
MARKET ANALYSIS FOR ZERO ENERGY MODULAR IN COLORADO

April 2019

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1. Executive Summary

In Colorado, the gap between demand for affordable housing and the availability of units is growing at an alarming rate. Colorado Housing and Finance Authority (CHFA), the City of Boulder, Energy Outreach Colorado (EOC), and Habitat for Humanity of Colorado (HFH CO) commissioned VEIC to assess the feasibility of bringing Zero Energy Modular (ZEM) homes to Colorado. An emerging housing type, ZEM homes combine the benefits of zero energy homes with the cost efficiencies of modular construction. Currently unavailable in Colorado, ZEM homes have been installed in Massachusetts, Delaware, and Vermont over the last five years. Our study characterizes the potential ZEM market in Colorado and documents what would be required to launch a successful ZEM pilot program in the state.

Why ZEM?

All-electric and highly efficient, ZEMs are often outfitted with rooftop solar arrays and use about as much energy as they produce each year, resulting in low or no monthly energy bills for residents. Although ZEM homes cost more than those built to baseline code, **when the incremental cost of the energy efficiency and renewable energy features are rolled into the fixed rate mortgage financing, and the utility offers net metering, homeowners are cash flow positive from day one.** Zero energy modular offers a new, truly affordable housing option. This housing type is:

- **Healthy:** ZEM homes use only high-quality and non-toxic materials and incorporate a fresh air ventilation system providing optimal air quality.
- **Wealth building:** ZEM homes are considered real property and an appreciating asset, building long-term wealth for households. ZEM homes are eligible for low-interest, long-term mortgages.
- **Ultra-efficient:** ZEM homes are affordable and comfortable to occupy with low monthly energy costs.
- **Quick and inexpensive to build:** Modular construction can be less expensive and quicker than almost any other form of home construction or affordable housing development. Through ZEM, quality affordable housing stock in Colorado could grow rapidly.

In contrast, traditional mobile and manufactured housing (MMH), which seems affordable initially by offering a relatively low purchase price, can trap occupants in an unhealthy indoor environment and high monthly energy costs. Further, MMH is often financed via personal chattel loans, subject to short pay-back periods and high interest rates. When the land below the MMH is not owned, and the housing not affixed to a permanent foundation, these units may actually depreciate in value over the course of the loan, doing little to build household wealth over the long-term. For many Coloradans, achieving homeownership is hard work, with hours of hunting to find a home they can afford, usually defined by lowest first cost. Although a low initial price might make a home seem affordable, other costs associated with the home, especially the costs of energy, contribute to the hidden costs of living across the full tenure of owning.

Our financial modeling found that in locations across Colorado, rural and urban, ZEMs were consistently an affordable option. Monthly costs were comparable to or *less* than manufactured housing, after accounting for financing and energy costs. ZEM occupants would have access to

healthier, more efficient housing that would build households' long-term wealth, for the same amount or less than it would cost to live in MMH. The monthly cost to occupy a ZEM was approximately one third the cost to occupy a site-built ranch home (Figure 1).

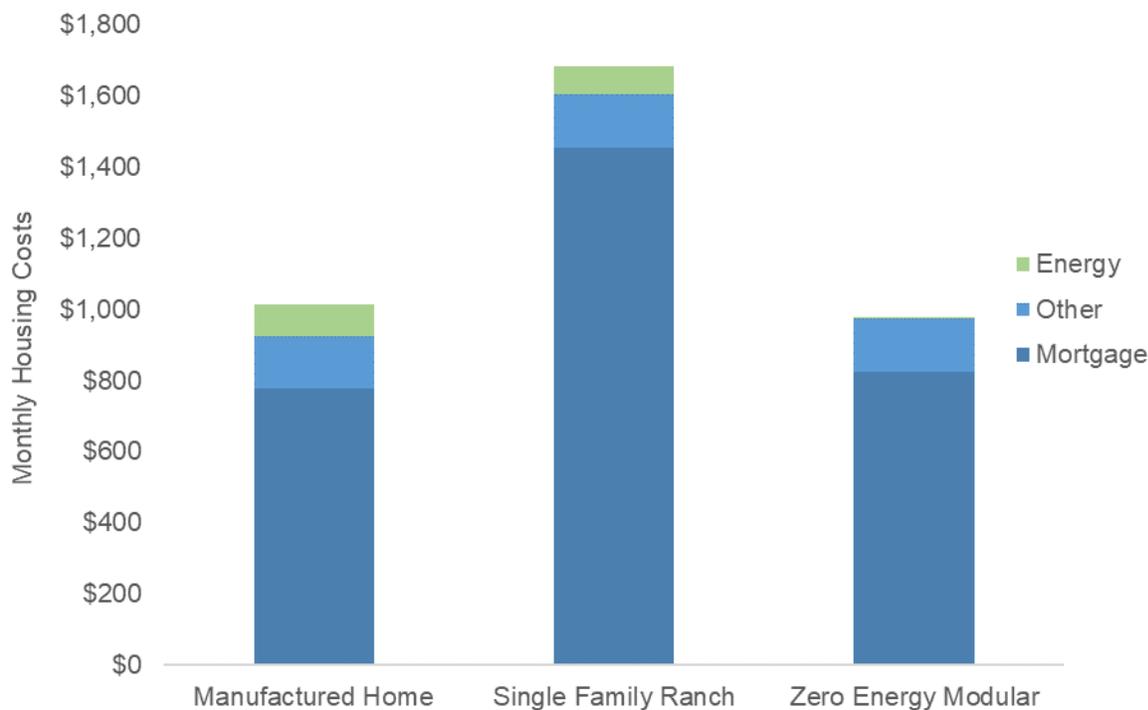


Figure 1. Estimated Monthly Costs by Housing Type in Alamosa County, CO.

Residential homes have been built in factories for over a hundred years. In recent years modular has been getting another look from local and national affordable housing advocates as a possible solution to the housing crisis. As new construction costs soar in rural and urban areas across the United States, modular construction offers a solution for cost containment and reduced construction time. These benefits are achieved through a fixed decision-making process, controlled construction environments, and economies of scale – all of which can save between 10-20% on costs and 30-50% on construction time.¹ Combining the benefits of both zero energy and modular as an affordable housing solution can expand the clean energy economy to low income home buyers.

