ZERO ENERGY READY HOMES BEST PRACTICES GUIDE

As of May 10, 2024

Prepared for: Town of Crested Butte
Prepared by: Michael Harris

TABLE OF CONTENTS

List of Acronyms

ASHP	Air source heat pump
ASRE	Adjusted sensible recovery efficiency
AHJ	Authority having jurisdiction
CEO	Colorado energy office
COP	Coefficient of performance
EPA	Environmental protection agency
ERV	Energy recovery ventilator
EV	Electric vehicle
EVSE	Electric vechicle supply equipment
GHG	Greenhouse gas
GSHP	Ground source heat pump
HPWH	Heat pump water heater
HRV	Heating recovery ventilator
HSPF	Heating seasonal performance factor
IAQ	Indoor air quality
MEP	Mechanical, electrical, plumbing
NEEP	Northeast energy efficiency partnership
SEER	Seasonal energy efficiency ratio
ZERH	Zero energy ready homes

ZERO ENERGY READY HOMES BEST PRACTICES GUIDE

Introduction

This guide is designed to help users navigate the ENERGY STAR and Zero Energy Ready Homes (ZERH) certification process. It covers program requirements at a high-level with a specific focus on Crested Butte's climate zone and local code amendments. The guide also covers suggestions for all-electric, cold-climate mechanical equipment selection as required by Crested Butte's building codes.

Purposes and Limitations of this Guide

The most comprehensive resource available for both programs is the information from the Department of Energy directly (links in Appendix A). This guide is not a substitute for engaging an energy consultant during the design and construction process. A third party energy rater will need to be engaged to complete the required construction phase testing; however the best results will be achieved if the consultant is engaged early during the design phase.

Types of Construction Covered

This guide is focused primarily on the single-family and multifamily programs of the Zero Energy Ready Home program. Key differences between the single and multifamily programs are called out. The guide does not cover technologies that are multifamily specific, such as central HVAC or water heating systems.

High-Level Best Practices

While many of the suggestions in this document are specific to building systems and programmatic requirements, there are two high-level best practices that are overarching and should be implemented in every scenario:

Engage an Energy Rater Early

All of the ZERH pathways require the use of a certified energy rater or energy rating company. This entity is qualified to complete the necessary reviews, modeling, and/or testing required to achieve ZERH certification and is responsible for submitting this information to the DOE. The energy rater should be engaged during conceptual or schematic design to provide project specific ZERH requirements. Late engagement can result in redesign efforts and inaccurate construction cost estimates. A list of local energy rating companies is included in Appendix B.

Budget Appropriately

Outside of very high-performing green buildings, most standard designs will be an inaccurate basis of pricing for designing to ZERH requirements. When working with general contractors and subcontractors to secure pricing, ensure that they are referencing the specific equipment and assemblies in the ZERH design.

Background on Electrification

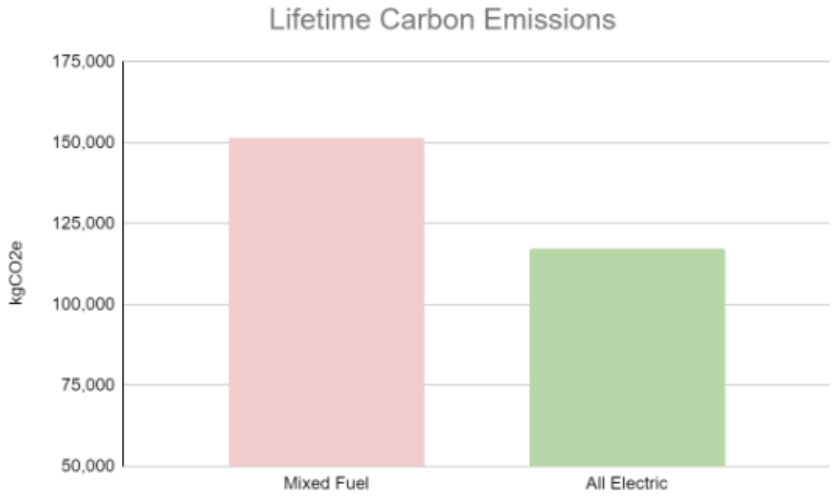
Why Require ZERH Certification and All-Electric Design?

Previous updates to building energy codes have focused on health, safety, and efficiency. In contrast, requirements around all-electric design are primarily driven by carbon emission reduction goals.

Buildings are a significant source of carbon emissions in the United States. Electrification is a powerful emission mitigation strategy for regions with a clean electricity grid. As the electricity grid transitions to renewable energy generation, the carbon emission intensity of all-electric buildings is reduced. In contrast, the carbon emissions from natural gas fueled equipment are fixed. Electrifying Colorado buildings at new construction is often the most cost effective route to a lower emissions profile over a property's useful life.

Lifetime Carbon Emissions

The State of Colorado has recognized the need for action on climate change. In 2021, Colorado released its Greenhouse Gas (GHG) Pollution Reduction Roadmap with a plan to reduce grid emissions 50% by 2030 and 90% by 2050. The greening of Colorado's electricity grid makes the elimination of on-site fossil fuel use a critical GHG reduction strategy. This is also true for Crested Butte. Tri-state, the entity that provides power to Gunnison County Electric Association, has adopted carbon reduction policies that will drastically reduce the carbon footprint of their electricity. The lifetime carbon emissions of an all-electric design is 23% less than a comparable mixed-fuel building If the grid decarbonizes faster than anticipated, these carbon savings will increase.



