2022 Denver Energy Code
Commercial Performance Path Compliance

Community Planning and Development / Office of Climate Action, Sustainability and Resiliency

Presented by Elizabeth Gillmor | PE, BEMP, LC, LEED AP
President – Energetics Consulting Engineers, LLC
Questions?

- Time is reserved at the end of the presentation for Q&A
- Please use the Q&A feature to submit your questions

- Responses to all questions not addressed today will be sent out by email to registered participants
- Additional questions may be sent to: energy.review@denvergov.org
# Training Series

## Commercial/Multifamily
(Wednesdays at 12 pm)

<table>
<thead>
<tr>
<th>Training Topic</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrification</td>
<td>May 24</td>
</tr>
<tr>
<td>Prescriptive Path</td>
<td>May 31</td>
</tr>
<tr>
<td>Performance Paths</td>
<td>June 7</td>
</tr>
<tr>
<td>Contractor/Inspector Part 1</td>
<td>June 14</td>
</tr>
<tr>
<td>Contractor/Inspector Part 2</td>
<td>June 21</td>
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</table>

## Residential
(Thursdays at 1 pm)

<table>
<thead>
<tr>
<th>Training Topic</th>
<th>Dates</th>
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<tbody>
<tr>
<td>Compliance Overview</td>
<td>May 25</td>
</tr>
<tr>
<td>June 1</td>
<td></td>
</tr>
<tr>
<td>June 8</td>
<td></td>
</tr>
<tr>
<td>June 22</td>
<td></td>
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<tr>
<td>June 29</td>
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</tbody>
</table>
### Timeline - Commercial Electrification and Performance Requirements

<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2024</td>
<td>Jan 1, 2024, partial electrification of space and water heating.</td>
</tr>
<tr>
<td>2025</td>
<td>GOAL: New Buildings are designed Net Zero Energy.</td>
</tr>
<tr>
<td>2026</td>
<td>Heat pump installation required when replacing “easy to electrify” gas-fired equipment at end of system life.</td>
</tr>
<tr>
<td>2027</td>
<td>Heat pump installation required when replacing “hard to electrify” gas-fired equipment at end of system life.</td>
</tr>
</tbody>
</table>

**Building Projects**

- **Commercial and Multifamily Code Changes**: May 1st mandatory use of the 2022 Denver Energy Code and limited mandatory use of the 2022 Denver Green Code.
- **Energize Denver Permit Changes**: March 1st permit process changes for gas furnaces, unitary AC/condensing units, gas water heaters.
- **Energize Denver Equipment Replacement**: Heat pump installation required when replacing “easy to electrify” gas-fired equipment at end of system life.
- **Energize Denver Performance Targets for Buildings 25k+ SF**: Final Performance Target Due. GOAL: Existing buildings perform as Net Zero Energy.
- **Energize Denver Performance for Buildings 5k-25k SF**: 1st Interim Performance Target Due.

**Existent Commercial and Multifamily Buildings**

- **Energize Denver Performance for Buildings 25k+ SF**: 2nd Interim Performance Target Due.
- **Energize Denver Performance for Buildings 5k-25k SF**: Dec. 31: Compliance deadline for buildings 15,001-24,999 sq. ft.
- **Energize Denver Performance for Buildings 5k-25k SF**: Dec. 31: Compliance deadline for buildings 10,001-15,000 sq. ft.
- **Energize Denver Performance for Buildings 5k-25k SF**: Dec. 31: Compliance deadline for buildings 5,000-10,000 sq. ft.
2022 Denver Energy Code Performance Path

• This is a high-level summary of the **commercial performance path** of the 2022 Denver Energy Code

• Does not include all changes to the 2022 Denver Energy Code. Please refer to the 2022 Denver Energy Code for specific code language. [Denvergov.org/BuildingCode](https://www.denvergov.org/BuildingCode)

• Denver-specific COMcheck and REScheck are anticipated fall 2023
Net Zero Energy Hub – Codes and Resources

www.denvergov.org/EnergyCode

Resources for:

• New provisions in the 2022 Denver Energy Code
• The Denver Energy Code compliance pathways
• Specifics to each phase of a new building project, from design and construction to alterations and additions
• Training videos to walk you through specific provisions that have been updated since the 2019 Denver Building Code
Design Support: partial funding for drawing sets and as-built drawings that can be reviewed by Denver builders to help inform how electrification can work for their projects.

Pilot Projects: partial funding for builders or property owners interested in leveraging city funds to help a new building project be built all-electric.

www.denvergov.org/NetZero

Equity and Local Focus: 50% of the pilot project funds will be prioritized for affordable housing or otherwise serve or benefit under-resourced communities in Denver. Denver-based and/or MWBE firms and organizations are especially encouraged to apply for incentives.
Tips for referencing code

2022 Denver Amendments
+  
2021 International Energy Conservation Code (IECC)
=  
2022 Denver Energy Code (DEC)
Purpose: This presentation provides an overview of the performance path for commercial building projects. Other presentations cover electrification, prescriptive path, and contractor / inspector focus.

Agenda

- 2022 DEC Requirements overview
- Performance Path Overview
- Performance Path Mandatory requirements
- Commissioning – HVAC & Air Leakage
- Modeling details of the Performance Path
- Existing Buildings
- Modeling Protocol
- Case Studies
- Energy model reporting & Demo
- Q&A
2022 DEC Submittal Overview
Definition: Commercial Building

Residential buildings are detached one- and two-family dwellings and multiple single-family dwellings (townhouses) and Group R-3 and R-4 buildings three stories or less in height above grade plane.