ZEM Can be an Affordable Housing Solution in Colorado

Our research and stakeholder engagement consistently showed a strong potential to address the need for affordable housing in Colorado by expanding existing construction capacity and delivering high quality and durable ZEM homes. This study focuses on the opportunity ZEM presents as an alternative to manufactured housing and single-family home construction, although zero energy modular construction can be applied in other contexts, including

¹ Disruptive Development: Modular Manufacturing in Multifamily Housing.
http://turnercenter.berkeley.edu/uploads/A.Stein_PR_Disruptive_Development_-_Modular_Manufacturing_in_Multifamily_Housing.pdf

multifamily. ZEM also presents workforce and economic development opportunities. Market demand for ZEM homes will be met with new modular factories, creating living wage, factory jobs. Establishment of even a small ZEM factory has potential to create 20 full time jobs and produce 50 homes per year.

Discussions with the ZEM Workgroup (EOC, the City of Boulder, CHFA, HFH CO) and other Colorado stakeholders revealed clear demand for ZEM homes under a variety of development models, including mobile home replacement and residential new construction. The lack of affordable housing in Colorado is a widely recognized issue, and both renters and homeowners in Colorado commonly struggle with high energy burdens. We also know that there are no modular factories located in Colorado. Currently, the state's modular homes are built elsewhere in places like Kansas and Idaho. Because a ZEM program could create adequate demand for an in-state ZEM factory, we also assess possible ZEM factory start-up scenarios.

Through our work in Vermont, Delaware and Massachusetts, we have identified roles needed to implement ZEM programs. With this lens, VEIC inventoried existing activities, resources and programs necessary for a ZEM pilot program in three areas: demand for zero energy modular, customer economics, and opportunities to create modular capacity in Colorado. The study has been informed by the engagement of key stakeholders on the potential for catalyzing the entry of these homes into the market.

Our key findings include:

Potential for ZEM housing development is strong: There are over 95,000² manufactured and mobile homes in Colorado, and many of those are in poor condition. Every year about 24,000³ new single family homes are built in Colorado. Even if only a small portion of these were replaced with ZEM homes, that would create a sizable market and improvement to Colorado's housing stock, reducing households' energy costs and building their wealth, long-term.

ZEM homes are affordable for low and moderate income Coloradans: Both as manufactured housing replacement, and new single family homes, our analysis shows that ZEM homes are affordable with the right financing, grants and energy efficiency incentives in place. Rather than spending \$1,000- \$1,500+ each year on energy costs, as MMH require, ZEM households would spend \$30-\$330, instead investing in an appreciating asset and building long-term wealth. Across all three of the Colorado's climate zones we analyzed, ZEM homes had the costs of occupancy lower than or nearly the same as MMH.

There is a will to increase modular capacity in Colorado: There are no modular factories in Colorado, but there is interest from a variety of affordable housing advocates, educators, developers and private business owners. Creating modular capacity will require multiple factories and we recommend that a ZEM pilot program support three scenarios:

Small factories that build up to 50 homes a year. This factory type could be privately owned or owned and operated by a community college, vocational school or Habitat for Humanity affiliate. These factories would have a mission to train workforce and/or leverage volunteer hours to keep the cost of the home low.

Medium-sized factories that sell over 50 units a year, incorporate lean manufacturing principles and are optimized to deliver quality ZEM homes at the lowest price. Medium-sized factories could be privately owned or owned and operated by affordable housing developers

² U.S. Census Bureau, American Housing Survey. <https://www.census.gov/programs-surveys/ahs.html>

³ U.S. Census Bureau, Building Permit Survey. <https://www.census.gov/construction/bps/stateannual.html>

who build ZEM homes for their own developments, and potentially sell modules to other affordable housing agencies directly without the involvement of a modular home dealer. Large factories that sell hundreds of ZEM homes to affordable housing developers directly and retail through a dealer.

Considerations for a Pilot Program and Key Challenges

Because our study uncovered enormous potential for ZEM homes to meet Colorado's increasingly acute housing shortage, we recommend implementation of a ZEM pilot. Our experience in other states has shown that ZEM pilots are complex. We recommend that one organization centrally manage operations like outreach, program design, partner recruitment, coordination and implementation over the long term. Close collaboration with existing affordable housing efforts will be critical. These efforts must be integrated into and leveraged by the pilot. Collaboration with utilities will also be necessary to ensure that all possible energy efficiency and renewable energy incentives and grants are leveraged and net metering is offered.

Through our research and stakeholder engagement, we identified five key challenges that will need to be addressed to ensure successful ZEM development in Colorado:

1. Challenge: No existing modular factories in Colorado
Solution: Focused effort to create ZEM factory capacity in Colorado, supported by a ZEM Pilot. Investment in ZEM factories in the state would most likely need to be preceded by or happened in tandem with establishment of a ZEM program to create a guaranteed market.
2. Challenge: Local zoning may prohibit modular construction and permanent foundations in some MMH communities and resident owned cooperatives. This zoning was designed to protect communities and preserve manufactured homes as an affordable housing solution which would inadvertently preclude ZEM.
Solution: Find communities interested in ZEM development and willing to grant variances or make necessary changes to existing regulations.
3. Challenge: High land costs can exceed upper limits of low and moderate income household financing, making ZEM development as single family homes difficult.
Solution: Partnership with affordable housing advocates such as Habitat for Humanity and local housing trusts can provide access to donated land.
4. Challenge: Colorado does not have uniform statewide net metering or energy efficiency and renewable energy incentives
Solution: Launch pilot within targeted utilities that have existing programs to support ZEM
5. Challenge: Most mortgage programs for low and moderate income households are not structured as construction loans, although this loan type is often required for modular homes.

Solution: Work with lenders to create ZEM-specific mortgage products for homebuyers and collaborate with affordable housing developers who could finance construction and sell to homeowners upon completion.

2. Background

Colorado's Affordable Housing Needs

Spanning 64 counties, Colorado is a diverse state and housing needs vary across cities, college towns, rural areas, and ski towns. Much of the state has seen population growth in the past 10-15 years and the lack of affordable housing is consistently acute across many of the state's counties and landscapes. Colorado residents are challenged to find quality affordable housing as both renters and owners.

VEIC was commissioned by Colorado Housing and Finance Authority, the City of Boulder, Energy Outreach Colorado, and Habitat for Humanity of Colorado to assess the feasibility of Zero Energy Modular (ZEM) homes as one solution to this housing shortage. An emerging housing type, ZEM homes combine the benefits of zero energy homes with the cost efficiencies of modular construction. Currently unavailable in Colorado, ZEM homes have been installed in Massachusetts, Delaware, and Vermont over the last five years. Our study explores the potential of ZEM development in Colorado and documents what would be required to launch a successful ZEM pilot program for the state.

What is ZEM?

