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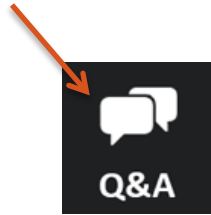
# 2022 Denver Energy Code Commercial Performance Path Compliance

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](mailto:energy.review@denvergov.org)

# Training Series

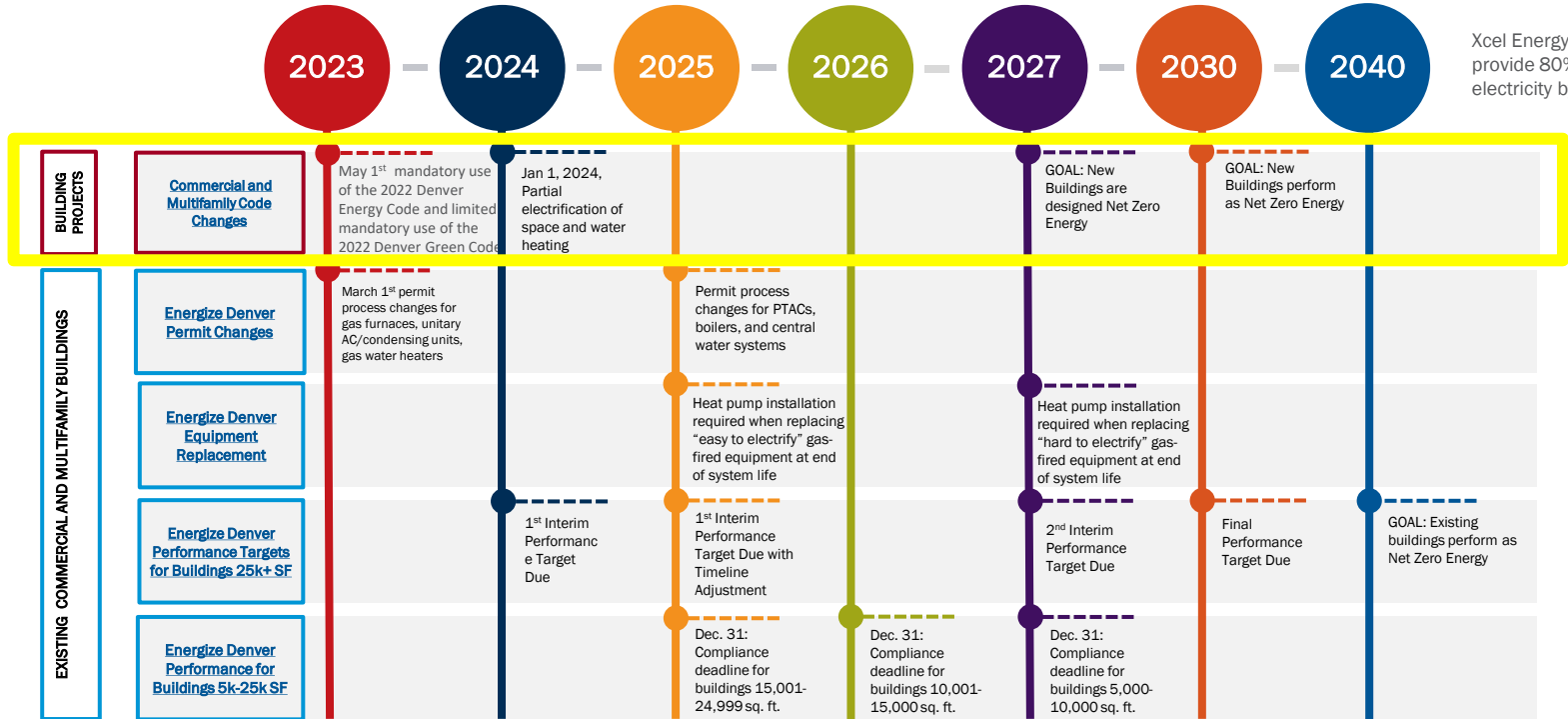


SCAN ME



	<b>Commercial/Multifamily (Wednesdays at 12 pm)</b>	<b>Residential (Thursdays at 1 pm)</b>
	Electrification May 24	Compliance Overview May 25
Prescriptive Path	May 31	June 1
Performance Paths	June 7	June 8
Contractor/Inspector Part 1	June 14	June 22
Contractor/Inspector Part 2	June 21	June 29

# Timeline - Commercial Electrification and Performance Requirements



Xcel Energy required to provide 80% renewable electricity by 2030

# 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://denvergov.org/BuildingCode)
- Denver-specific COMcheck and REScheck are anticipated fall 2023

# Net Zero Energy Hub – Codes and Resources

[www.denvergov.org/EnergyCode](http://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

Home / Government / Agencies, Departments, and Offices / Climate Action, Sustainability & Resiliency / High Performance Buildings and Homes / **Net Zero Energy Hub - Codes and Resources**

## Net Zero Energy Hub - Codes and Resources

This resource hub pulls together information from Denver and pairs it with resources from across the country to help building owners, professionals, and residents:

- Learn about changes in the 2022 Denver Building and Fire Code and the 2022 Denver Green Code
- Understand the importance of building electrification and energy efficiency
- See examples of successful Net Zero Energy building projects in a variety of building types and uses
- Navigate new regulations and requirements with confidence!