Commercial buildings are all other buildings
Definition: All-Electric Property

*All-Electric Property* is one that contains no permanently installed equipment or appliances that utilize *combustion*, plumbing for fuel gas or fuel oil or *fuel gas utility connection*, installed within the *building(s)* or site, except for *emergency power systems* and *standby power systems*. 
Commercial Compliance Process

• Choose a Compliance Pathway (C401.2.1): Prescriptive or Performance
• Meet requirements for all paths - partial list:
  ➢ HVAC/DHW/Lighting Commissioning
  ➢ Building Envelope Verification and Air Leakage Testing
  ➢ Complete 2022 DEC Checklist for Requirements
    ❖ Includes reporting Energize Denver Ordinance 2030 EUI Target
• Related
  ➢ Denver Green Buildings Ordinance - denvergov.org/Greenroofs
  ➢ Denver Green Code - denvergov.org/Greencode
Prescriptive vs Performance

**Prescriptive**
- Easy to see what is needed for compliance
- No energy modeling required
- Can be completed quickly
- 2022 DEC requirements
- Submit compliance documentation, i.e., COMcheck

**Performance**
- Allows for more flexibility and holistic design process
- Modeling can help inform Energize Denver Ordinance compliance. Can also provide utility incentives, tax deductions
- Submit energy model documents
Performance Pathways

- Performance – Three options:
  - Compliance by Energy Cost (C407)
  - Compliance by Site Energy (Appendix SE)
  - Compliance by fixed energy Performance Target (Appendix PT)

Denver.gov/energycode
Instructions for CPD Plans Reviewers

Action for Reviewer

To facilitate inspections, record in Permit Scope of Work text box on permit:

1. One **compliance path** from four options:
   - Prescriptive Compliance Path
   - C407 Energy Cost
   - Appendix SE Site Energy
   - Appendix PT Performance Target

2. Record if **All-Electric Property**:
   - All-Electric Property

Note: dedicated Accela fields for this information are in development
All Pathways – Report the Energize Denver Ordinance Target EUI

- Energy Use Intensity (EUI)
- Buildings 25,000 SF and larger have 2030 EUI targets
- Include 2030 EUI Target in permit documents (reported in IECC Checklist)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>2030 Target EUI (kBtu/sf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>48.3</td>
</tr>
<tr>
<td>Medical Office</td>
<td>69.0</td>
</tr>
<tr>
<td>Multifamily</td>
<td>44.2</td>
</tr>
<tr>
<td>Hotel</td>
<td>61.1</td>
</tr>
<tr>
<td>Restaurant</td>
<td>194.1</td>
</tr>
</tbody>
</table>

Energize Denver Ordinance - Performance Requirements
Submitting the Performance Checklist

Note new policy for submitting Checklists:

• Complete all tabs and print each to pdf
• Put each tab onto drawing sheets within the Construction Documents, separately by discipline
• Drawing sheets should have stamp and signature by discipline
• No other signatures required!!

Links to Checklists
Green Buildings Ordinance (GBO) applies to:
• New buildings and additions 25,000 square feet or larger
• Existing buildings 25,000 square feet or larger, upon roof recover or replacement
• Some multifamily residential projects need only comply with roof reflectance requirements and not additional green building options

NOTE: New construction options which require an extra 12% or 5% energy savings beyond code also require the project to be an All-Electric Property*

*Green Building Ordinance updates for Council approval June 2023 and effective October 1, 2023
Limited mandatory use for new and major renovation commercial projects

denvergov.org/GreenCode

### Table 101.4.1 Limited Mandatory Use: Quantity of Provisions Required

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Scope and Administration: Ecological Impact Statement (EIS)</th>
<th>New Construction</th>
<th>Major Renovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Reserved</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>3</td>
<td>Definitions</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>4</td>
<td>Residential Energy [RE]</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Site Sustainability</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Water Use Efficiency [WE]</td>
<td>1</td>
<td>0</td>
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<td>7</td>
<td>Commercial Energy</td>
<td>1</td>
<td>1</td>
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<tr>
<td>8</td>
<td>Indoor Environmental Quality [EQ]</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Materials and Resources [MR]</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>Construction and Plans for Operation [CX]</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Performance Path Overview
Performance Paths – What’s Required

- Energy modeling by ASHRAE Building Energy Modeling Professional (BEMP) certification (or approved equivalent)
- Utilize the Denver Energy Code Modeling Report Template
- Report the 2030 target EUI as required by Energize Denver
- Use the 2022 Denver Energy Code Commercial Performance Checklist to document requirements
- Additional mandatory requirements from ASHRAE 90.1-2019
- Up to 10% of the Proposed design’s energy cost or energy usage may be offset by on-site renewables
- Can be used for Additions and Alterations without impacting unaltered portions and with slightly relaxed targets
## Performance Path Options

<table>
<thead>
<tr>
<th>Compliance Path</th>
<th>Energy Cost</th>
<th>Site Energy</th>
<th>Compares to Baseline Building</th>
<th>Compares to Performance Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified C407: Energy Cost</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appendix SE: Site Energy</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Appendix PT: Performance Target</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Benefits:
- Allows for a more holistic design process
- More flexibility with prescriptive requirements
- Calibrated towards Denver’s NZE goals
- Plan for GBO compliance
- Incentivizes all-electric buildings
Performance Path
Mandatory Requirements
Mandatory Requirements

All Performance Paths must meet 2022 DEC C407.2 mandatory requirements and 90.1-2019 Appendix G mandatory provisions.