The table above compares the carbon emissions of the same project in Crested Butte using natural gas and all-electric systems.

Electrification Costs and Incentives

A number of tax credits, rebates, and grants exist to help pay for building electrification. **Links to funding sources available at the time of publication are provided in Appendix A.** Below is a summary of these funding sources and cost saving opportunities:

- **Natural gas infrastructure costs** - All-electric projects avoid costs associated with utility natural gas service, distribution infrastructure, and the equipment venting required by combusting fossil fuels.

- **State of Colorado heat pump tax credit** - This program provides a tax credit to the owner or contractor for air source heat pumps, ground source heat pumps, and heat pump water heaters.

- **Inflation Reduction Act -** This nationwide piece of legislation has a number of incentives and tax credits available for heat pump equipment. Please see Appendix A for links to each of these programs.
  - 45L tax credit (see section below)
  - Revised Section 48 Solar Investment Tax Credit
  - Home Energy Rebate Program (rehabilitation projects only)
  - Clean Energy Tax Credits (single family)

- **Gunnison County Electric Association** - Gunnison County Electric Association provides equipment specific rebates as well as a bonus rebate for all-electric new construction.

45L Tax Credit

The Inflation Reduction Act passed in 2022 adjusted the existing 45L tax credit so that it is tied to achieving ENERGY STAR or Zero Energy Ready Homes certification. For the multifamily certification, the amount of the tax credit varies by whether Davis Bacon wages are paid. The 45L tax credit amounts are as follows:

Certification	Base level credit	Credit with prevailing wage
Zero Energy Ready Homes MF	$1,000/Unit	$5,000/unit
Zero Energy Ready Homes SF	$5,000/home	

45L Tax Credit Process

The outline below summarizes the process of claiming the 45L tax credit associated with ZERH. There are numerous financing scenarios and ownership structures that would change the nature of how this tax credit is claimed. The description below assumes a standard development structure with an equity partner providing the capital for construction.

1. **Design and early financing phase**
   A. Equity partner agreement - Ensure that the equity partner or primary investor has interest in purchasing the 45L tax credits.
      i. For tax credit projects – The tax credit investor must buy the 45L tax credits, so this should be incorporated into the project's yield analysis.
      ii. For market rate projects – The limiting factor for market rates projects is whether the equity partner has the capacity/interest in utilizing the 45L tax credits. Before moving forward, this partner should be consulted to see if this is a viable option.
   B. Engage an energy rating company to ensure that the design will meet the requirements of the certification being pursued.

2. **Construction phase** - Ensure that the energy rating company is coordinated with the general contractor and that the required inspections and testing are occurring.

3. **Post construction monetization**
   A. Once construction is completed and all programmatic requirements have been achieved, the energy rating company will provide one certificate per unit demonstrating that the certification has been achieved. This information should be shared with the tax preparer/ accountant associated with the project.
      i. Optional - If pursuing the increased incentive associated with Davis Bacon wages, the General Contractor will provide or have on file the documentation for this requirement.
   B. The tax preparer will finalize the process through completing IRS Form 8908, Energy Efficient Home Credit.

Local Requirements

Crested Butte Requirements

Crested Butte has adopted a number of code amendments that differ from the standard I-code requirements. Below is a summary of the key requirements around energy efficiency and electrification as they apply to new construction.

Crested Butte Energy Requirements

Crested Butte has the following requirements that impact energy efficiency and design of new construction:

- The 2021 series of I-codes - Crested Butte has adopted the 2021 versions of the International codes. Please see Appendix A for links to free online copies of these codes. A summary of their currently adopted codes is as follows:
  - 2021 International Building Code
  - 2021 International Residential Code
  - 2021 International Mechanical Code
  - 2021 International Fire Code
  - 2021 International Property Maintenance Code
  - 2021 International Energy Conservation Code
  - 2021 International Green Construction Code
  - 2021 International Existing Building Code
  - 2023 National Electrical Code
  - 2021 International Fuel Gas Code
  - 2021 International Plumbing Code
- Zero Energy Ready Homes certification - New residential construction, as defined by the IECC, is required to achieve ZERH certification under the currently applicable program requirements.
- Renewable Energy Mitigation Program - Outdoor energy uses, such as snowmelt and pool heating, require using REMP documentation to demonstrate compliance with Crested Butte requirements. This documentation demonstrates how your design will generate the appropriate renewable energy offset necessary to install this equipment. This program also provides a fee in lieu option for compliance.
- Solid Fuel Burning Device Permit - In order to install solid fuel burning devices (i.e. wood-stoves) Crested Butte has specific requirements. If this is an element of the design, make sure to review these requirements prior to submitting for permit.

Crested Butte Electrification Requirements

In addition to the efficiency requirements described above, Crested Butte has a number of amendments and requirements around electrification and electrification ready design. These are described below:

- All-electric design - New construction, with the exception of commercial kitchens, is required to use electricity for space heating, water heating, and appliances.
- Electric Vehicle Ready - All new residential construction must meet electric vehicle readiness requirements. Please review Appendix C for a detailed comparison of the EV requirements in Crested Butte code and ZERH. Both sets of requirements must be met.
- Solar Photovoltaic Requirements - Depending on the type and size of the building in question, different solar PV requirements will apply. Below is a high-level summary of the requirements
  - Commercial construction < 5,000 square feet - Must be solar-ready
  - Commercial construction >5,000 square feet - Must include solar PV
  - Residential construction - Must meet the solar PV ready requirements within ZERH

Crested Butte Existing Building Requirements

Crested Butte has modified the Existing Building Code to be in line with the electrification requirements described above. Below is a high-level summary of these requirements. It is recommended that this code section be reviewed in detail early in the design process.