Across a wide array of incomes, locations and development scenarios, zero energy modular (ZEM) homes can rise to meet Colorado's housing challenges. Zero energy homes are designed to drastically reduce energy use and are matched with a source of electricity that is generated through a renewable energy system such as roof mounted solar panels or community solar. Although there are building science principals that must be followed to achieve zero energy such as high levels of insulation, continuous air barrier, thorough air sealing, fresh air ventilation and ultra-efficient appliances and mechanical systems, zero energy homes will be designed to meet the conditions of the local climate zone. Industry standards, such as Passive House and Department of Energy Zero Energy Ready Homes, go beyond the EPA ENERGY STAR Certified Homes Program and provide a framework to achieve zero energy.

In Vermont, Delaware and Massachusetts, we have witnessed the power of ZEM homes to build residents' wealth through ownership of an appreciating asset, stabilize finances through low and predictable energy bills, and improve health through indoor air quality much better than traditional MMH. Quick to build and subject to rigorous standards and inspection, ZEM homes will add quality units to Colorado's housing stock more quickly and for less money than nearly any other form of affordable housing development. While ZEM homes are currently located in rural areas, often as MMH replacement, they have enormous potential to also serve as a new single family option on owned land, infill development and accessory dwelling units (ADU) in urban and metropolitan areas, and as high quality rental housing.

ZEM as Single Family Affordable Housing

Multiple stakeholders have noted that Colorado needs hundreds of affordable units built every year. For example, Elevation Community Land Trust has a goal of 700 new units by 2022. Habitat for Humanity affiliates in Colorado build about 100 homes per year across the state, but

there is a need for at least two to three times that number. An analysis of El Paso County from 2014 estimated that there is a gap of over 24,000 affordably priced rental and ownership units for households making up to 120% area median income.⁴ In 2015, Colorado added 26,000 total housing units, although the number of new households (household formations) was 33,000-35,000.⁵ In short, it is widely acknowledged that the state's existing supply of housing affordable for low and moderate income households is less and less adequate each year. Although a suite of solutions will be ultimately be required, across Colorado, there is a growing need for housing that is affordable, efficient, and quickly constructed.

ZEM as Manufactured Housing Replacement

A clear potential for ZEM homes are as a replacement for or alternative to manufactured or mobile homes (MMH), which are often characterized by inefficient construction, high energy costs for residents, and poor indoor air quality. According to the American Community Survey (ACS) from 2013 through 2017, 4% of all housing units in Colorado are MMH: 9% of housing units in rural areas, and 3% in the state's non-rural and urban areas.⁶ Median value of MMH in the state was estimated to be \$36,300. The ACS estimates that there are 95,400 MMH units total in Colorado.⁷ Demographic data on MMH residents is available through the American Housing Survey, although only for the Denver metropolitan area. According to the American Housing Survey, there are 17,600 MMH in the Denver metro area, 12,000 of which are owner-occupied. Over half of the area's MMH (9,600 units) are located in communities with over 20 homes. The rental vacancy rate in MMH located in these larger communities is over 6%, three times the rental vacancy rate for MMH in the Denver metro area overall (2%).

We identified 28 counties in Colorado where MMH makes up at least 10% of total housing units. The ACS recorded MH in every county in the state. MMH made up less than 1% of housing units in Denver and Douglas Counties, and over 20% in Moffat and Saguache Counties.

Table 1. Colorado Counties Where MMH is at Least 10% of Total Housing Units.⁸

	% of MMH housing units
Statewide	4.1
Moffat County	20.8
Saguache County	20.6
Costilla County	19.7
Montezuma County	19.3
Montrose County	19.0

⁴ Affordable Housing Needs Assessment:

https://coloradosprings.gov/sites/default/files/community_development/pages/final_colorado_springs_hna_10.30.14.pdf

⁵ Bell Policy Center. Housing: Calling Colorado Home: <https://www.bellpolicy.org/wp-content/uploads/2018/01/Housing-Guide-to-Economic-Mobility.pdf>

⁶ The U.S. Census classifies as rural any area that is *not* classified as either an urbanized area (area with 50,000 people or more) or urbanized cluster (area with more than 2,500 people and less than 50,000 people).

⁷ U.S. Census Bureau, American Housing Survey, 2015.

⁸ U.S. Census Bureau, American Community Survey, 2013-2017.

	% of MMH housing units
Conejos County	18.6
Crowley County	18.1
Alamosa County	18.0
Jackson County	17.8
Kiowa County	17.3
Delta County	16.5
Kit Carson County	15.8
Dolores County	15.3
Cheyenne County	14.8
La Plata County	14.7
Lake County	14.6
Lincoln County	14.5
Bent County	14.3
Morgan County	13.3
Prowers County	13.1
Rio Grande County	13.1
Fremont County	12.8
Baca County	12.1
Archuleta County	11.8
Las Animas County	11.1
Huerfano County	10.7
Yuma County	10.4
Garfield County	10.0

Ideally, ZEM homes are installed as a single family home (on land owned by the homeowner) or within a nonprofit, housing authority or cooperatively owned mobile home park (i.e., not a privately owned park). It can be difficult to secure financing for ZEM homes on leased land, as would be the situation in a privately owned park (discussed further under 'ZEM Development Scenarios'). We identified ten existing nonprofit, housing authority or cooperatively mobile home communities in Colorado (Table 2).

Table 2. Existing Nonprofit, Housing Authority or Cooperatively Owned MMH Communities.

Community	Location	Owner	Number of lots
Mapleton MHP	Boulder	Thistle Communities	135
Ponderosa MHP	Boulder	City of Boulder	68
Fish Creek MHP	Steamboat Springs	Yampa Valley Housing Authority	68
Smuggler Park Subdivision	Pitkin County	Pitkin County Housing Authority	87
Smuggler Run Subdivision	Pitkin County	Pitkin County Housing Authority	17
Woody Creek Mobile Homeowners' Association	Pitkin County	Pitkin County Housing Authority	58
Lazy Glen Subdivision	Pitkin County	Pitkin County Housing Authority	100
Aspen Village	Pitkin County	Pitkin County Housing Authority	150
Rocky Mountain Homeowners Cooperative	Canon City	Resident Owned Community; ROC affiliate	51
LMP Coop	Longmont	LMP Coop; Thistle	36

3. Regulations Governing Manufactured and Modular Housing

One objective of this study is to assess the feasibility and cost effectiveness of using ZEM Homes as a replacement for manufactured homes on owned land and within MMH communities. In order to do so, we must consider the definitions and differences between MMH and modular, and any regulatory and zoning differences between these housing types.