Why ASHRAE 90.1-2019 requirements?
• Since the Performance Path follows ASHRAE 90.1 Appendix G modeling protocol, those requirements supersede 2021 IECC
• Refer to the Prescriptive Path training for more details

Performance Checklist

Use the Performance Checklist during design to help identify mandatory requirements
Mandatory Requirements – Envelope

2022 Denver Energy Code
• C402.1.5 Minimum insulation
• C402.5 Thermal envelope and air barrier requirements
• C402.5.5 Room containing fuel burning appliances
• C402.5.8/9 Loading docks and vestibules
• C402.5.10 Recessed lighting
• C403.12 Data centers

ASHRAE 90.1-2019
• Use Appendix G for envelope baselines
• Can use semi-heated space categories
C402.1.5 Minimum Insulation Requirements

- All conditioned areas are insulated
  - Cores (i.e., stair/elevator in an unconditioned parking garage)
  - Back of house spaces
- Can exclude spandrel and up to 5% of remaining envelope
- Exception for data centers or computer rooms

<table>
<thead>
<tr>
<th>Component</th>
<th>New Maximum U-Factor</th>
<th>C402.1.3 R-Value Reference</th>
<th>C402.1.4 U-Factor Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof insulation above deck</td>
<td>0.048</td>
<td>R-30</td>
<td>U-0.032</td>
</tr>
<tr>
<td>Roof metal building</td>
<td>0.055</td>
<td>R-19+R-11 LS</td>
<td>U-0.035</td>
</tr>
<tr>
<td>Roof attic and other</td>
<td>0.027</td>
<td>R-49</td>
<td>U-0.021</td>
</tr>
<tr>
<td>Wall mass</td>
<td>0.090</td>
<td>All Other: R-11.4ci</td>
<td>All Other: U-0.090</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group R: R-13.3ci</td>
<td>Group R: U-0.080</td>
</tr>
<tr>
<td>Wall metal building</td>
<td>0.069</td>
<td>R-13+R-14ci</td>
<td>U-0.050</td>
</tr>
<tr>
<td>Wall metal framed</td>
<td>0.064</td>
<td>R-13+R-10ci</td>
<td>U-0.055</td>
</tr>
<tr>
<td>Wall wood framed and other</td>
<td>0.064</td>
<td>R-13+R-7.5ci OR R-20+R-3.8ci</td>
<td>U-0.051</td>
</tr>
<tr>
<td>Above grade floors mass</td>
<td>0.074</td>
<td>All Other: R-14.6ci</td>
<td>All Other: U-0.057</td>
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<tr>
<td></td>
<td></td>
<td>Group R: R-16.7ci</td>
<td>Group R: U-0.051</td>
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<tr>
<td>Above grade floors framed</td>
<td>0.074</td>
<td>R-30</td>
<td>U-0.033</td>
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</tbody>
</table>
Air Barrier and Thermal Envelope Example
Mandatory Requirements – HVAC & Kitchen

2022 Denver Energy Code
- C402.4.11 Operable openings
- C403.1.2 Data centers
- C403.2.3 Fault detection diagnostics
- C403.2.4 Space heating equipment electrification

Alterations:
- C503.3.2 Low NOx Emissions requirements
- C503.3.3 Partial electrification

ASHRAE 90.1-2019
- Follow Appendix G modeling guidelines
- 6.4.1 Minimum equipment efficiencies*
- 6.4.2.1 Calculation of heating/cooling loads*
- 6.4.3 HVAC control requirements
- 6.4.3.4.5 Enclosed parking garage ventilation controls
- 6.4.3.6 Humidification/dehumidification*
- 6.4.4.1.3 Pipe insulation*
- 6.4.4.2.2 Duct/plenum sealing & leakage testing
- 6.4.5 Walk-in coolers and 6.4.5 Refrigerated display cases*
- 10.4.5 Air curtains*

*same or similar to 2022 DEC
Mandatory Requirements – Ventilation

What to design:
• Multifamily: Denver Mechanical Code, DMC (not ASHRAE 62.2)
• Everything else: DMC OR ASHRAE 62.1 (both will be accepted)
  ➢ Note that the Indoor Air Quality (IAQ) Procedure of ASHRAE 62.1 requires an Administrative Modification to use

What to model:
• Multifamily: As designed, PLUS assume running continuously
• Everything else: As designed
  ➢ References to ASHRAE 62.1 Appendix G for Ez zone air distribution effectiveness can be applied to either method
Mandatory Requirements – Service Water Heating

2022 Denver Energy Code
- C404.10 Water heating equipment electrification
- C404.11 Demand response controls for electric storage DHW
- C404.12 Provide electric infrastructure for fossil fuel equipment

Alterations:
- C503.4.1 Partial electrification requirements

ASHRAE 90.1-2019
- Follow Appendix G modeling guidelines
- 7.4.2 Minimum equipment efficiencies*
- 7.4.3 Pipe insulation*
- 7.4.4 Service water heating controls*
- 7.4.5 Pool controls and covers
- 7.4.6 Heat traps*
- 10.4.2 Service water pressure booster systems