- All Level 3 alterations shall be Electric-Ready as defined by the code. This applies to the following equipment: natural gas heating systems, water heating, cooking equipment and clothes dryers.

- Commercial Level 3 Alterations
  - < 5,000 square feet - Must be solar-ready
  - >5,000 square feet - Must include solar PV
  - Regardless of size - Buildings with 2 or more parking spaces shall have one Level II EVSE installed. 10% of the total required parking spaces shall be EV-ready.

- Residential Level 3 Alterations
  - Home Energy Assessment - A Building Performance Institute accredited professional must complete an energy audit of the structure and provide a list of recommended improvements. These assessments are provided through Energy Smart Colorado. A link to this webpage is in Appendix A.
  - There shall be one EV-ready parking space per dwelling unit

- Historic Building Level 3 Alteration - These buildings shall meet the requirements of the 2021 IECC as adopted by Crested Butte in as much as they can be met without damaging existing historic structure. It is recommended that the project team consult with the Town of Crested Butte Building Department early in design to review the project, exceptions, and proposed scope of work.

Zero Energy Ready Homes Overview

Program Introduction

The Department of Energy's Zero Energy Ready Homes program is designed as an add on to the existing ENERGY STAR for New Construction programs. The intent of the program is to build upon the requirements in ENERGY STAR so that with the addition of solar PV, a home can operate on a Net Zero energy basis. To achieve this, ZERH program requirements have been designed with above-code levels of performance for envelope and MEP systems. Costs associated with ZERH will be higher than standard, code-minimum construction.

ENERGY STAR Requirements

As mentioned above, the ZERH program is built upon ENERGY STAR requirements. These requirements will not be reviewed in detail within this document as they are generally superseded in difficulty by ZERH. Comprehensive resources for ENERGY STAR can be found on their website linked in Appendix A.

Program Versions

ZERH is divided into three separate programs: single family, multifamily, and modular. This document will focus on the requirements within the single and multifamily programs. Compliance with the modular program is managed at the factory level and has much less involvement from the design and construction teams. The single family and multifamily programs function substantially the same: the envelope and MEP system requirements are similar and the same macro categories are in each program. The main difference is that the multifamily standard considers items that are unique to those building types, such as common area equipment or EV requirements across shared parking lots.

Townhomes

There are some construction types, such as townhomes, that can potentially certify under either the single or multifamily versions of ZERH. A townhome is defined by ANSI/RESNET/ICC 301 as a "single-family dwelling unit constructed in a group of three or more attached units in which each unit extends from the foundation to roof and with open space on at least two sides." If the structure in question meets this definition, it can certify under either version. In this case the project team has leeway to choose the pathway that makes the most sense for the project. This has implications for the 45L Tax Credit and the applicable requirements within ZERH.

ZERH Requirements

The program requirements below reflect the **Version 2 Revision 01** ZERH documentation available from the DOE. This guide is not intended to be a substitute for the published documentation, but to highlight the key areas to focus on in design.

Pathways

ZERH has multiple compliance pathways that allow the project team to choose the most appropriate path. All of the pathways below require the use of a third-party energy rater and/or energy modeler. The pathways are as follows:

- **Prescriptive compliance** - This pathway involves complying with all requirements of the ZERH program as written. The energy rater gathers documentation of compliance throughout the course of design and construction. This documentation is submitted to a DOE csubcontractor for review and approval. The main benefits of this pathway are that it is straightforward and predictable: as long as the project meets the program requirements and can provide sufficient documentation, certification will be achieved. The downside of this pathway is that outside of the alternatives included in footnotes, there is no flexibility in how requirements are met.

- **Energy Rating Index (ERI) -** This pathway involves using a Energy Rating Index (ERI) model developed by the energy rater to confirm compliance with ZERH requirements. In this scenario, some ZERH requirements are still prescriptive, but more flexibility is offered around the selection of select building system components. As long as the modeled home is at or below the performance of the reference home as determined by the modeling software, it meets ZERH requirements. During the construction phase, the energy rater completes testing and site observations to confirm that their model matches the built structure. Any changes from their model will need to be incorporated before the project is registered. The benefit of this pathway is that it provides additional flexibility not available in the prescriptive pathway. The drawback of this pathway is that the HERS model requires a fairly well developed design to be accurate, so warranting compliance early in the design process is difficult.

- **ASHRAE Pathway (multifamily only)** - In this pathway, an energy modeling company completes a whole-building energy simulation which is paired with an energy rater completing field verification activities to achieve ZERH certification. In many cases, this requires two separate energy consultants to complete this pathway, as many energy rating companies do not also provide whole building modeling services.

Envelope

Version 2 of ZERH requires compliance with the 2021 IECC envelope targets. As mentioned above, the pathway chosen for ZERH will have implications about how firm these targets are and if any trade-offs are available. In general, assemblies that prescriptively meet the applicable 2021 IECC requirements serve as a good basis of design that ensures compliance with ZERH and energy code requirements.

To navigate the table below, a number of factors should be considered:

- The IECC defines the applicable requirements based on a mix of occupancy and building height. Multifamily buildings greater than 4 stories will meet the commercial requirements. Multifamily buildings 3 stories or less, townhomes, duplexes, and single family dwellings will all fall under the residential requirements.

- The ZERH requirement listed is based on the ZERH model home. This is only a hard requirement under the prescriptive pathway, other pathways would allow for trade-offs in the model.

