405.5 – Dwellings, electrical meter
  - C405.6 – Electrical transformers
  - C405.7 – Electric motors
  - C405.8 – Vertical and horizontal transportation systems
  - C405.8.1 – Elevator cars
  - C405.8.2 – Escalators, and moving walks
  - C405.8.21 – Regenerative drive
  - C405.9 – Voltage drop in feeders and branch circuits

You will not be able to check all of these requirements!
Spot Checks!

- From the list of requirements, select a few - randomly or on a rotating basis

- Check for compliance
  - If calculations needed, request documentation
  - Documentation needs to allow inputs to be traced back to the design documents

- If the checks show compliance, you’re done

- If not, add a correction comment and send the plans back
  - Pay extra attention next time
VOLTAGE DROP LIMIT

- C405.9 – Voltage drop in feeders and branch circuits
  8.4.1 – Voltage Drop

- 5% Voltage drop limit is a new mandatory requirement in both the IECC and 90.1

- Checking will require documentation of calculations
  - Circuit type (single-phase or three-phase)
  - Number and gauge of conductors per phase
  - Conduit types (magnetic or nonmagnetic)
  - Power factor of the load
  - Circuit length
  - Load current

- Standard 90.1 User’s Manual has example calculations and tables of factors. Tables came from the *National Electrical Code Handbook* from NFPA.
PERFORMANCE APPROACH - ELECTRICAL AND LIGHTING
PERFORMANCE PATH – OVERVIEW

- Energy Simulation Model Based

- Proposed Design Model
  - Generally based on actual design
  - Code allows for some simplification
  - Code does apply a few rules

- Baseline Model
  - Same geometry and zoning as proposed
  - Glazing area may change
  - Opaque envelope specified by code
  - HVAC system specified by code
  - Lighting power specified by code
  - HVAC and lighting controls specified by code
PERFORMANCE PATH – OVERVIEW (CONT’D)

- IECC and 90.1 specify the baseline model very differently
  - 90.1 baseline nominally based on 90.1-2004
  - IECC baseline uses prescriptive requirements

- Compliance shown when Proposed consumption is less than 85% of the baseline target

- Consumption can be either Energy Cost or Source Energy

- The baseline target is directly from the baseline model in IECC

- The baseline target is a calculation using BPFs (Building Performance Factors) applied to “regulated” energy consumption in 90.1
Start with the Compliance Report
- Required by C405.1 and G1.3
- Required information specified by Table C407.5.1(1), amendments require site energy

Check:
- It is for the correct project
- Which code is being used
- That the simulation results show compliance

Compliance Report shows additional information which should be spot checked
- Lighting power – proposed and baseline, interior and exterior
- Lighting controls included – proposed and baseline, interior and exterior
- 90.1 only, elevator, escalator and moving walkway modeling
### 3.3. Baseline and Proposed Model Comparison Table

<table>
<thead>
<tr>
<th>Description</th>
<th>Baseline Model</th>
<th>Proposed Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Utility Cost (electric, $/year)</td>
<td>$6,712</td>
<td>$5,751</td>
</tr>
<tr>
<td>Annual Utility Cost (gas, $/year)</td>
<td>$5,033</td>
<td>$3,472</td>
</tr>
<tr>
<td>Total Utility Cost ($/year)</td>
<td>$11,750</td>
<td>$9,222</td>
</tr>
<tr>
<td>Annual Electricity Purchased from Utility (kWh/year)</td>
<td>90,707</td>
<td>77,713</td>
</tr>
<tr>
<td>Annual Natural Gas Purchased from Utility (therms/year)</td>
<td>11,121</td>
<td>7,663</td>
</tr>
<tr>
<td>Site Energy Use Intensity (kBtu/SF-year)</td>
<td>387</td>
<td>281</td>
</tr>
<tr>
<td>Peak Electric Demand (kW)</td>
<td>20.5</td>
<td>19</td>
</tr>
<tr>
<td>% Annual Utility Cost Savings (for proposed compared to baseline)</td>
<td>-----</td>
<td>21.5%</td>
</tr>
</tbody>
</table>

*All inputs above this line are for energy purchased from the utility only – excludes energy produced from on-site renewables*

| Capacity of On-Site Renewables (kW)               | -----           | 9.3            |
| Annual Production of On-Site Renewables (kWh/year) | -----           | 13,477         |
| Annual Production of On-Site Renewables ($/year)  | -----           | $997           |
| % Annual Utility Cost Savings Including Renewables (for proposed compared to baseline) | -----          | 30.0%          |
Lighting Power – extremely important to showing compliance

Calculations of lighting power will be needed

Proposed design:
  - Calculation by space
  - Number of each type of fixture
  - Watts of each type of fixture (including both lamp and driver or ballast)

Model input – Lighting Power (W) or Lighting Power Density (W/ft²)
  - If W/ft², calculations also need area of each space

Baseline:
  - Lighting Power Density – C405.3.2 or Table G3.7

Mandatory requirement that lighting power in the proposed design be no greater than the baseline lighting power
3.2. **Description of energy efficiency or renewable energy measures implemented in this project.**

Please list the drawing number in the plan set that shows this measure, and a brief description of how it saves energy above the baseline code in the “Notes” column.

