



City of Boulder Commercial Energy Code

A Prescriptive Pathway to Compliance for Buildings
Less Than 20,000 Square Feet Using the
Advanced Buildings: New Construction Guide

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Introduction

The City of Boulder recently updated the Boulder Energy Conservation Code and its minimum energy conservation requirements for new buildings, additions, alterations, renovations and repairs to existing buildings. The Energy Conservation Code updates are important not just to keep up with the many developments within sustainable construction practices but also continue an effort to make the building regulatory process work toward overall Climate Commitment goals.

In 2013 the City passed a resolution to reduce greenhouse gas emissions by 80% by the year 2050. Since buildings contribute upwards of 75% of greenhouse gas emissions, reducing emissions by improving building energy efficiencies is important to attaining the Climate Commitment goals. These guidelines are intended to assist building permit applicants in demonstrating compliance with the requirements of Chapter 10-7, Energy Code, Boulder Revised Code (B.R.C.) 1981. To the extent there is any conflict between these guidelines and the Boulder Revised Code, the Boulder Revised Code shall govern.

Code Compliance with the *Advanced Buildings: New Construction Guide*

Under Boulder's Energy Conservation Code, commercial buildings must achieve energy performance significantly exceeding national code baselines such as *ASHRAE/IESNA Standard 90.1* or the *International Energy Conservation Code (IECC)*. Permit applications for commercial buildings larger than 20,000 sf must utilize predictive computer modeling to demonstrate energy performance that is at least 30% better than *ASHRAE/IESNA Standard 90.1*. Permit applications for commercial buildings of 20,000 sf or less may also demonstrate energy code compliance by predictive modeling, but are also allowed to utilize *approved* prescriptive standards that achieve energy performance of at least 30% better than the 2012 edition of the *IECC*.

This document, hereinafter referred to as the *Boulder Application Guide*, describes how compliance with the prescriptive path options for commercial buildings of 20,000 sf or less and for remodels can be demonstrated using New Buildings Institute's *Advanced Buildings: New Construction Guide*. For more information about New Buildings Institute and the *New Construction Guide*, visit www.newbuildings.org.

Advanced Buildings: New Construction Guide

The *Advanced Buildings: New Construction Guide* is a comprehensive guide to achieve significant, predictable energy savings in new commercial construction. The Guide is composed of individual Criteria that define simple, discrete integrated design strategies and building features capable of delivering significant energy savings beyond energy code baselines such as the 2012 *International Energy Conservation Code*. The *Advanced Buildings: New Construction Guide* is structured in a series of increasingly stringent Tiers capable of delivering savings over different code baselines with different levels of stringency or different levels of savings over the same code baseline.

Each Criteria includes a “Requirements” section. These requirements constitute the content of each Criteria that must be met. Other sections, including Purpose, General, Best Practices and Application, support the criteria. These sections do not contain any requirements that must be met, but rather provide context and guidance as to how to meet the requirements of the Criteria.

Tiers 1 and 2 each contain a comprehensive set of Criteria addressing a full array of building features, from the thermal envelope to lighting efficiency and control to HVAC components. Tier 1 is equivalent to the 2012 IECC, and Tier 2 delivers significant savings above modern code baselines such as the 2012 IECC and 2010 ASHRAE-90.1. Tier 3 does not contain a comprehensive set of criteria as in Tiers 1 and 2. Instead, Tier 3 contains a set of “performance pathways¹,” energy savings measures that can save significant energy but may not be appropriate for all building types or all individual designs due to the impact on the building design. Although many of these performance pathways can be used together, designers would generally select only one or two of the performance pathways since each can have significant design impacts.

An extensive energy modeling protocol has been implemented to support development of the *Advanced Buildings: New Construction Guide*. The results of over 100,000 energy modeling runs using eQUEST software to run DOE-2 have been evaluated using a batch analysis protocol built into the eQUEST energy modeling tool. For each of the prototype buildings, three to five typical mechanical systems were defined to represent typical construction practice. For a more in-depth description of the modeling behind the development, see the Introduction of the *Advanced Buildings: New Construction Guide*.

Subsequent energy modeling was implemented to support the development of the *Boulder Application Guide*’s compliance packages for the City of Boulder. For additional information, see Appendix A.

For more information about the *Advanced Buildings: New Construction Guide*, visit <http://advancedbuildings.net/newconstruction>.