### Resources for New Commercial and Multifamily Buildings

Buildings that are regulated by the Denver Commercial Building Code, which include commercial buildings and multi-unit residential buildings that are not regulated by the Denver Residential Code.



### Resources for New Single Family, Duplex, and Townhomes

Any detached one- or two-family dwelling unit and townhomes three stories or less are regulated by the Denver Residential Code.

# New Building Electrification Pilots



**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](http://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)**



# 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

**Purpose:** This presentation provides an overview of the performance path for commercial building projects.

Other presentations cover electrification, prescriptive path, and contractor / inspector focus.



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# 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](https://denvergov.org/Greenroofs)
  - Denver Green Code - [denvergov.org/Greencode](https://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
- 2022 DEC Mandatory Requirements + ASHRAE 90.1-2019 Mandatory Provisions
- 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)



[Denvergov.org/energycode](https://denvergov.org/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)

Building Type	2030 Target EUI (kBtu/sf)
Office	48.3
Medical Office	69.0
Multifamily	44.2
Hotel	61.1
Restaurant	194.1

## [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!!

## CHECKLIST TABS:

General Compliance  
 Building Envelope  
 HVAC & Kitchen  
 Service Water Heating  
 Power & Lighting

### 2022 Denver Energy Code - Commercial Compliance Checklist

#### Performance Path - Building Envelope



Project Address:		Date:			
Code Section	Focus Area	Code Description	Drawing or Specification Number (N/A if not applicable)	Submitter Notes (e.g. if "N/A" Please explain why requirement does not apply or is not demonstrated on drawings/specs)	Submittal Requirements and Clarifications
<b>ALL COMPLIANCE PATHS</b>					
C402.1.5	Minimum Insulation	Roofs, walls, and floors shall meet applicable maximum U-factor requirements of Table C402.1.5			Indicate location of: - Supplemental calculations if applicable
C103.2.1	Thermal Envelope	Thermal envelope shall be depicted.			Indicate location of: - Drawings with thermal envelope as required by C103.2.1
C402.5	Air Barrier	Continuous air barrier shall be provided.			Indicate location of: - Drawings with continuous air barrier and air sealing details as required by C103.2
C402.5.5	Room Containing Fuel Burning Appliances	Rooms containing fuel burning appliances and combustion air openings shall be located outside the building thermal envelope or located in a room that is enclosed and isolated from conditioned spaces inside the thermal envelope, note the exception.			Indicate location of: - Drawings showing rooms containing fuel burning appliances and combustion air openings

[Links to Checklists](#)

# All Pathways – Denver Green Buildings Ordinance

## 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**\*



[denvergov.org/greenroofs](https://denvergov.org/greenroofs)

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

# All Pathways – Denver Green Code (DGC)

Limited mandatory use for new and *major renovation commercial projects*

[denvergov.org/GreenCode](https://denvergov.org/GreenCode)

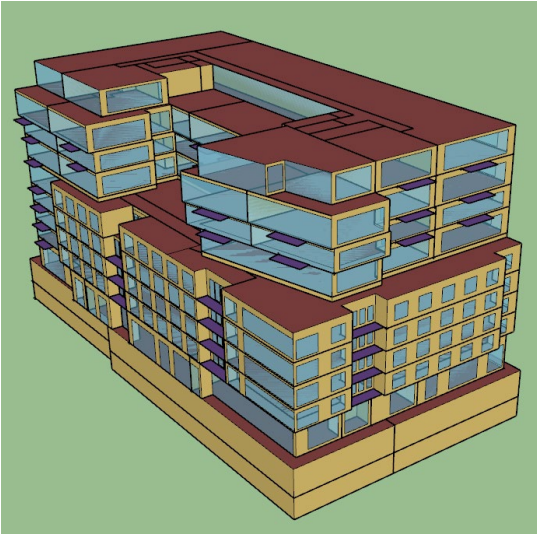
Table 101.4.1 Limited Mandatory Use: Quantity of Provisions Required		New Construction	Major Renovation
Chapter 1	Scope and Administration: Ecological Impact Statement (EIS)	0	0
Chapter 2	Reserved	n/a	n/a
Chapter 3	Definitions	n/a	n/a
Chapter 4	Residential Energy [RE]	0	0
Chapter 5	Site Sustainability	4	2
Chapter 6	Water Use Efficiency [WE]	1	0
Chapter 7	Commercial Energy	1	1
Chapter 8	Indoor Environmental Quality [EQ]	1	1
Chapter 9	Materials and Resources [MR]	3	1
Chapter 10	Construction and Plans for Operation [CX]	2	2