- It is necessary to coordinate ZERH and code compliance approaches to ensure that assemblies are compliant for both sets of requirements.

- As mentioned above, the simplest and most direct route to ZERH compliance is to simply choose prescriptive, code-compliant assemblies.

Component	2021 IECC Residential Targets	ZERH Target Home Requirement - SF*
Air leakage target	Single-family (all) - 3ACH50 Multifamily - 0.30 CFM/SF Shell	Detached - 2.0 ACH Attached - 3.0 ACH Multifamily - 0.25 CFM/SF Shell
Basement Wall	- R15 continuous interior -R19 cavity interior -R13 cavity + R5 continuous	- R15 continuous interior -R19 cavity interior -R13 cavity interior + R5 continuous
Ceilings	R60	R60
Fenestration - U-factor	0.30	0.30
Floor over exterior	R38	R38
Slab edge insulation	R10 to 4ft	R10 to 4ft
Walls	- R20 Cavity + R5 continuous - R13 Cavity + R10 continuous - R20 continuous	- R20 Cavity + R5 continuous - R13 Cavity + R10 continuous - R20 continuous

**The ZERH program allows for multifamily buildings to meet either the 2021 IECC Residential or Commercial envelope targets. The reference home will always be based on the Residential requirements (shown here).*

Mechanical, Electrical, and Plumbing Systems

Given Crested Butte's all-electric code requirement, the number of ZERH-compliant MEP systems are limited to a handful of selections at this time. The sections below focus on the types and efficiencies of relevant all-electric equipment.

Electric Equipment and Cold Climates

In order to effectively choose electric equipment in cold climates, it is necessary to understand how electric equipment functions and the types of equipment available. Broadly speaking, all-electric heating equipment falls into two efficiency categories:

1. **Electric resistance** - This equipment relies on electric resistance elements to produce heat for space or water heating purposes. While electric resistance is close to 100% efficient, it is still an expensive way to generate heat. This technology has a lower upfront cost as compared to the heat pump equipment covered below. It is incredibly hard to achieve ZERH performance levels with the use of electric resistance equipment alone. This guide focuses primarily on heat pump equipment. It is important to note that in many cases, heat pump equipment will have electric resistance back-up. This is acceptable under ZERH, as proper design and operation will minimize electric resistance back-up heat run-time.
2. **Heat pump equipment** - A heat pump is a generic term for a piece of equipment that is moves heat from one place to another. In general, heat pumps are distinguished by the source of heat, such as air source, ground source, and water source. The most common heat pumps are air and ground source heat pumps:

   Heat pump technology is rapidly changing and available product lines are expanding daily to meet the demand for all-electric systems. The information in this guide is a point in time snapshot based on the current state of the industry. It is highly like that the price, reliability, and availability of this equipment will improve significantly in the next 5-10 years. The optimal equipment selection for a building should be based on what is available at the time of design.

Life Cycle Cost Analysis

A life cycle cost analysis (LCCA) is a holistic tool for evaluating system alternatives. Full life cycle analysis is traditionally used to quantify both environmental and economic impacts. Operational and embodied carbon calculations show the cradle to grave emissions associated with a design. However, LCCAs are an excellent tool for estimating the monetary impacts of various building system options. Key components include:

- Incentives, rebates, and grants
- First cost
- Utility cost
- Maintenance cost
- Equipment estimated useful life and replacement equipment costs
- Residual Value

Less efficient building systems are typically cheaper upfront, while high efficiency buildings typically have reduced operating costs and higher residual values. Some high efficiency technologies have varying maintenance and estimated useful life values, which can significantly impact an LCCA. While collecting the information needed for a quality LCCA can be a time intensive effort, the analysis will significantly improve early design decisions.

Space Heating and Cooling Selection

In order to meet ZERH performance requirements, there are essentially two all-electric options: air source heat pumps and ground source heat pumps. While it is technically possible to achieve ZERH performance levels with electric resistance heat, the levels of insulation required are well beyond standard construction techniques and are typically not cost-effective. Given Crested Butte's climate, cooling efficiency generally has minimal impact on overall building performance in ZERH models. This climate zone has very small cooling loads so cooling equipment has minimal runtimes and uses little energy compared to space heating.

Air Source Heat Pumps

The ZERH efficiency target for air source heat pumps is an Heating Seasonal Performance Factor (HSPF) of 9.5. An important performance factor for air source heat pumps is low temperature operation. At very cold temperatures, if the air source heat pump cannot keep up with the load, supplementary electric resistance heating is required. The temperature at which the heat pump transitions to electric resistance is known as the changeover temperature. While not a published requirement in ZERH literature, this changeover temperature is an important factor in performance models. Choose an ASHP with the lowest changeover temperature that is financially feasible for the project. At a minimum, the equipment should be capable of retaining 75% of its capacity down to 5F.

Air source heat pumps (ASHP) draw heat from the air. This technology can achieve 300-400% efficiency, meaning that for every 1 unit of electricity going into the equipment, 3-4 units of heat are put into the home. This level of performance significantly reduces operating cost, reducing the utility cost gap between all-electric and gas fueled systems. A limitation of air source heat pumps is that as outdoor air temperature changes, so does the efficiency of the equipment. As outdoor air temperature decreases, there is less available energy and the heat pump must work harder. Up until the past few technology cycles, air source heat pumps could not operate in very cold climates like Crested Butte. This is no longer true, as many manufacturers offer ASHPs that can operate in heat pump mode down to -22F. There is significant variation in the capabilities of ASHPs, making the selection of appropriate equipment challenging. In general, ENERGY STAR or Northeast Energy Efficiency Partnership (NEEP) certified cold-climate equipment are good ways to identify equipment suitable for Crested Butte's climate.