¹ These “performance pathways” should not be confused with the “compliance packages” described later in the *Boulder Application Guide*.

Compliance Packages for New Construction

This section details how to use the *Advanced Buildings: New Construction Guide* to demonstrate compliance with the prescriptive compliance path option in Boulder’s Energy Conservation Code for new construction of, and additions resulting in, buildings 20,000 sf or smaller. It defines five compliance package options based on the *Advanced Buildings: New Construction Guide* that will result in a building complying with Boulder’s Energy Conservation Code.

The Criteria in the *Advanced Buildings: New Construction Guide* each contain a set of requirements related to a single topic. For each Criteria, the *Advanced Buildings: New Construction Guide* also includes narrative guidance to help designers and contractors meet the requirements listed in the Criteria. The tiered structure of the *Advanced Buildings: New Construction Guide* allows it to address multiple code baselines with different levels of stringency or to deliver different levels of savings. However, the tiered structure is not utilized in the *Boulder Application Guide*. The five compliance packages presented in this section are composed of Criteria from Tier 2 and Tier 3 of the *Advanced Buildings: New Construction Guide* and are described in the following sections. Table 1 contains a summary of the Criteria that compose each Compliance Package.

Compliance requires meeting all the requirements of each Criteria listed in the Compliance Package. Each of the Compliance Packages also includes meeting or exceeding the 2012 IECC as a requirement. While Criteria in Tier 1 of the *New Construction Guide* are not required to be met as part of the Compliance Packages, the guidance provided for Tier 1 can be useful for meeting the requirements of the 2012 IECC. The Compliance Packages are described below:

Table 1: New Construction Compliance Packages

ALL Criteria this Column	PLUS ONE Package from this Column
Criteria 2.1: IECC 2012 Compliance Criteria 2.2: Air Barrier Performance Criteria 2.5: Daylighting Criteria 2.6: Lighting Controls Criteria 2.8: Exterior Lighting Efficiency Criteria 2.10: Economizer Criteria 2.11: Duct Construction Criteria 2.12: Fan Power Reduction Criteria 2.13: HVAC Controls Criteria 2.14: Fault Detection and Diagnostics Criteria 2.15: Water Heating Criteria 2.16: Acceptance Testing (Cx) Criteria 2.20: Lighting Power Density Criteria 2.22: Energy Recovery Ventilation Criteria 2.23: Demand Control Ventilation Criteria 3.8: Plug Loads	Package A: Advanced Envelope: Criteria 3.2: Advanced Envelope
	Package B: Advanced Daylighting: Criteria 2.18: Opaque Walls Criteria 2.19: Fenestration Criteria 3.3: Advanced Daylighting
	Package C: Advanced Office Lighting: Criteria 2.18: Opaque Walls Criteria 2.19: Fenestration Criteria 3.4: Advanced Office Lighting
	Package D: Advanced HVAC: Criteria 2.18: Opaque Walls Criteria 2.19: Fenestration -AND EITHER- Criteria 2.9: Efficient Equipment -OR- Criteria 3.6: VRF -OR- Criteria 3.7: Radiant Heating and Cooling
	Package E: Renewable Energy: Criteria 2.18: Opaque Walls Criteria 2.19: Fenestration -AND- An installed Renewable Energy System with a minimum system rating of 0.3 W/sf of conditioned area.

Package A: Advanced Envelope

The Advanced Envelope Compliance Package is organized around a super-efficient building thermal envelope with constrained window area and significantly reduced infiltration. The Package requires compliance with the following Criteria from the *Advanced Buildings: New Construction Guide*:

- Criteria 2.1: IECC 2012 Compliance
- Criteria 2.2: Air Barrier Performance
- Criteria 2.5: Daylighting
- Criteria 2.6: Lighting Controls
- Criteria 2.8: Exterior Lighting Efficiency
- Criteria 2.10: Economizer
- Criteria 2.11: Duct Construction
- Criteria 2.12: Fan Power Reduction
- Criteria 2.13: HVAC Controls
- Criteria 2.14: Fault Detection and Diagnostics
- Criteria 2.15: Water Heating
- Criteria 2.16: Acceptance Testing (Cx)
- Criteria 2.20: Lighting Power Density
- Criteria 2.22: Energy Recovery Ventilation
- Criteria 2.23: Demand Control Ventilation
- Criteria 3.8: Plug Loads
- Criteria 3.2: Advanced Envelope