Manufactured Housing Construction

At the federal level, manufactured housing construction standards are regulated by HUD's Office of Manufactured Housing. HUD defines a manufactured home as one built in a factory to HUD standards. These homes must be built on a permanent chassis and be transportable, although they are rarely actually moved after delivery. Data from the 2011 American Community Survey, reported in a study on eradicating substandard manufactured housing, indicate that nationally 79 percent of manufactured homes are located where they were first sited.⁹

⁹ Furman, Matthew, "Eradicating substandard manufactured homes: Replacement programs as a strategy," co-published by the Harvard Joint Center on Housing Studies and NeighborWorks America, November 2014.

Prior to 1976, there were no federal standards for manufactured housing.¹⁰ In 1976, HUD established the Manufactured Home Construction and Safety Standards, which superseded state and local building codes for this particular type of housing. This code sets minimum standards for fire safety, construction (including ventilation and allowable materials), plumbing, and heating and cooling systems.¹¹ The differences in manufactured housing before and after 1976 are notable and as a general rule, HUD will not issue a certification label for a manufactured home built before 1976. Every manufactured home that is for sale or lease must display a red certification label on each transportable section.

The most recent update to federal manufactured home construction standards were implemented nearly 25 years ago in 1994. Following Hurricane Andrew, HUD set new standards, principally focused on wind-load and energy efficiency.

State Regulations

The Colorado Office of Economic Development and International Trade includes both MMH and modular housing in its definition of 'manufactured housing.' The state cedes regulation of MMH to HUD (and the standards described above), although the installation of both MMH and modular housing is regulated by the state. Modular housing must be inspected following installation, by the Colorado Division of Housing. MMH is taxed 'as if they were real property.'¹² Colorado state statutes provide the following definitions of mobile, manufactured and modular housing:

"Manufactured home" means any preconstructed building unit or combination of preconstructed building units that:

- (a) Include electrical, mechanical, or plumbing services that are fabricated, formed, or assembled at a location other than the site of the completed home;
- (b) Is designed for residential occupancy in either temporary or permanent locations;
- (c) Is constructed in compliance with the federal act, factory-built residential requirements, or mobile home standards;
- (d) Does not have motor power; and
- (e) Is not licensed as a recreational vehicle.

"Mobile home" means a manufactured home built prior to the adoption of the federal act [pre-1976 HUD regulation].

"Modular home" means a factory-built residential structure.¹³

A memo from the Colorado Department of Revenue provides the following clarification of these definitions:

¹⁰ HUD Manufactured housing standards, https://www.hud.gov/program_offices/housing/rmra/mhs/faqs.

¹¹ See *Code of Federal Regulations* 3280- Manufactured home construction and safety standards, <https://www.gpo.gov/fdsys/pkg/CFR-2010-title24-vol5/pdf/CFR-2010-title24-vol5-part3280.pdf>.

¹² Manufactured Homes in Colorado: <http://www.co.arapahoe.co.us/DocumentCenter/View/105/Manufactured-Home-Brochure-2017?bidId=>

¹³ Colorado Revised Statutes: <https://leg.colorado.gov/laws>

A mobile home is on a permanent chassis, intended as a dwelling, and not on a permanent foundation.

A manufactured home is pre-constructed unit(s) made in a factory or somewhere other than the residential site.

A modular home is a factory built structure that may qualify for long-term financing, is not titled, complies with conventional residence building codes, and is separate from its delivery chassis.¹⁴

Modular Housing Construction

There are no federal regulations governing modular housing, rather, modular housing is generally subject to the same state and local regulations as site-built homes. The Colorado Constitution grants counties, cities and towns the ability to pass laws to govern their local jurisdiction. In many cases, state regulations are used when local regulations have not been adopted to govern a particular area. However, there are also instances where state law supersedes local regulations. Modular builders may have to comply with both state and local regulations.

Factory registration, design review, and state inspection/certification of modular homes fall under the jurisdiction of the Colorado Department of Local Affairs (DOLA) Division of Housing. Local permitting, foundation design and inspection, and more stringent snow/wind load requirements (if applicable) fall under the local jurisdiction. Electrical and plumbing requirements outside of the modular home, i.e. the connections from the home to utility services are regulated either by the State Electrical Board and State Plumbing Board housed within the Colorado Department of Regulatory Agencies (DORA), or by the local building department if it elects to take on the responsibility for either or both. All modular homes must be designed and constructed to the codes adopted by the State Housing Board. The statewide residential code is the 2018 International Residential Code (IRC). The building energy code is the following:¹⁵

“Residential buildings shall meet the provisions of the 2015 IECC—Residential provisions. Where the location the factory-built structure is to be permanently set is known and the local jurisdiction has adopted the 2012 IECC, the building may comply with the 2012 IECC. Where the location of the factory-built structure is to be permanently set is known and the local jurisdiction has adopted an earlier version of the energy code which is less restrictive than the 2012 IECC, including any local jurisdiction amendments, or where no code has been adopted that regulates the design of buildings for effective energy use, the structure may comply as far back as the 2009 IECC.”

“Zero-Energy Buildings: Zero energy buildings are exempt from the provisions of the International Energy Conservation Code.”

¹⁴ Colorado Dept. of Revenue:

<https://www.colorado.gov/pacific/sites/default/files/Modular%20Home%20General%20Information%20Letter%20GIL%202009-024.pdf>

¹⁵ Regulations and inspection requirements can be found in: Department of Local Affairs, Division of Housing. *Non-residential and residential factory-built structures; sellers of manufactured homes; manufactured home installations; and hotels, motels, and multi-family dwellings in those areas of the state where no standards exist.* 8 ccr 1302-14.