Ground Source Heat Pumps

The ZERH performance target for GSHP systems is a coefficient of performance (COP) of 2.8 or greater, which is easily achievable for most GSHP systems. GSHPs can also be used to provide domestic hot water as well as space heating. The primary drawback of GSHPs are the significant first costs associated with installing the required ground loops. The location of the site is also an important factor as the soil must be appropriate for the ground loops.

Ground source heat pumps (GSHP) use the soil as a source for energy. Since the ground remains at a relatively constant temperature below frost depth, this is an ideal source of energy for a heating system. The primary drawback of GSHPs is the first cost associated with the ground portion of the loop, which adds a significant cost not present with ASHPs. Operating and equipment replacement cost savings can help offset GSHPs first cost premium.

Heat Delivery Method

Both ASHPs and GSHPs can deliver heat into a home via air-based or water-based delivery systems. Air-based delivery systems will generally require central ducting and integrate well with balanced ventilation systems. Ducting triggers several ZERH performance requirements:

- Locate the ductwork within the thermal envelope
- Duct leakage targets must be achieved during construction
- Pressure balancing is required to ensure adequate return air flow.

Water-based delivery systems, or radiant delivery, use thermal mass to capture and evenly distribute heat throughout the home. These systems are generally perceived to be more comfortable as radiant heat more closely matches the ideal heating curve for the human body. Additionally, water based heat delivery can have air quality benefits associated with not distributing allergens and other contaminants through forced air systems. There are typically increased costs associated with radiant heat, as it requires a flooring system with sufficient thermal mass to function properly.

Water Heating

There are two forms of electric water heating: electric resistance and heat pump water heaters (HPWH). The ZERH performance target is a heat pump water heater with a minimum Uniform Energy Factor (UEF) of 2.2. Most available heat pump water heaters will meet this requirement. A HPWH is a form of air source heat pump: it pulls in warm air to heat water and discharges cool air after the heat has been removed. Unlike a cold-climate heat pump, HPWHs are fed by the air within the home, instead of outside air, as the systems are not capable of extracting heat at very cold temperatures. This requirement drives two design considerations:

- How warm air is fed to and cold air is taken from the equipment.
- Mitigating the noise of the compressor component of the HPWH (comparable to a loud refrigerator for some models).

Most HPWHs can come in a ducted or ductless configuration. Ducted configurations provide maximum control over air management and the location of the system, making this the preferred configuration. Ducting also helps with mitigating the noise of the compressor as a solid door, rather than a louvered door, can be used with the system. The second concern, compressor noise, mainly drives the location of the equipment within the home. Ideally the system is not located near a bedroom, where the noise of the compressor could be heard at night.

Infrequently, electric resistance water heating can be incorporated with other HVAC systems. This is typically seen when electric resistance hot water heaters are connected to an air-to-water heat pump as part of a buffer tank or connected to a desuperheater as part of a GSHP configuration. In both cases the electric resistance tank should function as a backup heat source. When properly controlled and designed, backup electric resistance water heating can be incorporated into ZERH compliant designs. Otherwise, electric resistance water heating should be avoided.

Water Distribution

Hot water requirements are one area where the single and multi-family versions of ZERH diverge significantly. The requirements for each are highlighted below:

Single Family - The single family program offers three pathways for water efficiency/distribution compliance: meeting design requirements for hot water delivery systems, meeting efficiency criteria for water heaters and fixtures, or certifying the home under WaterSense Labeled Homes Version 2.0. The most direct route for compliance is the efficiency option as the water heaters that meet those efficiency requirements align well with code performance requirements. This option still requires a stored water volume of 1.8 gallons or less between the water heater and furthest fixture, as well as requirements for the type of recirculating pump used.

Multifamily - The multifamily requirements are not structured as options, they are simply requirements which are driven by the design of the building. The requirements vary depending on the location of the hot water source and the distribution method. In general this can be simplified to having one set of requirements for in-unit water heaters and a separate set of requirements for central water heating plants.

Ventilation

ZERH requires the use of balanced ventilation with heat recovery in Crested Butte's climate zone. This is achieved through the use of a Heat Recovery Ventilator (HRV) or Energy Recovery Ventilator (ERV). These forms of ventilation utilize a heat exchanger where the incoming air is tempered by the outgoing stream of air, reducing the energy impact of bringing fresh air into the home. While still considered to be a "premium" system for standard construction, ERVs/HRVs represent the highest efficiency and best performing ventilation option available. By providing both filtered fresh air and exhausting stale air from the home, the system ensures optimal indoor air quality (IAQ). The ZERH target home has a minimum of 1.2 CFM/watt for fan efficiency and a minimum 65% Adjusted Sensible Recovery Efficiency (ASRE).

Suggested MEP Packages

Three ZERH compliant system packages are presented below. This is not an exhaustive list, but provides typical ZERH system combinations with relative cost comparisons. In general, the equipment and building components required by ZERH in Crested Butte's climate zone will be on the "premium" end of the pricing spectrum.

- **Strategy 1** - Air to air heat pump with heat pump water heater

This option typically has the lowest first cost of the presented strategies. This configuration also provides the most flexibility in terms of manufacturer selection and value engineering potential.

- **Strategy 2** - Air to water heat pump with heat pump water heater

This design is similar to Strategy 1 in terms of overall equipment function, but uses water instead of air to deliver heat. This system is well suited for projects that are willing to absorb higher first costs to achieve comfort goals.