<table>
<thead>
<tr>
<th>ECM</th>
<th>Drawing # from Plans</th>
<th>Notes (How the ECM saves energy compared to baseline inputs?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce Vertical Fenestration U-Value</td>
<td>Specification section O8 4113 H</td>
<td>Aluminum framing and glazing specified to have U-value of not more than 0.38 which is less than ASHRAE baseline of 0.45 for metal framing/storefront resulting in less heat loss.</td>
</tr>
<tr>
<td>Increased Roof Insulation</td>
<td>AS.35</td>
<td>Approximately R-36 insulation reduces heat loss compared to baseline R-20.</td>
</tr>
<tr>
<td><strong>Reduce Interior Lighting Power</strong></td>
<td>E.01, E.2.0</td>
<td>Self-explanatory</td>
</tr>
<tr>
<td>Increased Pool Heating Efficiency</td>
<td>Pool Boiler Submittal</td>
<td>Proposed pool “boiler” is 85% efficient which is higher than the baseline efficiency of 78% resulting in less gas consumption</td>
</tr>
<tr>
<td>RTU AAHX</td>
<td>AHU Submittal</td>
<td>The plate HX reduces OA heating loads</td>
</tr>
<tr>
<td>RTU Fan Power and Controls</td>
<td>AHU Submittal</td>
<td>Specific fan power (W/cm²) is less than the baseline value. The fan has a VSD which is used to reduce airflow at night also reducing fan electricity consumption at those times.</td>
</tr>
<tr>
<td>Photo Voltalc panels</td>
<td>Letter of Intent AES LOI Solar.pdf</td>
<td>100 kW is to be purchased 16 kW will be used for this project to comply with the energy conservation code 1 kW of this system is allocated to the Arts &amp; Education building on the project campus (PMT2017-05656)</td>
</tr>
</tbody>
</table>
Both codes include two methods of determining prescriptive and baseline lighting power

- Building Area Method
- Space by Space Method

Building Area Method – One LPD value applies to the entire floor area of the building

- Except mixed use buildings – each use type gets its own LPD

Space by Space Method – Spaces get an LPD value by type, multiplied by the floor area of the rooms of that type

Office Example

- Building Area Method – 0.79 W/ft²
BASELINE LIGHTING POWER

- Office Example – 50,000 ft²

- Building Area Method – 0.79 W/ft²
  - \(0.79 \text{ W/ft}^2 \times 50,000 \text{ ft}^2 = 39,500 \text{ W}\)

- Space by Space Method

<table>
<thead>
<tr>
<th>Space Type</th>
<th>LPD (W/ft²)</th>
<th>Total Area (ft²)</th>
<th>Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office - Enclosed</td>
<td>0.93</td>
<td>15,000</td>
<td>13,950</td>
</tr>
<tr>
<td>Office - Open Plan</td>
<td>0.81</td>
<td>24,000</td>
<td>22,680</td>
</tr>
<tr>
<td>Conference Room</td>
<td>1.07</td>
<td>3,000</td>
<td>3,638</td>
</tr>
<tr>
<td>Lobby</td>
<td>1.00</td>
<td>500</td>
<td>800</td>
</tr>
<tr>
<td>Corridor</td>
<td>0.66</td>
<td>600</td>
<td>396</td>
</tr>
<tr>
<td>Restroom</td>
<td>0.85</td>
<td>800</td>
<td>1,020</td>
</tr>
<tr>
<td>Break Room</td>
<td>0.62</td>
<td>700</td>
<td>620</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>50,000</td>
<td>43,104</td>
</tr>
</tbody>
</table>
IECC allows user to select which method to use
  - Building Area Method easier
  - Space by Space Method allows more power

90.1 specifies method
  - If space types have been assigned – use Space by Space method
  - If space types unknown – use Building Area Method

For both IECC and 90.1, selected method must be used for the entire building – No mix ‘n match!
Proposed Design Lighting Power Calculations for each unique space

Spot Check!

- Pick a few rooms of different type and compare lighting plan to calculations – do the number and type of luminaires match?
- Check the baseline LPD (lighting power density) for the same rooms against the code - C405.3.2 or Table G3.7
- Is the proposed less than the baseline?
Compliance report should specify controls modeled in proposed and baseline

**Spot Check!**

- Proposed Design: Pick a few rooms of different type and confirm modeled controls are shown on design documents
- IECC baseline includes no special controls - no need to check
- 90.1 baseline must include occupancy sensor controls in certain spaces, listed in Table G3.1, item 6, Lighting. Table G3.7 provides the LPD and an occupancy sensor reduction percentage. A few rooms in the baseline should be spot checked to ensure the LPD has been reduced.
QUESTIONS

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