Package B: Advanced Daylighting

The Advanced Daylighting Compliance Package is organized around a building design where pervasive daylighting and daylighting controls fulfill the lighting needs of nearly all the occupied spaces during daylight hours. The Package requires compliance with the following Criteria from the *Advanced Buildings: New Construction Guide*:

- Criteria 2.1: IECC 2012 Compliance
- Criteria 2.2: Air Barrier Performance
- Criteria 2.6: Lighting Controls
- Criteria 2.8: Exterior Lighting Efficiency
- Criteria 2.10: Economizer
- Criteria 2.11: Duct Construction
- Criteria 2.12: Fan Power Reduction
- Criteria 2.13: HVAC Controls
- Criteria 2.14: Fault Detection and Diagnostics
- Criteria 2.15: Water Heating
- Criteria 2.16: Acceptance Testing (Cx)
- Criteria 2.18: Opaque Walls
- Criteria 2.19: Fenestration
- Criteria 2.20: Lighting Power Density

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- Criteria 2.22: Energy Recovery Ventilation
 - Criteria 2.23: Demand Control Ventilation
 - Criteria 3.8: Plug Loads
 - Criteria 3.3: Advanced Daylighting

Package C: Advanced Office Lighting

The Advanced Office Lighting Compliance Package is organized around an office building design with a very advanced lighting system and a spatial design that optimizes the performance of the lighting system. This Package may only be used for buildings where no less than 85% of the conditioned floor area is office space. The Package requires compliance with the following Criteria from the *Advanced Buildings: New Construction Guide*:

- Criteria 2.1: IECC 2012 Compliance
- Criteria 2.2: Air Barrier Performance
- Criteria 2.5: Daylighting
- Criteria 2.6: Lighting Controls
- Criteria 2.8: Exterior Lighting Efficiency
- Criteria 2.10: Economizer
- Criteria 2.11: Duct Construction
- Criteria 2.12: Fan Power Reduction
- Criteria 2.13: HVAC Controls
- Criteria 2.14: Fault Detection and Diagnostics
- Criteria 2.15: Water Heating
- Criteria 2.16: Acceptance Testing (Cx)
- Criteria 2.18: Opaque Walls
- Criteria 2.19: Fenestration
- Criteria 2.20: Lighting Power Density
- Criteria 2.22: Energy Recovery Ventilation
- Criteria 2.23: Demand Control Ventilation
- Criteria 3.8: Plug Loads
- Criteria 3.4: Advanced Office Lighting*

*Where requirements from Criteria 3.4 conflict with the requirements from other Criteria, the requirements of Criteria 3.4 shall be met. The requirements of Criteria 3.4 shall apply only to office spaces.

Package D: Advanced HVAC Systems

The Advanced HVAC Systems Compliance Package is organized around an HVAC system design that utilizes either high efficiency equipment or highly efficient HVAC system selections. The Package requires compliance with the following Criteria from the *Advanced Buildings: New Construction Guide*:

- Criteria 2.1: IECC 2012 Compliance
- Criteria 2.2: Air Barrier Performance
- Criteria 2.5: Daylighting
- Criteria 2.6: Lighting Controls

Criteria 2.8: Exterior Lighting Efficiency
Criteria 2.10: Economizer
Criteria 2.11: Duct Construction
Criteria 2.12: Fan Power Reduction
Criteria 2.13: HVAC Controls
Criteria 2.14: Fault Detection and Diagnostics
Criteria 2.15: Water Heating
Criteria 2.16: Acceptance Testing (Cx)
Criteria 2.18: Opaque Walls
Criteria 2.19: Fenestration
Criteria 2.20: Lighting Power Density
Criteria 2.22: Energy Recovery Ventilation
Criteria 2.23: Demand Control Ventilation
Criteria 3.8: Plug Loads
Criteria 2.9: Efficient Equipment or Criteria 3.6: VRF or Criteria 3.7: Radiant Heating & Cooling

Package E: Renewable Energy System

The Renewable Energy System Compliance Package is organized around an onsite renewable energy system. The Package requires compliance with the following Criteria from the *Advanced Buildings: New Construction Guide* and the following sections:

Criteria 2.1: IECC 2012 Compliance
Criteria 2.2: Air Barrier Performance
Criteria 2.5: Daylighting
Criteria 2.6: Lighting Controls
Criteria 2.8: Exterior Lighting Efficiency
Criteria 2.10: Economizer
Criteria 2.11: Duct Construction
Criteria 2.12: Fan Power Reduction
Criteria 2.13: HVAC Controls
Criteria 2.14: Fault Detection and Diagnostics
Criteria 2.15: Water Heating
Criteria 2.16: Acceptance Testing (Cx)
Criteria 2.18: Opaque Walls
Criteria 2.19: Fenestration
Criteria 2.20: Lighting Power Density
Criteria 2.22: Energy Recovery Ventilation
Criteria 2.23: Demand Control Ventilation
Criteria 3.8: Plug Loads

Compliance with Package E requires the installation of an onsite renewable energy system (as defined by the IECC) with a system rating of at least 0.3 W/sf of conditioned floor area.

Compliance Packages for Existing Building Projects

As with new construction projects, Boulder’s Energy Conservation Code allows existing building project applications to demonstrate compliance through predictive modeling that shows that the entire building’s performance is 30% better than ASHRAE/ANSI Standard 90.1-2010. However, the Code also sets three additional energy efficiency options for existing building project applications to demonstrate compliance. One option is to demonstrate that the altered building area or system is 30% better than the 2012 IECC through modeling energy performance in accordance with Section 407 of the 2012 IECC. Another option allows the registered design professional to submit an “implementation plan” which shows how the “process will contribute to future energy efficiency improvements to bring the building up to 30% above the 2012 IECC.” A final option is to follow an approved set of prescriptive requirements that are at least 30% more efficient than the 2012 IECC. This section describes this last option.

This section of the *Boulder Application Guide* presents the “set of prescriptive requirements” that are at least 30% more energy efficient than the 2012 IECC. It defines a discrete set of building systems and directly relates them to Criteria from the *Advanced Buildings: New Construction Guide*. Improvements to existing buildings require greater flexibility, and the *Boulder Application Guide* attempts to provide a large variety of options for meeting an approved set of prescriptive requirements.

The application scope of the *Boulder Application Guide* to existing buildings is determined in accordance with Section C101.4 of the 2012 IECC. Section C101.4.3 lists 8 exceptions where remodeling projects do not need to meet the compliance requirements of Boulder’s Energy Conservation Code. Remodel work that is limited to mechanical equipment replacement, need only meet the requirements of Sections C403 and C404. For projects with additions, to show compliance under the prescriptive path options presented in this *Boulder Application Guide*, the addition must meet the requirements of the New Construction section while all remodel work on the existing building must meet the requirements of this section.

Linking Remodel Activities to Requirements

The matrix in Table 2 below lists the building systems that might be affected by a permitted remodel activity and connects them to the Criteria from the *Advanced Buildings: New Construction Guide*. It also includes requirements for all remodel projects. In order to comply with the Boulder Energy Conservation Code using the “prescriptive path” a permitted remodel activity that affects a building system in Table 2 must meet the requirements for that building system listed in Column A in addition to the requirements from Column B, Column C or Column D. The requirements for the buildings systems are described in greater detail on the next page.

Table 2: City of Boulder
Energy Code Existing Buildings
Compliance Options

System Type	PLUS Either Column B OR Column C OR Column D			
	Column A	Column B	Column C	Column D
All Projects:	Criteria 2.1: IECC 2012 Compliance Criteria 2.16: Acceptance Testing (Cx)			
HVAC:	Criteria 2.12: Fan Power Reduction Criteria 2.11: Duct Construction (where exposed)	Criteria 2.14: Fault Detection and Diagnostics plus Criteria 2.13: HVAC Controls plus Criteria 2.10: Economizer plus Either Criteria 2.18: Energy Recovery Ventilation OR Criteria 2.19: Demand Control Ventilation	Criteria 3.7: Variable Refrigerant Flow OR Criteria 3.8: Radiant Heating and Cooling	A renewable energy system with a minimum system rating of 0.1 W/sf of conditioned area
Envelope: Walls	Criteria 2.18: Opaque Walls Criteria 2.19: Fenestration Performance Criteria 2.2: Air Barrier Performance (when exposed)	Table 3.2.1 of Criteria 3.2: Advanced Envelope Performance	Criteria 3.3: Advanced Daylighting	A renewable energy system with a minimum system rating of 0.1 W/sf of conditioned area
Envelope: Roof	Criteria 2.18: Opaque Walls (Roof only) Criteria 2.19: Fenestration Performance (Skylights only)	Table 3.2.1 of Criteria 3.2: Advanced Envelope Performance	Criteria 3.3: Advanced Daylighting	
Interior Lighting	Criteria 2.20: LPD Criteria 2.6: Lighting Controls	Criteria 3.8: Plug Loads OR Criteria 3.4: Advanced Office Lighting (for office occupancies only)	Criteria 3.3: Advanced Daylighting	A renewable energy system with a minimum system rating of 0.1 W/sf of conditioned area
Exterior Lighting	Criteria 2.8: Exterior Lighting Efficiency	N/A	N/A	N/A
Water Heating	N/A	Criteria 2.15: Water Heating	N/A	An onsite solar hot water system, renewable energy system or waste heat recovery system capable of delivering 60% of peak hot water demand