*same or similar to 2022 DEC
Mandatory Requirements – Power & Lighting

**2022 Denver Energy Code**
- C405.4 Lighting for plant growth
- C405.12 Energy monitoring
- C405.13 EV Spaces
- C405.14 Solar ready requirements
- C405.15 Electric infrastructure

**ASHRAE 90.1-2019**
- Follow Appendix G modeling guidelines
- 8.4.1 Voltage drop*
- 8.4.2 Automatic receptacle control*
- 8.4.4 Electric transformers
- **9.4.1 Interior/Exterior lighting controls**
- 9.4.1.2 Parking garage lighting controls*
- **9.4.1.3 Special application lighting controls**
- **9.4.3 Dwelling unit lighting efficacy**
- 10.4.1 Electric motor efficiencies*
- 10.4.3 Elevators & 10.4.4 escalators*
- **10.4.6 Whole building energy monitoring***

*same or similar to 2022 DEC*
Commissioning & Envelope Verification
C408 Commissioning

C408.2 - Mechanical & Service Water System Commissioning:

- Commissioned by a Colorado registered design professional or approved agency
  - Exceptions for
    - Small capacity systems in C408.2
    - Systems for individual sleeping and dwelling units
    - Systems in existing buildings where the area of work is less than 10,000 square feet
- Air balancing testing (TAB) to be completed by an approved contractor

C408.3 - Lighting Controls Functional Testing:

- Commissioned by a Colorado registered design professional or approved agency
  - Exception for systems in existing buildings where the area of work is less than 10,000 square feet and the new installed lighting load is less than 10 kW*

*Updates for Council approval June 2023
C408 Commissioning

Required at Permit:

☑️ Letter with qualifications of the commissioning agent

Required at project completion:

☑️ Preliminary Commissioning Report
☑️ Final Commissioning Report
☑️ HVAC, SHW, and Lighting Controls
C402.5.1.5 Envelope Performance Verification

Colorado registered design professional or approved agency shall:

- Review of continuous air barrier in construction documents
- Inspect continuous air barrier components and assemblies during construction while the air barrier is still accessible for inspection and repair
- Provide commissioning report for completed inspections
C402.5 Air Leakage Testing

- Required for
  - New commercial buildings and new envelope assemblies of alterations
- For R and I occupancies: C402.5.2 Dwelling and sleeping unit enclosure testing
  - Sampling permitted for 8 units or more
  - Apply weighted average
- For all other occupancies: C402.5.3 Building thermal envelope testing
  - Entire envelope of stories with a roof, entrance, exposed floor, or below grade
  - Building sections totaling at least 25% of walls for remaining conditioned space

Resources for Air Leakage Testing Success
C402.5 Air Leakage Rates

Test with corrective action until measured air leakage is

1) At or below target
   - OR -
2) At or below the maximum limit (from exceptions) plus
   • Conduct a diagnostic evaluation using smoke tracer or infrared imaging while building is pressurized along with a visual inspection of the air barrier
   • Any leaks noted shall be sealed
   • Submit additional report identifying corrective actions taken

<table>
<thead>
<tr>
<th>Measured Air Leakage</th>
<th>C402.5.2 Dwelling and Sleeping Units</th>
<th>C402.5.3 All Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Differential</td>
<td>50 Pa</td>
<td>75 Pa</td>
</tr>
<tr>
<td>Target</td>
<td>0.3 CFM/SF</td>
<td>0.4 CFM/SF</td>
</tr>
<tr>
<td>Maximum Limit</td>
<td>0.45 CFM/SF</td>
<td>0.6 CFM/SF</td>
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</tbody>
</table>
Performance Path Modeling Details
Appendix PT – Performance Target

• No baseline model
• Only available for certain building types
• Blend multiple targets for mixed use projects (weighted average)
• Add an allowance for parking garages
• Follow standardized schedules in “Denver Modeling Rules and Procedures” for compliance (may be less accurate than predictive modeling)
• Uses energy use intensity (EUI in kBtu/SF) like Energize Denver reporting requirements for operating buildings

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Modeled Performance Target (kBtu/SF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apartment (Multifamily)</td>
<td>38</td>
</tr>
<tr>
<td>Hotel (Motel)</td>
<td>55</td>
</tr>
<tr>
<td>Office</td>
<td>43</td>
</tr>
<tr>
<td>Retail</td>
<td>39</td>
</tr>
<tr>
<td>Restaurant/Bar</td>
<td>175</td>
</tr>
<tr>
<td>Parking Garages</td>
<td>3</td>
</tr>
</tbody>
</table>

Link to Denver Modeling Rules and Procedures
Denver Modeling Rules and Procedures

Used for Appendix PT – Performance Target

- How to calculate target adjustment for projects with pools
- Documentation requirements
- Which weather file should be used
- COMNET reference schedules & loads
- Altitude effects on HVAC efficiency

Find this link with the Checklists:

Reference schedules include:
- Occupancy
- Lighting
- Receptacles
- Infiltration
- Heating/Cooling schedules & setpoints
- Service hot water schedule & setpoints

Reference loads include:
- Equipment power density
- Occupant density
- Sensible/latent Btu-h per person