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# 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

Compliance Path	Energy Cost	Site Energy	Compares to Baseline Building	Compares to Performance Target
Modified C407: Energy Cost	X		X	
Appendix SE: Site Energy		X	X	
Appendix PT: Performance Target		X		X

## 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



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# 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

[Performance Checklist](#)

## 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

*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

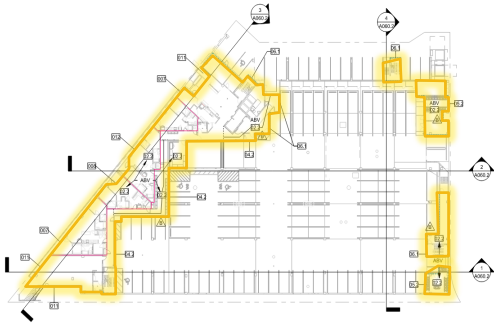
- Use Appendix G for envelope baselines
- Can use semi-heated space categories

# C402.1.5 Minimum Insulation Requirements

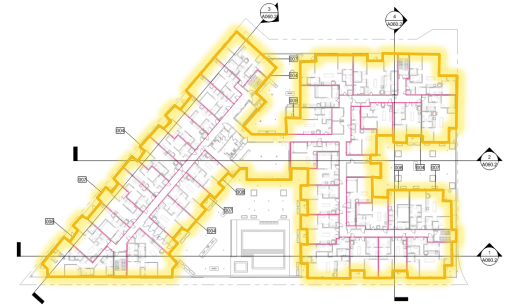
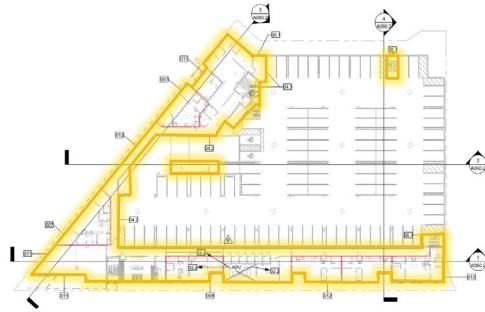
- All conditioned areas are insulated
  - Cores (i.e., stair/elevator in an unconditioned parking garage)
  - Back of house spaces
- Can exclude spandrel and up to 5% of remaining envelope
- Exception for data centers or computer rooms

Component	NEW Maximum U-Factor	C402.1.3 R-Value Reference	C402.1.4 U-Factor Reference
Roof insulation above deck	<b>0.048</b>	R-30	U-0.032
Roof metal building	<b>0.055</b>	R-19+R-11 LS	U-0.035
Roof attic and other	<b>0.027</b>	R-49	U-0.021
Wall mass	<b>0.090</b>	All Other: R-11.4ci Group R: R-13.3ci	All Other: U-0.090 Group R: U-0.080
Wall metal building	<b>0.069</b>	R-13+R-14ci	U-0.050
Wall metal framed	<b>0.064</b>	R-13+R-10ci	U-0.055
Wall wood framed and other	<b>0.064</b>	R-13+R-7.5ci OR R-20+R-3.8ci	U-0.051
Above grade floors mass	<b>0.074</b>	All Other: R-14.6ci Group R: R-16.7ci	All Other: U-0.057 Group R: U-0.051
Above grade floors framed	<b>0.074</b>	R-30	U-0.033