- **Strategy 3** - Ground source heat pump for space heating and domestic hot water

This option represents the highest first cost, but also the best energy performance. Leveraging the efficiency of the GSHP for as many end-uses as possible will secure the maximum benefit from the system. This option also has the most incentive dollars available, which helps bring first costs closer to an ASHP.

Equipment Type	Strategy 1	Strategy 2	Strategy 3
HVAC Strategy	Cold Climate Air Source Heat Pump with air-based delivery	Cold climate air source heat pump with hydronic delivery	Ground source heat pump with air-based delivery
DHW	Heat Pump Water Heater	Heat Pump Water Heater	Heat pump connected to GSHP
First Cost	$	$$	$$$
Operational Cost	$$	$$	$
Incentive	$$	$$	$$$
Design	Requires locating heat pump unit in at an appropriate location outside, incorporating ductwork within the thermal envelope	Requires locating heat pump unit in at an appropriate location outside, incorporating thermal mass into flooring systems for radiant delivery	Soil testing needed to determine viability of GSHP, interaction with structural elements and limitations of site, first cost considerations
Installation	Requires duct testing, If supplementary heat sources are included this requires proper set-up of controls to ensure functionality	Requires thermal mass appropriately sized and installed	Ground loop drilling/ layout alters course of construction, requires duct testing
Maintenance	Filter changes, replacement of components at failure	Replacement of components at failure	Filter changes, replacement of components at failure

Other ZERH Requirements

Appliances

ZERH requires the use of ENERGY STAR certified refrigerators, dishwashers, ceiling fans, and lighting fixtures. These products are widely available and typically do not represent a cost premium.

ZERH does not require ENERGY STAR ranges. There are two types of electric ranges available: standard electric resistance and induction ranges. Only induction ranges can be ENERGY STAR certified. While induction ranges are more efficient, they require the use of cookware that incorporates ferromagnetic metals (cast iron, steel). Given this restriction, induction ranges may not be appropriate for rental properties. They can be a good choice in for-sale homes.

While not required in every instance, some ZERH pathways require the use of WaterSense bathroom faucets, aerators, and/or showerheads. It is recommended that WaterSense water fixtures are used as a basis of design, as they provide water savings and ensure compliance with the applicable ZERH requirements.

EPA Indoor airPLUS

All versions of ZERH require certifying under the Environmental Protection Agency's Indoor airPLUS program as an additional requirement. Some key requirements for this certification are as follows:

- Passive radon system installed for EPA Radon Zone 1 (Crested Butte is in this zone)
- Rodent/bird screens installed on all mechanical penetrations (except for dryer vents)
- Home ventilated before occupancy
- Following materials certified low-emission:
  - Composite wood products
  - Interior paints and finishes
  - Carpet, carpet adhesives, and carpet cushion

EV-Ready Requirements

All new residential construction must meet electric vehicle readiness requirements. Please review Appendix C for a detailed comparison of the EV requirements in Crested Butte code and ZERH. Both sets of requirements must be met.

Solar PV Ready

A core goal of the ZERH program is that a home could achieve Net Zero energy use with the addition of solar PV. The requirements vary slightly between multifamily and single family homes. In general, both require a solar-ready zone located on the roof, reserved and labeled space in the electrical panel for future solar installations, and documentation of these items in construction drawings and onsite. These requirements can also be satisfied by installing solar PV as part of the project. When considering solar PV, it is important to coordinate with local utility requirements. GCEA has specific interconnection requirements published on their website which is linked in Appendix A.

Heat Pump Ready

These sections of ZERH have not been addressed in this guide, as Crested Butte does not allow the installation of natural gas equipment for new residential structures. ZERH Heat Pump Ready requirements can be found in the full program guidelines linked in the guide appendix.

ZERH Process Outline

Compliance with the ZERH program has two generally distinct phases: design and construction. Incorporating ZERH requirements early in the design is critical to ensure that the applicable requirements are considered in the budget, design, and project timeline.

Design Phase

Much of the hard work for ZERH is completed during design. If sufficient time and effort are allocated to ZERH compliance during the design phase, the construction phase activities will be much simpler. At a high level the following activities occur during design, roughly in the order listed below:

1. The ZERH standard is incorporated into owner project requirements.
2. ZERH and 2021 IECC compliant assemblies are selected by the design team. There is minimal flexibility in this area. Generally, utilizing the prescriptive targets is the simplest approach.
3. A ZERH MEP compliance strategy is selected during early design. There are a range of possible design choices, and the cost implications of different strategies are significant. Close coordination between the mechanical design team, architectural team, and energy rater are required to ensure that an appropriate design is selected for the project. Pricing and constructability input from the general contractor can be invaluable.
4. Modeling, if applicable, occurs typically around the 100% Design Development stage of architectural design. Earlier modeling can provide design guidance, but a complete design is typically needed to warrant compliance. If a performance path is being used, a project should not proceed to permitting without ensuring the model shows that ZERH design requirements have been met.
5. During the development of Construction Documents and permitting, the energy rater needs to be engaged to validate the design continues to meet ZERH requirements.
6. If taking the prescriptive path, ZERH guidance recommends submitting preliminary documentation to a DOE approved Multifamily Review Organization (MRO) for review and approval. While this does not result in project certification, the certifying entity can confirm a ZERH compliant design or identify issues.