Link to Denver Modeling Rules and Procedures
Performance Paths – Modified C407 & App SE

- Uses ASHRAE 90.1-2019 Appendix G Performance Rating Method
- Uses natural gas for heating energy in the baseline
- Building Performance Factors (BPF) define how much the building’s Regulated loads must be reduced
- Denver's BPFs incentivize all-electric properties with higher BPFs for all-electric properties
- Proposed design must be less than target (by energy cost or site energy)

\[
\text{Target} = \left[ \text{Baseline Unregulated} + (\text{BPF} \times \text{Baseline Regulated}) \right] / \text{Total Baseline}
\]

*"Regulated":* Regulated by the energy code

*"Unregulated":* Everything else
Understanding BPFs

When using C407:

A BPF of 0.78 means that the building’s Regulated ENERGY COST must be reduced by 22%.

When using Appendix SE:

A BPF of 0.71 means that the building’s Regulated SITE ENERGY must be reduced by 29%.

<table>
<thead>
<tr>
<th>Building Type</th>
<th>MODIFIED C407</th>
<th>APPENDIX SE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Electric</td>
<td>Mixed Fuel*</td>
</tr>
<tr>
<td>Multifamily</td>
<td>0.78</td>
<td>0.57</td>
</tr>
<tr>
<td>Healthcare</td>
<td>0.70</td>
<td>0.56</td>
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<td>Hotel/Motel</td>
<td>0.71</td>
<td>0.51</td>
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<tr>
<td>Office</td>
<td>0.57</td>
<td>0.42</td>
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<tr>
<td>Restaurant</td>
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<td>Retail</td>
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<td>School</td>
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<td>0.40</td>
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<tr>
<td>Warehouse</td>
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<td>0.23</td>
</tr>
<tr>
<td>All Other</td>
<td>0.58</td>
<td>0.44</td>
</tr>
</tbody>
</table>

*From updates for Council approval June 2023
Green Buildings Ordinance
Energy Savings Options

- Select energy savings: 2.5%, 5%, 6% or 12%
- Note: New construction options which require an extra 12% or 5% savings beyond code also require the project to be an All-Electric Property*

- **Example for 12%-better:** GBO threshold =
  
  \[ \text{Target} \times (1 - 0.12) \quad \text{OR} \quad \text{EUI from Appendix PT} \times (1 - 0.12) \]

*Green Building Ordinance updates for Council approval June 2023 and effective October 1, 2023

denvergov.org/greenroofs
Existing Buildings
Existing Buildings – Performance Compliance

When can Performance Compliance be used for existing buildings?

- C502 Additions
- C503 Alterations
  - No change of use or space conditioning
  - Example: Tenant finish
- C505 Change of Occupancy or Use
  - Change to higher energy-demand category
  - Example: "Adaptive reuse" projects

Especially helpful for Combination projects!

More Resources for Alterations and Additions

<table>
<thead>
<tr>
<th>C505.1 Energy-Demand Category</th>
<th>IBC Occupancies</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 (highest)</td>
<td>A, B small assembly</td>
</tr>
<tr>
<td>3</td>
<td>B gym, E, I-4, M</td>
</tr>
<tr>
<td>2</td>
<td>B (all other), I-1, I-2, I-3, R</td>
</tr>
<tr>
<td>1 (lowest)</td>
<td>F, H, S</td>
</tr>
</tbody>
</table>
Existing Buildings – C503 Alterations

- Alterations with no change of use or space conditioning
- Use C407 or Appendix SE with special modeling rules
  - Systems not part of the alteration are modeled identically in baseline and proposed, can exclude unaltered spaces
  - Unknown conditions: use C407 or Appendix SE for baseline
  - Known conditions: may use existing conditions for baseline
  - For envelope improvements, use existing conditions for baseline

- Compliance options:
  - C503.1.1 Energy cost or use of alterations is less than or equal to existing building
  - OR -
  - C407.1.2 Additional 10% allowance for energy cost or use target (PCIt or PSEIt)
Existing Buildings – C505 Change of Occupancy

- C505 Change of Occupancy or Use to a higher energy-demand category
- Follow standard modeling protocol
- Use C407.1.2 for additional 10% allowance for energy cost or use target (PCIlt or PSEIt)
Modeling Protocol
Defining the Baseline

ASHRAE 90.1-2019 Appendix G
Performance Rating Method

- Akin to a 90.1-2004 compliant building
- Define baseline HVAC systems (all gas)
- Define baseline service water heating system (fuel varies by building type)
- Apply baseline Window to Wall Area Ratio
- Determine baseline inputs using Appendix G tables (not prescriptive baseline)

<table>
<thead>
<tr>
<th>Table G3.1.1-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Area Type</td>
</tr>
<tr>
<td>Healthcare (Outpatient)</td>
</tr>
<tr>
<td>Hotel/Motel &lt; 75 rooms</td>
</tr>
<tr>
<td>Hotel/Motel &gt; 75 rooms</td>
</tr>
<tr>
<td>Office &lt; 5000 sf</td>
</tr>
<tr>
<td>Office 5,000 – 50,000 sf</td>
</tr>
<tr>
<td>Office &gt; 50,000 sf</td>
</tr>
<tr>
<td>Restaurant (quick service)</td>
</tr>
<tr>
<td>Restaurant (full service)</td>
</tr>
</tbody>
</table>
## Defining the Baseline HVAC system