# Air Barrier and Thermal Envelope Example

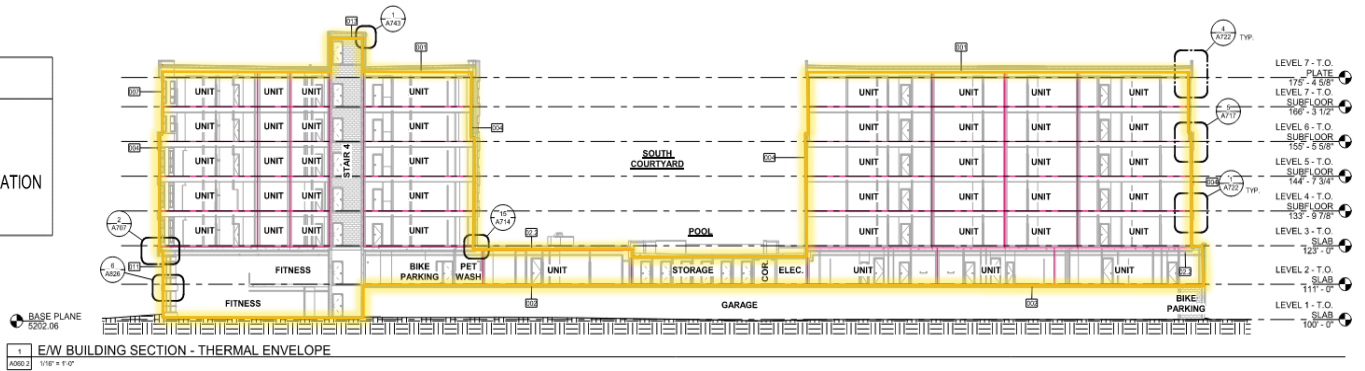


1 LEVEL 1 - THERMAL ENVELOPE



## LEGEND

-  AIR AND THERMAL ENVELOPE
-  INTERIOR COMPARTMENT, RE: UNIT COMPARTMENTALIZATION A060



1 E/W BUILDING SECTION - THERMAL ENVELOPE

# 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:

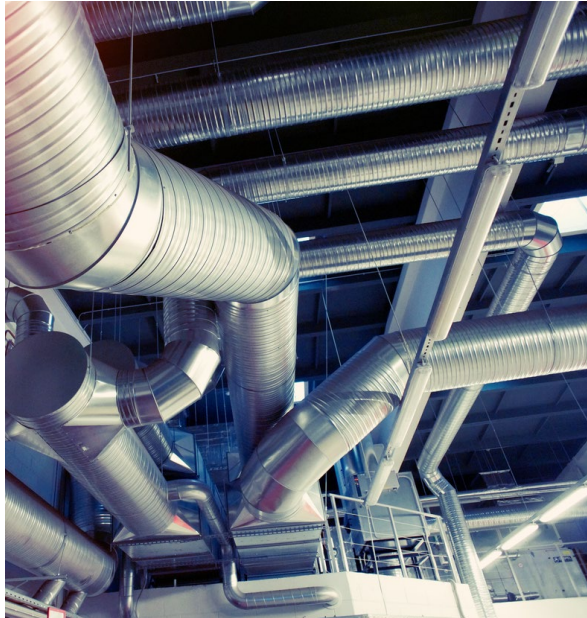
- C503.3.2 Low NOx Emissions requirements
- C503.3.3 Partial electrification

*\*same or similar to 2022 DEC*

## 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\*

# 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

*\*same or similar to 2022 DEC*

## 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**

# 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*





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# 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

### Commissioning Compliance Checklist

Project Information	Project Name:
	Project Address:
	Registered design professional or approved agency who completed commissioning:
Commissioning Plan (Section C408.2.1)	Commissioning Plan was used during construction and includes all items required by Section C408.2.1: (owner or owner representative to initial here)
Systems Adjusting and Balancing (Section C408.2.2)	Systems Adjusting and Balancing has been completed 1. Air and water flow rates have been measured and adjusted to deliver final flow rates within the tolerances provided in the produce specifications.
Functional Testing (Sections C408.2.3 and C408.3.1)	HVAC Equipment Functional Testing has been executed. If applicable, deferred and/or follow-up testing is scheduled to be provided on: __
	HVAC Controls Functional Testing has been executed. If applicable, deferred and/or follow-up testing is scheduled to be provided on: __
	Economizers Functional Testing has been executed. If applicable, deferred and/or follow-up testing is scheduled to be provided on: __
	Lighting Controls Functional Testing has been executed. If applicable, deferred and/or follow-up testing is scheduled to be provided on: __
Supporting Documents (Sections C408.2.5)	Service Water Heating System Functional Testing has been executed. If applicable, deferred and/or follow-up testing is scheduled to be provided on: __
	Manuals, record documents and training have been completed or are scheduled 1. System documentation has been provided to the owner or scheduled to be delivered to the owner on: __ 2. Record documents have been submitted to owner or scheduled to be delivered to the owner on: __ 3. Training has been completed or scheduled to be completed on: __
Preliminary Commissioning Report (Section C408.2.4 and C408.3.2.3.1)	Preliminary Commissioning Report submitted to Owner and includes all items required by Sections C408.2.4 and C408.3.2.3.1 as amended: (owner or owner representative to initial here) _
Certification	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 Denver Energy Code.
	Signature of Building Owner or Owner's Representative _____ Date _____

# 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

<b>Measured Air Leakage</b>	<b>C402.5.2 Dwelling and Sleeping Units</b>	<b>C402.5.3 All Other</b>
Pressure Differential	50 Pa	75 Pa
Target	0.3 CFM/SF	0.4 CFM/SF
Maximum Limit	0.45 CFM/SF	0.6 CFM/SF



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# 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

Building Type	Modeled Performance Target (kBtu/SF)
Apartment (Multifamily)	38
Hotel (Motel)	55
Office	43
Retail	39
Restaurant/Bar	175
Parking Garages	3

[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:*

[Link to Denver Modeling Rules and Procedures](#)

## 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

# 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)

**"Regulated":**  
Regulated by the energy code

**"Unregulated":**  
Everything else

$$\text{Target} = \frac{[\text{Baseline Unregulated} + (\text{BPF} \times \text{Baseline Regulated})]}{\text{Total Baseline}}$$