Construction Phase

The construction phase includes a number of ZERH coordination, inspection, and testing activities that generally flow as follows:

1. A construction kick-off meeting is recommended to ensure that the design and construction teams understand the relevant ZERH requirements. A key focus area is the coordination of inspections and testing.
2. As the construction team purchases equipment and materials for the project, it is important the Energy Rater review and approve key submittals related to ZERH certification. Any relevant substitutions must be reviewed by the Energy Rater to ensure that compliant equipment or materials are selected.
3. As components of the envelope are installed, they must be inspected by the Energy Rater to confirm that all required air sealing details are included and that Grade I insulation installation requirements are met. These inspections are mandatory and must be completed before the insulation is covered up with other materials and is no longer visible.

4. If ducted systems are used, specific duct leakage targets must be achieved by the installed systems. Duct leakage testing and duct sealing are most easily completed pre-drywall. These pre-drywall tests should be officially noted in the construction schedule. While it isn't mandatory to complete testing at this stage, it is highly recommended as duct sealing post drywall is difficult and costly.

5. Once drywall and a sufficient amount of the air barrier is installed, preliminary blower door testing can be performed. It is recommended that early diagnostic tests are conducted to ensure that the building is on track to meet leakage targets at final testing.

6. Once the building is in the final punch stage, final testing can be completed (if applicable) and all ZERH required items confirmed.

Post-Construction Phase

Once construction is complete, the project and associated documentation is submitted to the reviewing authority for approval. The project team should anticipate a wait period between the final inspections and when ZERH certificates are in hand. ZERH certificates are issued on a per home or per apartment basis. The ZERH program requires that certain information be posted in home and/or made available to the homeowner. This is an important step that can be difficult to coordinate given the timing of receiving certificates and turning the building over, so this should be considered as part of project close-out. If the 45L tax credit is claimed by the project, certification documentation should be retained on file.

Homeowner Guide

A ZERH certified home will function much like standard construction, but with lower operating costs and a more healthy environment. However, there are a handful of maintenance items specific to certain high efficiency systems worth noting.

Ventilation Maintenance - Many homeowners will not be familiar with the operation of an ERV/HRV and potentially have never lived in a home with a dedicated ventilation system. It is helpful for the homeowner to understand that this system provides a balanced source of fresh air that improves the air quality in their home. At a minimum these systems have filters that need to be changed on a regular basis. The homeowner should be aware of where the ERV is located and how to access the filter. Manufacturer literature will note the filter type and recommended replacement frequency.

Supplementary Heat Control - A number of mechanical systems utilize supplementary electric resistance heating. If designed and configured properly, these systems should primarily operate in heat pump mode and minimize electric resistance heat runtime. However, there is potential for the incorrect set-up of supplementary heat control during installation.

In these cases, the system often appears to be operating as intended (providing sufficient comfort), but the utility costs can be much higher than anticipated. The homeowner should be made aware of supplemental heat control settings so they can realize the lower operating cost associated with ZERH construction. It is recommended that the occupant monitor their electricity bills to ensure the system is working properly.

Heat Pump Temperature Settings - Heat pumps generally heat air and water more slowly than natural gas fired equipment. Additionally, cold climate heat pumps operate efficiently at part load. Due to these two factors, it is best to set thermostat control to a constant temperatures for longer periods of time. Programming the thermostat to have large setbacks when the home isn't occupied means that the heat pump will take longer to bring the home back to target temperatures. In general, heat pumps should only be setback by significant amounts when the home won't be occupied for an extended period.

Air Source Heat Pump Maintenance - Outside of regular filter changes, heat pump maintenance is substantially similar to maintaining a gas-fired furnace. One unique consideration is the location and functionality of the outdoor heat pump unit. This heat pump needs adequate airflow to function properly. As such, it should be located somewhere that it can be kept reasonably free of snow and ice. As the heat pump operates and draws heat from the air, it can drop the dew point to a level where water will condense and freeze on the heat pump coils. The heat pump is designed to address this problem through a defrost cycle. During this defrost cycle, ice will melt off of the heat pump and has the potential to refreeze beneath it. If this goes on for too long without opportunity for the ice to melt off completely it can form an ice dam. The heat pump should be checked in periods of extended cold weather, with snow and ice damming addressed as needed.

Heat Pump Water Heater Filters - Heat pump water heaters incorporate a filter to ensure the heat exchanger does not get clogged with debris. These filters require regular cleaning per the manufacturer's instructions.

CASE STUDIES

Mineral Point - Multifamily ZERH Certified

Project Summary

Mineral Point will be a 3 building, 34 unit permanently affordable housing project located just outside the heart of Crested Butte. The project features a holistic sustainability approach with a focus on energy efficiency, health, and human-centered design. The project is targeting ENERGY STAR MFNC certification, Zero Energy Ready Homes certification , and will achieve Enterprise Green Community +Plus. Enterprise Green Communities is the only green building certification designed specifically for affordable housing.

Building Financial Summary

Total square footage - (25,940) + Bike Barn (471) = 26,412
Total units - 34 plus bike barn
Total construction cost (projected) - $10,458,662
Cost per unit (projected) - $307,608
Cost per square foot (projected) - $395

Building Component Summary

- 2021 IECC compliant envelope
- Mechanical equipment summary:
  - Cold climate heat air to air heat pumps for space heating and cooling
  - Individual heat pump water heaters
  - Energy Recovery Ventilation systems
- Low power density LED lighting package and ENERGY STAR appliances
- Solar Photovoltaic Ready and Electric Vehicle charging infrastructure.
- Community connectivity through access to alternative transportation infrastructure, bike storage, bike maintenance equipment, and electric bike charging stations
- Enhanced water management through native landscape, onsite stormwater management, efficient irrigation, efficient plumbing layout, and a 30%+ reduction in indoor water usage
- Human-centered design elements focused on safety, universal design strategies, and fostering a connection to nature through outdoor spaces and biophilic design.
- Non-toxic materials and improved ventilation systems that improve air quality.