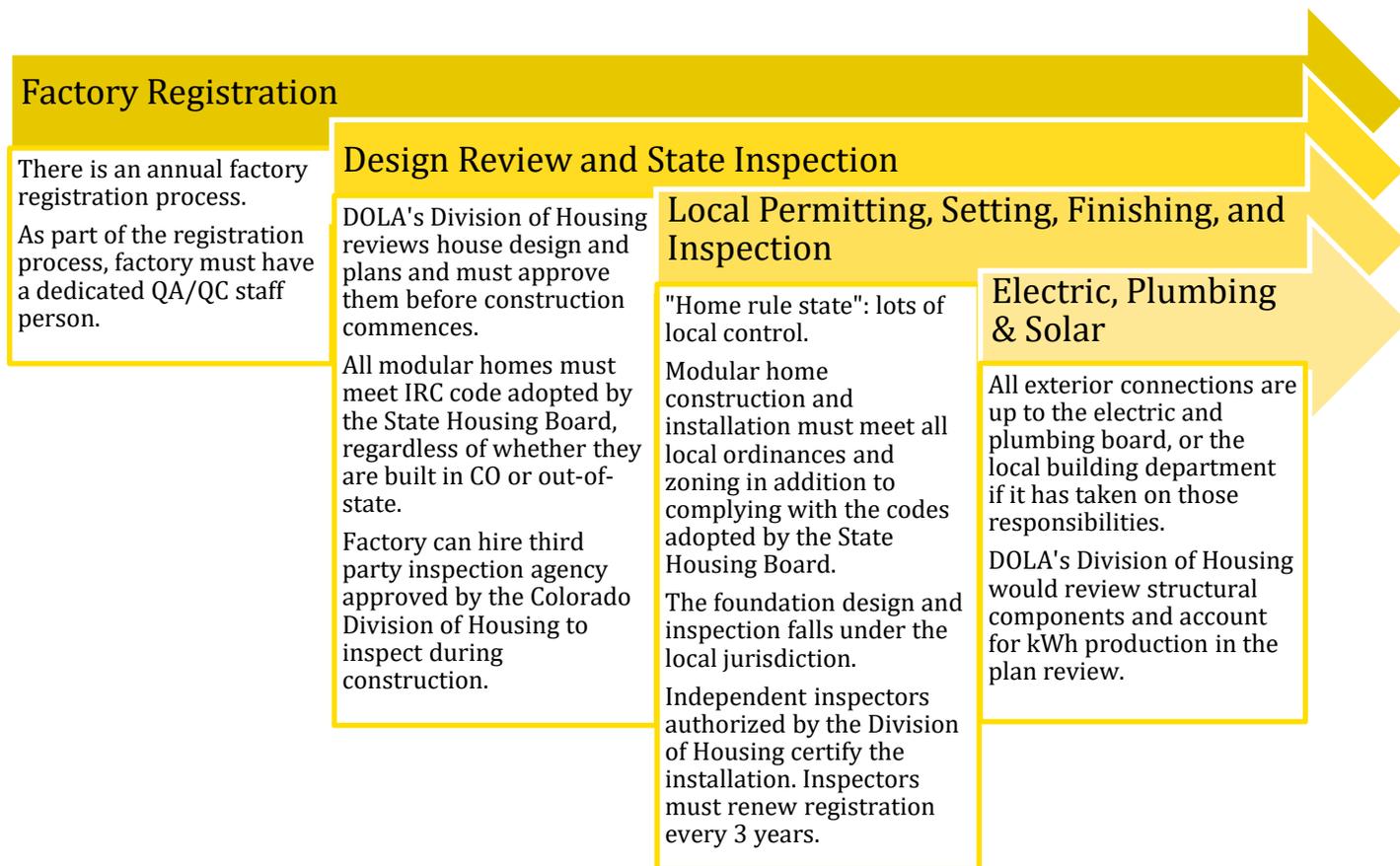


Figure 2. Steps to Modular Home Permitting in Colorado.

Figure 2 provides an overview of the steps for permitting a modular home in Colorado. The following provides additional details on the process:

Design Review and State Inspection:

Modular home must be on a permanent foundation. Piers would not be considered permanent foundation. If converting a MMH , there might be some permitting issues with foundations.

If a home passes inspection of its construction, it receives a silver insignia certifying the structure has been constructed to approved building plans.

Local Permitting, Setting, Finishing, and Inspection:

A certified installer can certify their own installations, unless they are installing in a local jurisdiction where its building department is authorized to act as a "participating jurisdiction" (will inspect and certify the installation).

A registered installer must hire a registered independent inspector or request an inspection through the Division of Housing, unless installing in a local jurisdiction where its building department is authorized to act as a "participating jurisdiction" (will inspect and certify the installation).

Both registered and certified installers have to renew status annually.

If a home passes an installation inspection, it will receive a copper-color insignia.

Direct Sales:

A factory is not required to go through a 3rd party to sell modular homes to consumers; however, anyone selling a modular home directly to a consumer must be registered as a seller. If more than one retail location is operated in Colorado, then each one has to be separately registered. If the seller is located out of state, then only one registration is required, regardless of how many retail locations the seller runs in Colorado.

The State of Colorado, Department of Local Affairs Building Codes and Standards Section maintains a list of all registered independent inspectors, dealers, installers, manufacturers, and third-party inspectors.¹⁶

There is currently “construction defect legislation” in effect in Colorado. That legislation allows a developer to be sued without a right to cure and renders the unit unavailable on the market, because a unit cannot be sold when there is a lawsuit associated with it. It is currently an impediment in the development of affordable condominiums in Colorado, resulting in very few new, affordable condos being built.

Local Zoning Consideration

In Colorado, local governments set the rules and regulations for land use under what’s referred to as Home Rule. Home Rule allows a community to create local definitions of manufactured, mobile, and modular homes. Local zoning will also dictate where MMH can be placed and where MMH communities can be developed within the town boundaries.

In this section, VEIC reviews two communities’ municipal codes to gain a cursory understanding of rules that would govern whether modular homes can be placed in existing MMH communities. Because each city and town could have its own unique set of definitions and zoning allowances for MMH, it’s important to understand local conditions before recommending a program using ZEM homes in MMH communities as modular homes are a distinct housing type and different than MMH.

Zoning in Boulder

In 2017, the City of Boulder purchased the Ponderosa Mobile Home Park with the intent to preserve long-term affordability, annex the property into the city, replace outdated infrastructure, and reduce flood risk to the community. Additionally, while the City is committed to allowing, to the degree feasible, those who wish to remain in their homes to do so, the City is also seeking to provide replacement housing options that are affordable to residents, work in the tight footprint of the older mobile home park and advance affordability and the City’s climate goals through high levels of energy efficiency.

The City of Boulder is keenly interested in ZEM homes as the housing solution when redeveloping Ponderosa Mobile Home Park. The land would remain owned in whole by an affordable housing nonprofit or housing authority and the intent, for these homes, is secure home owners’ rights to the land with a 99-year land leases. At the writing of this study, a site plan, annexation and land use designation change submittal for Ponderosa that proposed rezoning from MH (Modular Housing) to RM-2 (Med-Density Res), a zoning designation that

¹⁶ <https://www.colorado.gov/pacific/dola/factory-built-structures>

could more easily be modified through annexation to enable MMH side-by-side with modular homes. To understand whether modular could be placed in the other MMH communities in Boulder, we consulted with the Planning staff. Planning staff report that because Title 9. Land Use Code (Boulder Revised Code, 1981) does not contain a definition of “mobile home” in mobile home parks, staff defers to the definition of “mobile home” in Title 1. General Administration, which expressly excludes modular homes on foundations from what is allowable in mobile home parks.

Mobile home means a transportable, single-family dwelling unit, suitable for year-round occupancy that contains the same water supply, waste disposal, and electrical conveniences as immobile housing, but that has no foundation other than wheels or removable jacks for conveyance on highways, and that may be transported to a site as one or more modules, but the term does not include "travel trailers," "campers," "camper buses," "motor homes," or modular homes designed to be placed on a foundation.