# 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%

Building Type	MODIFIED C407		APPENDIX SE	
	All Electric	Mixed Fuel*	All Electric	Mixed Fuel
Multifamily	0.78	0.57	0.71	0.60
Healthcare	0.70	0.56	0.70	0.59
Hotel/Motel	0.71	0.51	0.73	0.62
Office	0.57	0.42	0.59	0.51
Restaurant	0.63	0.51	0.75	0.63
Retail	0.49	0.39	0.58	0.48
School	0.58	0.40	0.69	0.58
Warehouse	0.29	0.23	0.40	0.33
All Other	0.58	0.44	0.64	0.54

\*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 =  
= Target x (1 - 0.12) –OR–  
= (EUI from Appendix PT) x (1 - 0.12)



[denvergov.org/greenroofs](https://denvergov.org/greenroofs)

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



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# 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](#)

C505.1 Energy- Demand Category	IBC Occupancies
4 (highest)	A, B small assembly
3	B gym, E, I-4, M
2	B (all other), I-1, I-2, I-3, R
1 (lowest)	F, H, S

# 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 (PCIt or PSEIt)







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# 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 G3.1.1-1

<b>Building Area Type</b>	<b>Baseline Window to Wall Area Ratio</b>
Healthcare (Outpatient)	21%
Hotel/Motel <75 rooms	24%
Hotel/Motel >75 rooms	34%
Office <5000 sf	19%
Office 5,000 – 50,000 sf	31%
Office >50,000 sf	40%
Restaurant (quick service)	34%
Restaurant (full service)	24%

# Defining the Baseline HVAC system

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

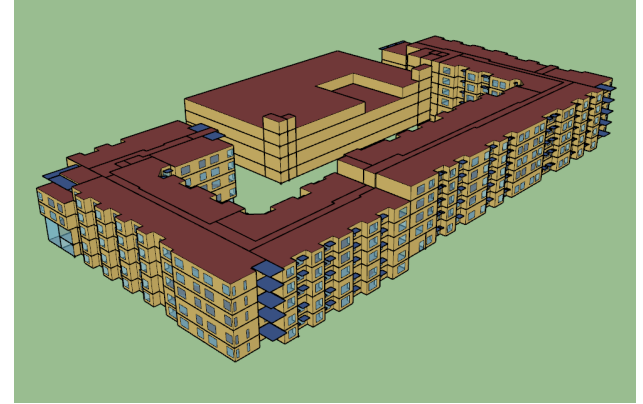
## Determine baseline by this priority:

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

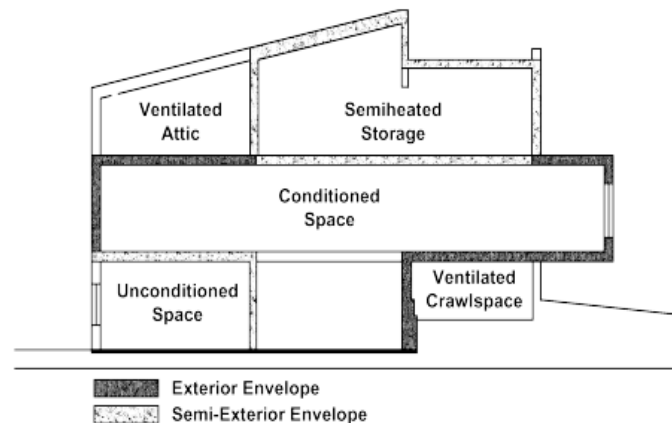


Building Type, Floors, and Gross Cond SF		Climate Zone 5 Systems
#1	Residential	System 1 - PTAC
#2	Other non-residential and <u>5 floors or fewer and 25,000 - 150,000 sf</u>	System 5 – Packaged VAV with reheat
#3	Other non-residential and 3 floors or fewer and < 25,000 sf	System 3 – PSZ-AC
#4	Heated-only spaces	System 9 – Gas furnace

# 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](#)\*

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

	Constant Coefficient (A)	Temperature Coefficient (B)	Window Speed Coefficient Linear Term (C)	Wind Speed Coefficient Quadratic Term (D)	Wind Speed
DOE-2 Infiltration Methodology	0	0	0.224	0	10 mph

\*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 ( $A_{FLR}$ ):
  - Air leakage as a function of above-grade walls ( $A_{AGW}$ ):

$$I_{FLR} = 0.112 \times I_{75Pa} \times S / A_{FLR}$$

$$I_{AGW} = 0.112 \times I_{75Pa} \times S / A_{AGW}$$

$I_{75Pa}$  = Air leakage of the thermal envelope at 0.3 in wg (75 Pa) =  $Q / S$

$Q$  = Volume of air flowing through building envelope

$S$  = Area of building envelope (above grade walls, floor, roof)