Package Application Descriptions

1. **All Projects** – All existing building projects, regardless of what building systems they affect, must meet the requirements of Criteria 2.1 and 2.6.
2. **HVAC Retrofit** – Projects that redesign or replace all or part of the mechanical system must meet the fan power requirements of Criteria 2.12 and the duct construction requirements of Criteria 2.11 (where ducts are accessible). Projects must then choose between a suite of requirements for traditional air-based systems, an alternate highly efficient HVAC system, or the installation of an onsite renewable energy system with a minimum system rating of 0.1 W/sf of conditioned area.
3. **Envelope Retrofit** – When existing building envelope elements are altered or replaced, those sections of the envelope must meet the applicable requirements of Criteria 2.18, Criteria 2.19 and Criteria 2.2. When there is a reroofing or roof replacement that exposes the insulation above deck, the insulation performance requirements of Criteria 2.18 must be met. In addition, envelope projects must choose between complying with Table 3.2.1 from Criteria 3.2, the implementation of Criteria 3.3 or 3.4 (for office types only), or the installation of an onsite renewable energy system with a minimum system rating of 0.1 W/sf of conditioned area.
4. **Interior Lighting Retrofit** – Replacements of more than 50% of the luminaires generally triggers the requirements of Boulder's Energy Conservation Code. Lighting systems must then meet the LPD and lighting requirements of Criteria 2.6 and 2.7. In addition, these project must choose between meeting the requirements of Criteria 3.8, the implementation of Criteria 3.3 or 3.4 (for office types only), or the installation of an onsite renewable energy system with a minimum system rating of 0.1 W/sf of conditioned area.
5. **Exterior Lighting Retrofit** – Projects that impact exterior lighting must meet the requirements of Criteria 2.8
6. **Water Heating** – Projects that impact Service Hot Water systems must choose between meeting the requirements of Criteria 2.15 or installing a renewable energy or waste energy recovery systems capable of providing at least 60% of the peak hot water demand of the building.

Appendix A: Modeled Savings For Boulder

The extensive modeling protocol used to develop the *Advanced Buildings: New Construction Guide* was augmented with specialized modeling specifically for Boulder. The analysis was limited to Boulder's climate zone, Zone 5, with climate data for the city of Boulder itself. In addition to the original building prototypes for office, retail and warehouse, a building prototype for restaurants was also added to the modeling protocol.

The savings requirements for the Boulder Energy Conservation Code require the additive savings from most of the Criteria in *Advanced Buildings: New Construction Guide*. In the original modeling protocol, all of the enhanced Criteria from Tier 2 and all of the Performance Pathways from Tier 3 were analyzed separately. However, due to the interactive effects of different building elements, those individual savings cannot just be added together in order to find out total savings for all of the Criteria combined.

Therefore, for the Boulder analysis, the Criteria from the *Advanced Buildings: New Construction Guide* were organized around the base measures from Tier 2 with one of each of the Performance Pathways from Tier 3. The remaining measures were then analyzed additively until the 30% target was achieved.

The renewable energy requirement was sized using the same methodology used to size the renewable energy option developed for Section C406 of the 2012 International Energy Conservation Code. That methodology uses a representative code compliant building and a national average production/capacity factor for a typical photovoltaic system to establish a sizing requirement. For the Boulder renewable energy option, the code compliant representative building is specific to the Boulder climate and weather data and the renewable energy production target is 2% of total building energy use. For the existing buildings section, that target was adjusted to represent a renewable energy production target that reflects the system energy use instead of whole building energy use.

This section may be updated as further savings analysis is performed.