Zoning in Steamboat Springs

The municipal code of Steamboat Springs regulates location, physical configuration, and operation of mobile home parks. MMH communities are permitted in the standard zoning district called “Manufactured Home (MH)” which determines development guidelines such as lot size, setbacks, and architectural features of homes like height. The language used in the code, may be interpreted to prohibit modular homes in a MMH Communities. The Municipal Code provides for variances and alternative compliance under certain conditions but this study did not explore the likelihood that a variance would be given for a ZEM in a MMH community.

As a pilot program moves forward, it will be important to understand local zoning in target areas which may prohibit modular construction and permanent foundations in some MMH community and resident owned cooperatives. We acknowledge this zoning was likely designed to protect communities and preserve manufactured homes as an affordable housing solution, but it may inadvertently preclude ZEM homes.

4. ZEM Development Opportunities

Based on our experience with ZEM programs in other states and our understanding of the Colorado housing market, we identified the four ZEM development scenarios described below.

Manufactured Housing Replacement

Owned Unit, Owned Land

For the owned unit, owned land scenario, we assume a ZEM home is replacing an existing MMH on owned land. Upfront costs would include new foundation and other necessary site preparation work (e.g., clearing trees), but most likely the existing infrastructure such as driveway, water, sewer and utilities can be re-used.

Owned Unit, Leased Land

In privately owned MMH communities, home sites are leased by the park owner to the homeowner and homeowners own their home. Because homeowners do not own the land, they often have little control over park owner decisions to raise lot rents or sell the park. Traditional MMH located within private communities on leased land is generally financed through chattel loans- short-term loans with high rates of interest. Placing a ZEM home on leased land can be problematic but is not impossible. If the park owner agrees to a long-term lease (one as long or longer than the length of the mortgage), a ZEM home can be financed using a traditional mortgage.

Owned Unit, Nonprofit, Housing Authority or Cooperatively Owned Land

Nonprofit, housing authority or cooperatively owned land (nonprofit MMH communities) are less common than privately owned MMH communities. We have identified 10 nonprofit MMH communities in Colorado (Table 10). These types of communities provide long term leases and limited cost increase giving MMH owners predictable terms. Homeowners are afforded more control over the land and access to more favorable financing through traditional lenders or lenders focused specifically on cooperatives. Because nonprofit MMH communities offer long term leases, lenders consider nonprofit MMH communities more stable than privately owned communities and are thus more willing to finance homes located within nonprofit MMH communities. In our experience, nonprofit MMH communities are an excellent location for ZEM home placement due to the stability that they offer to homeowners and the access to traditional mortgages that they can allow. It will be important to understand whether the MMH communities allow modular structures on permanent foundations. Structures other than MMH may be prohibited by MMH communities articles of incorporation or by local zoning provisions.

Rented Unit, Rented Land

Finally, ZEM homes can also serve as rental housing. In this scenario, ZEM homes can be placed either on private land or within a MMH community. A challenge of this scenario is ensuring that the monthly rent is affordable. Because many of the programs and incentives that make ZEM homes affordable for low and moderate income homebuyers would not necessarily be available to a developer or landlord building ZEM homes as rental housing, an alternate path or initiative would need to be developed (for instance, subsidies for developers who agree to rent to only income-qualified renters). ZEM homes offer renters the same benefits that they do those looking to buy a home: a healthy, efficient home. Indeed, low and moderate income renters may be even more energy-burdened than homeowners. However, convincing developers or landlords to take on the additional upfront expense of building a high-efficiency home, rather than cheaper traditional MMH could be a challenge. A thoughtful approach to a ZEM rental housing program would be required.

Single Family Homeownership

Owned Unit, Owned Land

For the owned unit, owned land scenario, home buyers must have the ability to purchase both the home and the land, or have access to land for the home through family subdivision or deeded rights. Upfront costs would also include utility connections, and foundation and other necessary site preparation work (e.g., clearing trees). In some cases, these costs can be rolled into an overall financing package for the home. This development option can have high upfront costs when the land is not already owned. Partnerships with affordable housing developers such as Habitat for Humanity or land trusts can be an effective way to acquire land without passing on full land cost to homeowner and implement this development scenario. Although upfront costs are high in this scenario, generally zoning and financing are easier than installation of a ZEM home in a MMH community. We believe there is tremendous potential for ZEM to serve as a new form of single family affordable housing, independent of its potential as MMH replacement. Inexpensive to build and affordable to occupy and own, ZEM homes are a cost-effective way to increase Colorado's supply of affordable single family homes.

Using the development opportunities discussed in the previous section and the data sources in this report, estimates of ZEM development potential were made, and are summarized in the following table:

Table 3. ZEM Home Development Opportunities.¹⁷

Ownership	Market	Technical potential ¹⁸	Potential for pilot program
MMH Replacement			
Owned Unit, Owned Land	Replacement Unit	32,000	Medium
Owned Unit, Leased Land (Nonprofit MMH Community)	Replacement Unit	770	High
Owned Unit, Leased Land (Private MMH Community)	Replacement Unit	32,000	Low
Rented Unit & Leased Land	Replacement Unit	30,000	Low
Single Family			
Owned Unit, Owned Land	New Unit, New Land	24,000	High

¹⁷ References and calculation method found in Estimated Benefits of ZEM 20190219.xls

¹⁸ Technical potential refers to the total number of units available for replacement in each scenario. A ZEM pilot program would target a small percent of each category

What do ZEM residents have to say?

ZEM residents consistently report high levels of comfort and low energy bills.

“I’m always thrilled to open my electric bill. With the money we’ve saved, we have helped out family members and paid medical bills.” ZEM owner since 2014.

“Our home is bright and comfortable, the park is friendly, and it’s all at an affordable price.” ZEM owner since 2017.

“Now I truly feel home. It’s a place to call my own. Each day I am in awe of how wonderful and efficient these homes really are.” ZEM renter since 2016.