<table>
<thead>
<tr>
<th>Building Type, Floors, and Gross Conditioned SF</th>
<th>Climate Zone 5 Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>System 1 - PTAC</td>
</tr>
<tr>
<td>Public Assembly &lt;120,000 sf</td>
<td>System 3 – PSZ-AC</td>
</tr>
<tr>
<td>Public Assembly &gt;120,000 sf</td>
<td>System 12 – SZ-CV-HW</td>
</tr>
<tr>
<td>Heated-Only Storage</td>
<td>System 9 – Heating and ventilation</td>
</tr>
<tr>
<td>Retail and 2 floors or fewer</td>
<td>System 3 – PSZ-AC</td>
</tr>
<tr>
<td>Other non-residential and 3 floors or fewer and &lt;25,000 sf</td>
<td>System 3 – PSZ-AC</td>
</tr>
<tr>
<td>Other non-residential and 4 or 5 floors and &lt;25,000 sf - OR- 5 floors or fewer and 25,000 - 150,000 sf</td>
<td>System 5 – Packaged VAV with reheat</td>
</tr>
<tr>
<td>Other non-residential and more than 5 floors or &gt;150,000 sf</td>
<td>System 7 – VAV with reheat</td>
</tr>
</tbody>
</table>

### Determine baseline by this priority:

1. Building type with largest conditioned floor area
2. Number of floors (above and below grade, excluding floors devoted to parking)
3. Gross conditioned floor area
4. Use additional system types for non-predominant conditions if those conditions exceed 20,000 sf
5. If baseline is system 5, 7, or 12, use separate System 3 for significantly differing zones by load or hours
6. Heated-only spaces
7. A few other rules to check – labs, computer rooms, hospitals
Defining the Baseline HVAC system example

Example: 5-story multifamily building totals 300,000 conditioned sf
Non-residential area = 80,000 sf with first level restaurant

- Primary baseline (residential): System 1
- Secondary baseline (non-residential): System 5
- Third baseline (restaurant): System 3
- Fourth baseline (heated-only spaces): System 9

<table>
<thead>
<tr>
<th>Building Type, Floors, and Gross Cond SF</th>
<th>Climate Zone 5 Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Residential</td>
<td>System 1 - PTAC</td>
</tr>
<tr>
<td>#2 Other non-residential and 5 floors or</td>
<td>System 5 – Packaged VAV with reheat</td>
</tr>
<tr>
<td>fewer and 25,000 - 150,000 sf</td>
<td></td>
</tr>
<tr>
<td>#3 Other non-residential and 3 floors or</td>
<td>System 3 – PSZ-AC</td>
</tr>
<tr>
<td>fewer and &lt; 25,000 sf</td>
<td></td>
</tr>
<tr>
<td>#4 Heated-only spaces</td>
<td>System 9 – Gas furnace</td>
</tr>
</tbody>
</table>
ASHRAE adds Semi-Heated Space Category

**Semiheated Space:** An enclosed space in a building that is heated by a heating system with output between 3.4 and 12 Btu/h per SF of floor area

- Teams should include semiheated spaces within the thermal envelope
- Future tenant spaces shall be assumed to be *conditioned spaces* and shall comply with the requirements for conditioned spaces at the time of construction, regardless of whether MEP equipment is included in the building permit application

ASHRAE provides guidance for *semiexterior* envelope elements, but these are not part of Denver's mandatory requirements.
C407.1 Denver Modeling Rules – Infiltration

Follow DOE-2 infiltration methodology as described in PNNL Protocol*

Infiltration = $I_{\text{design}} \times F_{\text{schedule}} \times (A + B \times |T_{\text{zone}} - T_{\text{odb}}| + C \times \text{Wind speed} + D \times \text{Wind speed}^2 )$

<table>
<thead>
<tr>
<th>Constant Coefficient ($A$)</th>
<th>Temperature Coefficient ($B$)</th>
<th>Window Speed Coefficient Linear Term ($C$)</th>
<th>Wind Speed Coefficient Quadratic Term ($D$)</th>
<th>Wind Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOE-2 Infiltration Methodology</td>
<td>0</td>
<td>0.224</td>
<td>0</td>
<td>10 mph</td>
</tr>
</tbody>
</table>

*From updates for Council approval June 2023
C407.1 Infiltration Rate

- Calculate model inputs following G3.1.1.4
  - Air leakage as a function of floor area (AFLR):
    \[ I_{FLR} = 0.112 \times I_{75Pa} \times S / AFLR \]
  - Air leakage as a function of above-grade walls (AAGW):
    \[ I_{AGW} = 0.112 \times I_{75Pa} \times S / AAGW \]

\[ I_{75Pa} = \text{Air leakage of the thermal envelope at 0.3 in wg (75 Pa) = } \frac{Q}{S} \]
\[ Q = \text{Volume of air flowing through building envelope} \]
\[ S = \text{Area of building envelope (above grade walls, floor, roof)} \]
C407.1 Infiltration Rates

- Infiltration rate:
  - Baseline: $I_{75Pa} = 1.0 \text{ cfm/sf of envelope}$
  - Proposed: $I_{75Pa} = 0.4 \text{ cfm/sf of envelope}$*