# C407.1 Infiltration Rates

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

*\*From updates for Council approval June 2023*

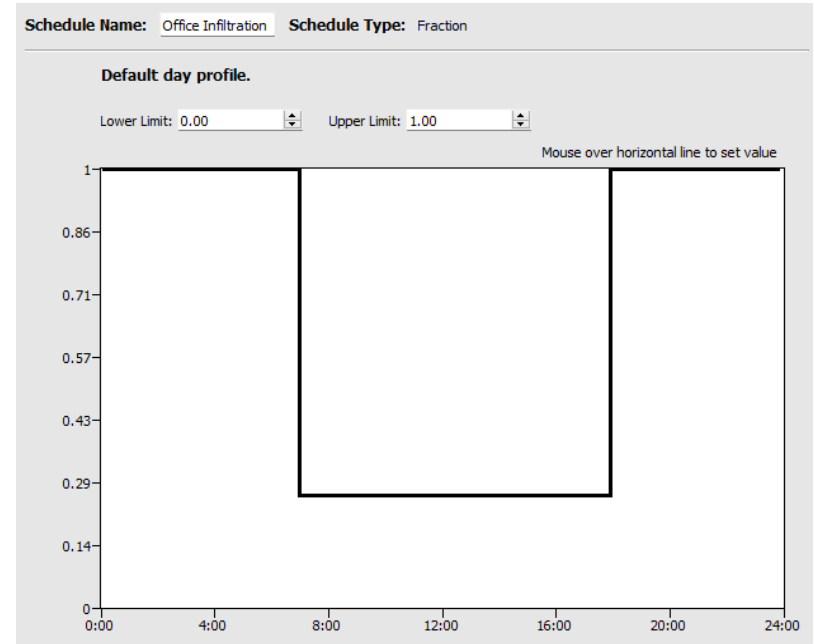




# C407.1 Infiltration Schedule

- 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

[Commercial Kitchen Equipment](#)

[Multifamily Modeling Protocol](#)

Fixture	Max Flow
Lavatory, private	1.5
Lavatory, public (metered)	0.25
Lavatory, public (non-metered)	0.5
Shower head	1.8
Sink faucet	1.5
Kitchen sink faucet	1.8

# 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  $(PBP_{nre} - PBP)/BBP > 0.10$ , new buildings, additions to existing buildings, and/or alterations to existing buildings shall comply with the following:

$$PCI + [(PBP_{nre} - PBP)/BBP] - 0.10 < PCI_t$$

# Instructions for CPD Plans Reviewers



## Action for Reviewer

*Note: dedicated Accela fields for this information are in development*

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<sub>DC</sub> array



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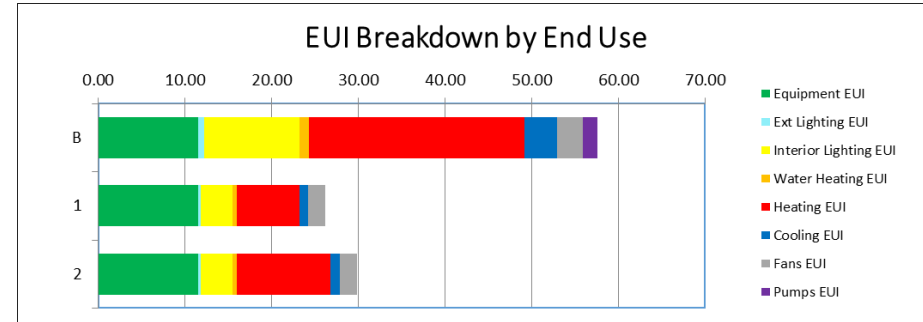
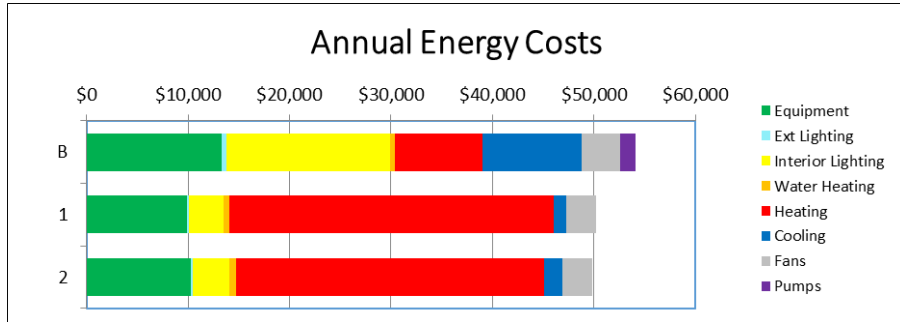
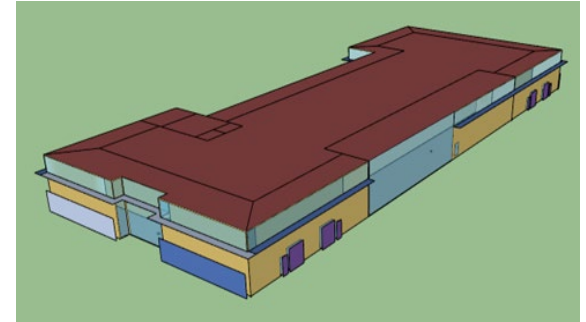
# Case Studies