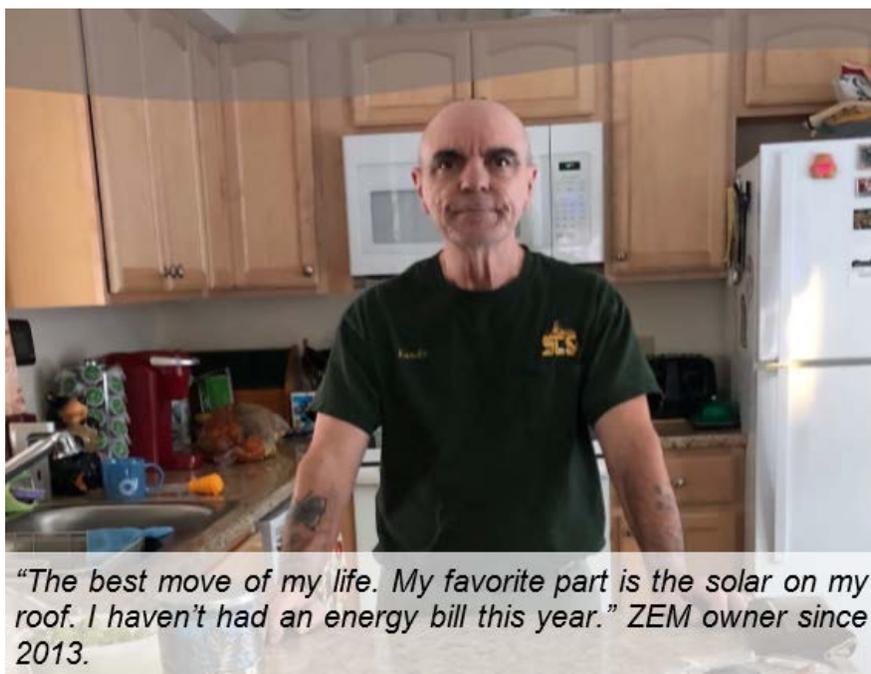


Figure 3. ZEM Homeowner Testimonial.

5. Existing Market Supports for ZEM

Homeowner Financing for ZEMs

ZEM homes on owned land on a permanent foundation should qualify for all available mortgage products in Colorado. CHFA has several mortgage products designed to help low income homebuyers achieve homeownership by allowing lower credit scores (620 or higher) and minimum down payment of \$1,000 which lowers the bar relative to market rate mortgage products. Homebuyer are required to attend homebuyer education classes before their loan closes.¹⁹ Each of the CHFA programs has income limits and purchase prices limits, some of which are calculated by county and other program establish a state wide earning and purchase cap.

¹⁹ <https://www.chfainfo.com/homeownership/Pages/chfa-loan.aspx>

A group of CHFA mortgage products have a statewide income limit of \$115,600 and maximum home purchase price of \$453,100. Table 4 provides the income and purchase price limits for the three example communities for one CHFA program.

Table 4. CHFA Mortgage Program Income Limits.

Location	Income limit
City of Boulder	\$54,300
Steamboat Springs (Routt County)	\$43,300
Alamosa County	\$33,600

With a purchase price of \$200,000, a ZEM home would be considered affordable for low and moderate income households. In many cases these mortgages may be used on lots with long term leases.

Although Colorado has many low and moderate income mortgage products and with our existing estimates the cost of ZEM homes falls well within the purchase price limits, the products may not work for modular construction as many modular factories require a deposit when signing a contract, progress payments during construction and upon delivery, and a final payment when the home certificate of occupancy is issued. This payment schedule requires a construction loan, then permanent financing when the homeowner moves into the house. For low income buyers, there are few available mortgage products that function as construction loans.²⁰

Energy Efficiency & Renewable Energy Programs

A successful ZEM program will need to access energy efficiency (EE) and renewable energy (RE) rebates and incentives available for new construction, high performance building practices and products, solar PV, as well as other programs targeted for the low to moderate income sector. Available EE and RE incentives vary widely from utility to utility. Investor-owned utilities (IOUs), that receive financial incentives for contributing to Colorado's statewide gas and electric savings goals and are regulated and overseen by the Public Utilities Commission (PUC), may offer more incentives than the numerous cooperatives and municipal utilities unregulated by the PUC. In Colorado, the comprehensive Residential New Construction Programs offered by the two IOUs, Xcel Energy and Black Hills, are gas programs for which ZEM all-electric homes are not eligible. However, ZEM homes are eligible for high performance product rebates offered by the IOU programs.

In addition to new construction and equipment incentives, income eligible ZEM homebuyers will be able to access incentives through state funds administered by Energy Outreach Colorado (EOC). As with market rate programs, incentives will vary widely from utility to utility. Specific examples of potential incentives available to ZEM home buyers in the selected scenario locations are detailed in Table 5 below.

²⁰ <https://www.chfainfo.com/homeownership/Pages/down-payment-assistance.aspx>

Similar to EE incentives, there is no single statewide renewable energy incentive. Available incentives, which may come in the form of a \$/watt PV system array rebate, installation cost buydown, net meter credits, and/or Renewable Energy Credits (RECs), vary by utility. For example, a resident of the City of Boulder within Xcel Energy's service territory may be eligible for rebates and grants administered by the city,²¹ as well as installation cost buydown due to an Xcel Energy settlement in addition to the net meter credits and RECs offered by Xcel Energy. Additionally, there is a recent incentive of \$2/watt for PV systems as part of an Xcel Energy settlement for the State Energy Office and Weatherization Assistance Program. It is unclear whether ZEM homes would qualify.

In contrast, no specific solar PV system-based incentives or rebates were found for residents of Steamboat Springs,²² which lies within Yampa Valley Electric Association (YVEA) service territory. YVEA does offer net meter credits, but does not offer RECs. Outside of utility incentives, working with GRID Alternatives may provide an opportunity to reduce the cost of PV systems for ZEM homeowners.²³ Flatirons Habitat for Humanity frequently works with GRID and has noted that recent projects have received ~30% incentive of total project cost.²⁴ Energy Outreach Colorado is exploring innovative opportunities to provide renewable capacity for low-income families across Colorado that won't require the expense of building solar systems on site, rather an aggregated community solar program. These types of partnerships may be an option to pursue in areas where higher utility-based incentives are not available.

In addition to city or program-based incentives, there has been a long-standing Federal tax credit available for PV system installations. The current Federal tax credit of 30 percent is available through 12/31/2019. The tax credit percent is legislated to begin decreasing in subsequent years and set to expire 12/31/2021. It should be noted that some ZEM homeowners may not have a high enough tax liability to be able to take advantage of this tax credit. However, the tax credit carries forward from year to year so if the ZEM homeowner has any tax liability, they should be encouraged to File Tax Form 5695 with their tax return.²⁵

VEIC researched potential incentives for ZEM in three geographic locations representing three ownership scenarios – City of Boulder, Alamosa County, and Steamboat Springs. Two of these locations, City of Boulder and Alamosa County, are served by the IOU Xcel Energy. The third, Steamboat Springs, is served by Yampa Valley Electric Association.

²¹ <https://bouldercolorado.gov/solar/solar-rebate-and-solar-grant-programs>

²² Residents of Routt County may be eligible for a rebate through Energy Smart Colorado.