*From updates for Council approval June 2023
C407.1 Infiltration Schedule

- Infiltration fractional schedule:
  - 0.25 - Building is pressurized (fans on)
  - 1.0 - Building is not pressurized (fans off)
  - Model multifamily projects with fans running continuously - always at 0.25*

*From updates for Council approval June 2023
Service Water Heating Load Reduction

- 90.1-2019 Appendix G allows you to claim savings for water heating load reductions
- Refer to the Denver Plumbing Code Table 604.4 to establish baseline flow rates
- Hot water reduction from commercial or residential appliances following Energy Star protocol

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Max Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory, private</td>
<td>1.5</td>
</tr>
<tr>
<td>Lavatory, public (metered)</td>
<td>0.25</td>
</tr>
<tr>
<td>Lavatory, public (non-metered)</td>
<td>0.5</td>
</tr>
<tr>
<td>Shower head</td>
<td>1.8</td>
</tr>
<tr>
<td>Sink faucet</td>
<td>1.5</td>
</tr>
<tr>
<td>Kitchen sink faucet</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Commercial Kitchen Equipment
Multifamily Modeling Protocol
On-site Renewable Energy

- Renewable energy may be used to meet the Performance Path requirements for up to 10% of the proposed design’s energy cost (C407) or energy use (appendix SE and PT).
- Requires a fully designed photovoltaic array ready to permit.
- PV array energy production calculated using software such as Helioscope or PV Watts.
- System must be owned, be under a lease of minimum 15 years, or be under contract to purchase the energy generated for a minimum of 15 years.

When \((\text{PBP}_{\text{p}} - \text{PBP})/\text{BBP} > 0.10\), new buildings, additions to existing buildings, and/or alterations to existing buildings shall comply with the following:

\[
\text{PCI} + \left(\frac{(\text{PBP}_{\text{p}} - \text{PBP})}{\text{BBP}} - 0.10\right) < \text{PCI}_t
\]
Instructions for CPD Plans Reviewers

**Action for Reviewer**

To facilitate inspections, record in Permit Scope of Work text box on permit:

- If *Renewable Energy* is included for compliance via drawings, lease, or contract, record
  - Renewable energy ___ kW$_{DC}$ array

*Note: dedicated Accela fields for this information are in development*
Case Studies
Case Study – Office

Baseline: System 5 – Packaged VAV with hot water heating

Proposed options:
1. All electric – Heat pump RTUs with electric reheat
2. Mixed fuel – Gas RTUs with electric reheat
# Office - Case Study

## Building Type

<table>
<thead>
<tr>
<th>Building Type</th>
<th>BPF – All-electric Properties</th>
<th>BPF – All other Properties*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office – C407 Energy Cost</td>
<td>0.57</td>
<td>0.42</td>
</tr>
<tr>
<td>Office – App SE Site Energy</td>
<td>0.59</td>
<td>0.51</td>
</tr>
</tbody>
</table>

## Annual Energy Costs and Savings

<table>
<thead>
<tr>
<th></th>
<th>Annual Energy Cost</th>
<th>% Cost Savings</th>
<th>Site EUI</th>
<th>C407 Target Cost</th>
<th>C407 Savings (%)</th>
<th>App SE Target EUI</th>
<th>App SE Savings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>$54,119</td>
<td>-</td>
<td>57.6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Proposed – Electric</td>
<td>$50,776</td>
<td>6.2%</td>
<td>26.2</td>
<td>$33,330</td>
<td>-52%</td>
<td>38.7</td>
<td>32%</td>
</tr>
<tr>
<td>Proposed – Mixed Fuel</td>
<td>$49,788</td>
<td>8.0%</td>
<td>29.8</td>
<td>$36,592</td>
<td>-36%</td>
<td>35.0</td>
<td>15%</td>
</tr>
</tbody>
</table>

*From updates for Council approval June 2023*
Case Study – Restaurant

Baseline: System 3 – Packaged RTU with gas heating

Proposed: Mixed fuel – Gas RTUs
## Restaurant - Case Study

### Building Type

<table>
<thead>
<tr>
<th>Building Type</th>
<th>BPF – All other Properties*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restaurant – C407 Energy Cost</td>
<td>0.51</td>
</tr>
<tr>
<td>Restaurant – App SE Site Energy</td>
<td>0.63</td>
</tr>
</tbody>
</table>

### Annual Energy Cost

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Annual Energy Cost</th>
<th>% Cost Savings</th>
<th>Site EUI</th>
<th>C407 Target Cost</th>
<th>C407 Savings (%)</th>
<th>App SE Target EUI</th>
<th>App SE Savings (%)</th>
<th>PV Required for C407</th>
<th>PV Required for App SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>$39,362</td>
<td>-</td>
<td>523</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Proposed – Mixed Fuel</td>
<td>$30,158</td>
<td>23.4%</td>
<td>432</td>
<td>$27,001</td>
<td>-12%</td>
<td>394</td>
<td>-10%</td>
<td>-21.7</td>
<td>-34.8</td>
</tr>
</tbody>
</table>

*From updates for Council approval June 2023
Case Study – Multifamily

Baseline:
- System 1 – PTAC, and System 5 – Packaged VAV with hot water heating
- Gas pool boiler as a regulated load

Proposed:
1. Residential: Hydronic fan coils, central gas DHW
2. Residential: Split heat pumps, central gas DHW
3. Residential: Split heat pumps, central heat pump DHW
# Multifamily - Case Study