# Case Study – Office

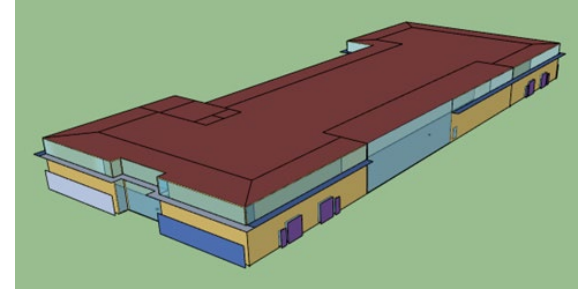
Baseline: System 5 – Packaged VAV with hot water heating

Proposed options:

1. All electric – Heat pump RTUs with electric reheat
2. Mixed fuel – Gas RTUs with electric reheat



# Office - Case Study



Building Type	BPF – All-electric Properties	BPF – All other Properties*
Office – C407 Energy Cost	0.57	0.42
Office – App SE Site Energy	0.59	0.51

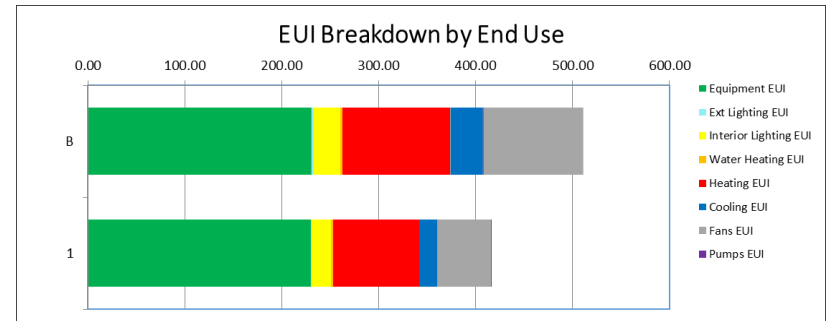
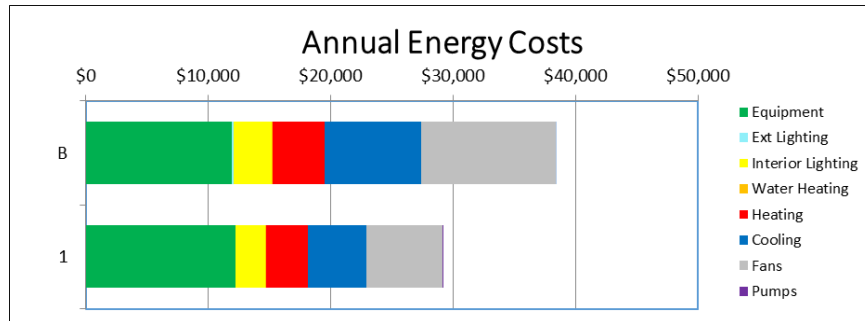
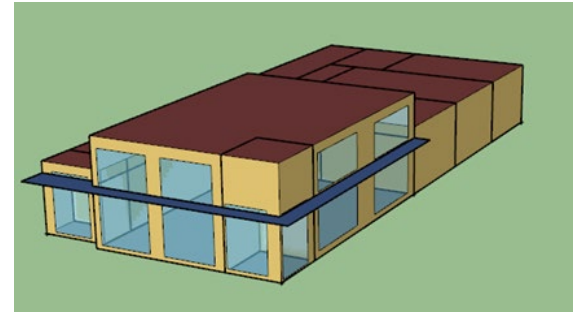
	Annual Energy Cost	% Cost Savings	Site EUI	C407 Target Cost	C407 Savings (%)	App SE Target EUI	App SE Savings (%)
Baseline	\$54,119	-	57.6	-	-	-	-
Proposed – Electric	\$50,776	6.2%	26.2	\$33,330	-52%	38.7	32%
Proposed – Mixed Fuel	\$49,788	8.0%	29.8	\$36,592	-36%	35.0	15%

\*From updates for Council approval June 2023

# Case Study – Restaurant

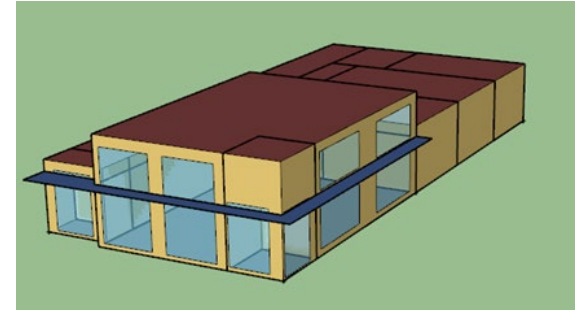
Baseline: System 3 – Packaged RTU with gas heating

Proposed: Mixed fuel – Gas RTUs





# Restaurant - Case Study



Building Type	BPF – All other Properties*
Restaurant – C407 Energy Cost	0.51
Restaurant – App SE Site Energy	0.63