Butte Avenue SFU and ADU - Single family ZERH Certified Housing Workforce H

Building Financial Summary

624 & 626 Butte Avenue SFD with Attached ADU

Total square footage - 2,468
Total units - 2
Total construction cost (projected) - $1,200,00
Cost per unit (projected) -
SFD - $618,164
ADU - $581,835
Cost per square foot (projected) - $486

722 and 724 Butte Avenue SFD and ADU

Total square footage - 3,124
Total units - 2
Total construction cost (projected) - $2,200,00
Cost per unit (projected) -
SFD - $1,465,148
ADU - $734,851

Building Component Summary

- 2021 IECC compliant envelope
- Mechanical equipment summary:
  - Cold climate heat air to air heat pumps for space heating and cooling
  - Individual heat pump water heaters
  - Energy Recovery Ventilation systems
- Low power density LED lighting package and ENERGY STAR appliances
- Solar Photovoltaic Ready and Electric Vehicle charging infrastructure.
- Community connectivity through access to alternative transportation infrastructure, bike storage, bike maintenance equipment, and electric bike charging stations
- Enhanced water management through native landscape, onsite stormwater management, efficient irrigation, efficient plumbing layout, and a 30%+ reduction in indoor water usage
- Human-centered design elements focused on safety, universal design strategies, and fostering a connection to nature through outdoor spaces and biophilic design.
- Non-toxic materials and improved ventilation systems that improve air quality.

APPENDIX A

Links to RequirementsWorkforce Housing

Program Requirements

- **ENERGY STAR Residential New Construction requirements** - https://www.energystar.gov/partner_resources/residential_new/homes_prog_reqs/multifamily_national_page
- **Zero Energy Ready Homes requirements -** https://www.energy.gov/eere/buildings/doe-zero-energy-ready-home-zerh-program-requirements

Crested Butte Code Requirements

- **Code amendments** - https://www.crestedbutte-co.gov/index.asp?SEC=202F995A-291E-4018-A747-6B2DE2B0C950
- **2021 I-codes -** https://codes.iccsafe.org/codes/i-codes/2021-icodes
- **Energy Smart Colorado home assessment -** https://energysmartcolorado.formstack.com/forms/residential_enrollment

Gunnison County Electric Association

- **General information -** https://www.gcea.coop/
- **Rebates -** https://www.gcea.coop/energy-efficiency/rebates/
- **Time of use billing -** https://www.gcea.coop/energy-efficiency/peak-demand-information/

Funding and Incentives

- **State of Colorado Heat Pump Tax Credits -** https://energyoffice.colorado.gov/hptc
- **45L tax credit -** https://www.energy.gov/eere/buildings/section-45l-tax-credits-zero-energy-ready-homes
- **Solar investment tax credit -** https://www.energy.gov/eere/solar/homeowners-guide-federal-tax-credit-solar-photovoltaics
- **Home Energy Rebate Program (Federally funded, administered by CEO) -** https://www.energy.gov/articles/biden-harris-administration-announces-state-and-tribe-allocations-home-energy-rebate
- **Clean Energy Tax Credit (Single family development only) -** https://www.energy.gov/policy/articles/making-our-homes-more-efficient-clean-energy-tax-credits-consumers

Technical Resources

- **Northeast Energy Efficiency Partnership heat pump list -** https://ashp.neep.org/#!/product_list/

APPENDIX B

Local HERS Rating Companies

If you are interested in becoming a HERS rater, there is a local scholarship program to help cover the educational costs:
https://www.gunnisoncounty.org/1072/Energy-Efficiency-Professional-Scholarsh

1. Hearth Design Build
Edward Morrison
Email: edward.morrison@westeralum.org
Phone: 720-480-6197

2. Little Foot Building
Andy Tocke
Email: adtocke@gmail.com
Phone: 970-596-6300

APPENDIX C

Comparison of EV Ready Requirements

Item	Crested Butte Residential Requirement	ZERH v2 Single Family
Requirement	1 Parking space **per dwelling unit or garage**; Parking spaces that have full circuit installations of 208/240-volt (or greater), **40-ampere** (or greater) panel capacity, raceway wiring, receptacle and circuit overprotection devices. This strategy provides all required electrical hardware for the future installation of EV Supply Equipment (EVSE). Anticipating the use of dual head EVSE, the same circuit may be used to support charging in adjacent EV-Ready spaces.	1 parking space per dwelling unit; Includes a powered 208/240v **30a** receptacle installed **in the dwelling unit's garage or within 6 feet of the dwelling units provided driveway.** The electrical service panel identities the branch circuit as "Electric Vehicle Charging"
Requirement	**Crested Butte Commercial Requirement**	**ZERH v2 Multifamily***
Requirement	1. Buildings with two or more parking spaces shall provide one (1) Level II EVSE. 2. Additionally, ten percent (10%) of total required parking spaces (rounded up) shall be Electric Vehicle Ready Space 3. One DC Fast Charger (25 kW) shall be provided for 5 or more required parking spaces.	1. 10% of the total must be EVSE Spaces 2. An additional 10% must be EVSE, EV Capable, or EV Ready*

**Please refer to ZERH documentation for definitions of EV Ready, EVSE and EV Ready.*