<table>
<thead>
<tr>
<th>Building Type</th>
<th>BPF – All other Properties*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multifamily – C407 Energy Cost</td>
<td>0.57</td>
</tr>
<tr>
<td>Multifamily – App SE Site Energy</td>
<td>0.60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Annual Energy Cost</th>
<th>% Cost Savings</th>
<th>Site EUI</th>
<th>C407 Target Cost</th>
<th>C407 Savings (%)</th>
<th>App SE Target EUI</th>
<th>App SE Savings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>$113,290</td>
<td>-</td>
<td>72.4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Proposed – Gas</td>
<td>$111,790</td>
<td>27.4%</td>
<td>50.2</td>
<td>$107,378</td>
<td>-4%</td>
<td>48.2</td>
<td>-4%</td>
</tr>
<tr>
<td>Proposed – Hybrid</td>
<td>$116,034</td>
<td>24.6%</td>
<td>47.5</td>
<td>$107,378</td>
<td>-8%</td>
<td>48.2</td>
<td>1%</td>
</tr>
<tr>
<td>Proposed – Electric</td>
<td>$134,840</td>
<td>12.4%</td>
<td>44.3</td>
<td>$107,378</td>
<td>-26%</td>
<td>48.2</td>
<td>8%</td>
</tr>
</tbody>
</table>

*From updates for Council approval June 2023
Energy Model Report
Energy Modeler Certification

ASHRAE Building Energy Modeling Professional (BEMP) certification

• ANSI-accredited certification program
• Validates competency to model new and existing buildings
• List of certified professional available on the ASHRAE website:
  https://certificants.ashrae.org/list?type=BEMP
Energy Model Report

Denver has adopted the DOE/PNNL 90.1 tool suite

- Leverages actively supported tools and technical assistance
- Provides modelers with a consistent tool compatible with other programs like LEED
- Submit both:

  Part 1 - **Compliance Form** - ASHRAE Standard 90.1 Appendix G

  Part 2 – **2022 DEC Companion Tool** – Denver-specific overlay for code and Green Buildings Ordinance
Energy Modeling Report

**90.1 Compliance Form**
- Energy modeler certification
- Building types, areas, new / renovation
- Energy sources, rates
- Energy demand, use and cost, EUI
- Renewable energy
- Envelope, Lighting, HVAC, SHW, Process*

**2022 DEC Companion Tool**
- All-Electric Property - Y/N
- Confirm areas
- BPF for project
- Compliance:
  - 2022 DEC - C407, SE, PT
  - Green Buildings Ordinance

*Can substitute 2019 Commercial Energy Modeling Report Table 2 through 9/30/2023*
Energy Model Submittal Package

Upload zipped file with:

- Energy model report files
- Input and output reports from energy simulation (IP units preferred)
- Energy rates
- Exceptional calculations
- On-site renewables – may be letter from owner with summary of contract or lease
- If adjacent buildings or topology shades building, include in a site plan

Naming convention: <energyreport>_<address>_<date>.zip
Compliance Form / Companion Tool Demonstration
## Energy Modeling Report - Minimum

### 90.1 Compliance Form Minimum Inputs

*If using 2019 Commercial Energy Modeling Report Table 2*

<table>
<thead>
<tr>
<th>TAB NAME</th>
<th>MINIMUM INFORMATION REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Information</td>
<td>Code / Energy Model Information / Simulation Tool</td>
</tr>
<tr>
<td></td>
<td>Table 1 Building Areas</td>
</tr>
<tr>
<td>Contact Information</td>
<td>Project Information, Lead Energy Modeler Name and Certifications</td>
</tr>
<tr>
<td>Energy Sources</td>
<td>Table 1 Energy Sources, Table 2 Charges</td>
</tr>
<tr>
<td>Envelope Areas</td>
<td>Note Baseline Orientation and Rotation (radio button at bottom)</td>
</tr>
<tr>
<td>Infiltration</td>
<td>Table 1 Infiltration, include Notes on modeling protocol</td>
</tr>
<tr>
<td>Renewable Energy</td>
<td>Tables 1 - 4</td>
</tr>
<tr>
<td>Results From Tool</td>
<td>Paste results from the energy model output</td>
</tr>
</tbody>
</table>
Summary

Projects may **follow one of four pathways** to comply with the 2022 DEC

- Prescriptive, C407 energy cost, Appendix SE site energy, and Appendix PT performance target
- This presentation covered code requirements for the performance paths

**Successful permit submittals** include Energy Code checklists in the drawings, compliance documentation (energy model submittal package), and construction documents that show how all requirements are met in the proposed design

Updates to the 2022 DEC are **designed to support electrification**

- Key new provisions: partial electrification of space and water heating effective 1/1/2024, demand responsive water heating, electric-ready infrastructure, and permit process parity for alterations replacing furnaces, unitary air conditioning for heated spaces and service water heating
Questions?

• Time is reserved at the end of the presentation for Q&A
• Please use the Q&A feature to submit your questions

• Responses to all questions not addressed today will be sent out by email to registered participants
• Additional questions may be sent to: energy.review@denvergov.org
Thank you!

For more information, visit:
Denver.gov/EnergyCode
Denver.gov/BuildingCode

Contact us:
Questions about energy code: energy.review@denvergov.org
Questions about programs & resources: sustainability@denvergov.org