	Annual Energy Cost	% Cost Savings	Site EUJ	C407 Target Cost	<del>C407 Savings (%)</del>	App SE Target EUJ	App SE Savings (%)	<del>PV Required for C407</del>	PV Required for App SE
Baseline	\$39,362	-	523	-	-	-	-	-	-
Proposed – Mixed Fuel	\$30,158	23.4%	432	\$27,001	-12%	394	-10%	21.7	34.8

\*From updates for Council approval June 2023

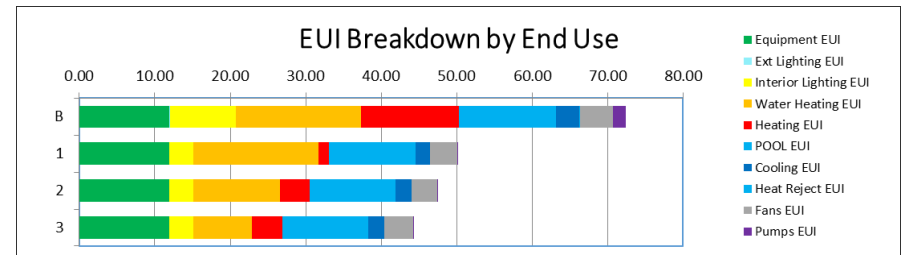
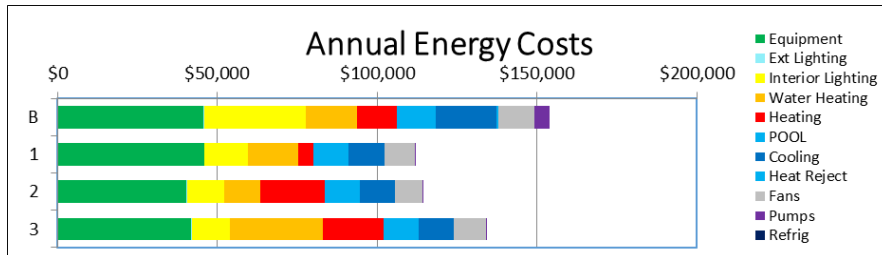
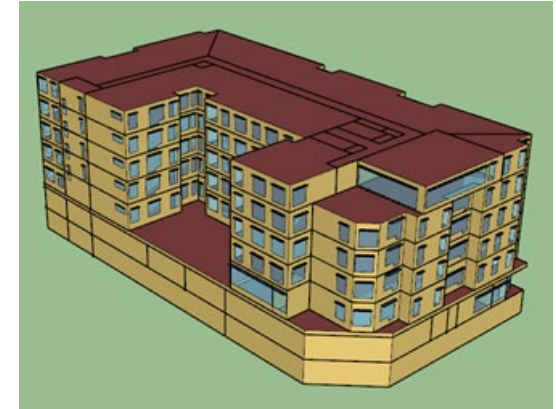
# Case Study – Multifamily

Baseline:

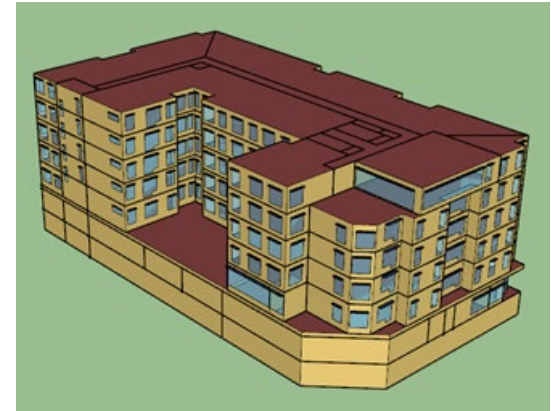
- System 1 – PTAC, and System 5 – Packaged VAV with hot water heating
- Gas pool boiler as a regulated load

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



Building Type	BPF – All other Properties*
Multifamily – C407 Energy Cost	0.57
Multifamily – App SE Site Energy	0.60

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

\*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



<https://www.energycodes.gov/ashrae-standard-901-performance-based-compliance-form>

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

<https://Denvergov.org/BuildingCode>

# 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\*

Model  
Results

## 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





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# Compliance Form / Companion Tool Demonstration

# Energy Modeling Report - Minimum

## 90.1 Compliance Form Minimum Inputs

*If using 2019 Commercial Energy Modeling Report Table 2*

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

# 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

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**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

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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](mailto:energy.review@denvergov.org)

# Thank you!

*For more information, visit:*

[Denvergov.org/EnergyCode](https://denvergov.org/EnergyCode)

[Denvergov.org/BuildingCode](https://denvergov.org/BuildingCode)

*Contact us:*

Questions about energy code: [energy.review@denvergov.org](mailto:energy.review@denvergov.org)

Questions about programs & resources: [sustainability@denvergov.org](mailto:sustainability@denvergov.org)