²³ <https://gridalternatives.org/colorado>

²⁴ VEIC calculated based on recent project data provided by Flatirons Habitat for Humanity, 12/4/2018

²⁵ https://apps.irs.gov/app/picklist/list/formsPublications.html;jsessionid=HJIXaguperE_OSnJhsN3GQmaCW8U7MrbRqwr111v.-?value=5695&criteria=formNumber&submitSearch=Find

Table 5. Energy Efficiency and Renewable Energy Incentives by Location Scenario.

	Alamosa County	City of Boulder	Steamboat Springs
Electric Utility	Xcel Energy		Yampa Valley Electric Association
Energy Efficiency Incentives			
Residential New Construction ⁽¹⁾	n/a		n/a
Existing Homes Low Income Incentive ⁽²⁾	\$3,300		n/a
Ductless Mini-split Heat Pump	\$300		n/a
Heat Pump Water Heater	\$450		n/a
LED Lighting ⁽³⁾			\$160
Renewable Energy Incentives			
PV System Rebate ⁽⁴⁾	n/a	TBD	n/a
Installation Cost Buy-Down ⁽⁵⁾	~\$2.35/watt ²⁶		n/a
Net Meter Credit	Residential rate (~\$0.10/kWh)		Avoided cost rate (~\$0.03/kWh)
Renewable Energy Credit (REC)	\$0.005/kWh		n/a

References:

- (1) Many utility funded Residential New Construction (RNC) programs will provide incentives for high performance RNC regardless of primary heating fuel. Xcel Energy's program is a gas program only, therefore ZEM is not eligible.
- (2) Administered by Energy Outreach Colorado. Homes in Xcel Energy service territory are eligible for prescriptive-based incentives for energy efficient measures including air sealing, insulation and LEDs. Homes in YVEA service territory are eligible for a small donation from EOC, but not prescriptive rebates.
- (3) Administered by Energy Smart Colorado
- (4) The City of Boulder administers a Solar Rebate and Solar Grant program. Specific incentives are determined on a case by case basis. No other PV system rebates were found for Alamosa County or Steamboat Springs.
- (5) This installation cost buy-down is only available to homeowners within Xcel Energy's service territory.

Appraisals

As ZEMs are introduced into the Colorado market, it will be important to educate real estate appraisers on the value of ZEMs and how these homes can fit into the classifications that appraisers routinely use in assessing value such as green and energy efficiency features, comparable sales and neighborhood conformity. If ZEMs are undervalued by appraisers who may equate them with MMH, or not fully understand the value of solar and energy efficiency

²⁶ Average installed cost per watt for 2018 WAP projects. Based on 12/11/2018 conversation with Luke Ilderton (Energy Outreach Colorado).

upgrades in a single family application, then the value to support mortgage lending will not be apparent, and loans will not be approved to cover the full cost of construction. Appraisers are selected by the financial institution that is originating a loan, but a builder or home buyer may notify the lender that their property is zero energy and has special features that require an appraiser that has experience and knowledge for that type of housing. Fannie Mae,²⁷ Freddie Mac²⁸ and FHA²⁹ require lenders to choose experienced appraisers.

Green Appraisals

ZEM homes include high efficiency equipment, a super insulated envelope and solar PV which have a higher first cost than a baseline code home. The Appraisal Institute, one of several approved real estate continuing education course providers in Colorado³⁰, offers the Valuation of Sustainable Buildings Professional Development Program which trains appraisers on the value of green features like increased insulation and solar PV. Appraisers who have completed courses and passed exams in the Valuation of Sustainable Buildings Professional Development Program are maintained in the AI Professional Development Program Registry.³¹ Additional AI members who are qualified to work with green / sustainable properties can be found in the main registry by selecting 'Sustainable Green Buildings' in the Residential Property Types filter.³² In CO, there are almost 50 appraisers listed in the Professional Development Registry.

For a zero energy home, the relevant documentation to guide the appraisal is the Residential Green and Energy Efficient Addendum³³ and the final Home Energy Rating System (HERS) report, both of which would be completed by one of the primary parties to the transaction (e.g., builder, HERS Rater). Appraisers typically do not have the expertise or sufficient information to complete this addendum without documentation from one of the primary parties.

Colorado has been one of the forerunners in "greening the MLS" and working to ensure appraisers and real estate professionals are trained in valuing green and sustainable property features. The Colorado Energy Office (CEO) was instrumental in establishing and implementing a consistent set of green fields to the MLS systems in Colorado beginning in 2010. More recently the state of Colorado participated in the U.S.DOE Better Buildings Home Energy Information Accelerator, Bringing Home Energy Information to Real Estate: A Toolkit.³⁴ The Colorado Energy Office has sponsored trainings for residential appraisers to become certified in the AI's Value of Sustainable Buildings Program as well as for real estate agents on Green MLS fields. As of 2015, the appraisers certified by these efforts accounted for over 10% of all appraisers nationally holding this certification.³⁵

²⁷ <https://www.fanniemae.com/content/guide/sel121614.pdf#page=590>

²⁸ http://www.freddiemac.com/singlefamily/appraiser_independence_faq.html#30

²⁹ <https://www.hud.gov/sites/documents/40001HSGH.PDF#page=73>

³⁰ https://docs.google.com/spreadsheets/d/1HAX5DK2DslLulicVpI-IdxXkDcFWIoOy7HT_mzi2bq0/edit#gid=0

³¹ https://www.myappraisalinstitute.org/findappraiser/green_sustainability_residential.aspx.

³² <https://www.myappraisalinstitute.org/findappraiser>

³³ <https://www.appraisalinstitute.org/assets/1/7/ResidentialGreenandEnergyEfficientAddendum.pdf>.

³⁴ <https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/HEIA%20TOOLKIT%20081318.pdf>

³⁵ https://rpsec.energy.gov/sites/default/files/publication/c-1176_Better_Buildings_Real_Estate_White_Paper.pdf

Comparable Sales

The most common appraisal approach is the Sales Comparison approach. Using this approach, appraisers find comparable properties, preferably those that have been sold recently within the local market. This poses a couple of problems for ZEM when used for MMH replacement. While a ZEM is built to the same footprint of a MMH, and is often placed within a MMH park, a MMH is not appropriate for use as a comparable property. MMH construction is not subject to local codes, therefore the baseline construction requirements are fundamentally different than for a ZEM.

This makes it difficult to find appropriate comparable properties. Ideally, comparables for ZEM would include other ZEMs and/or small homes built to a zero energy or high performance specifications. When the current market does not have adequate comparable properties, as is the case currently in Colorado, the Cost Approach can be utilized in the appraisal to document the actual cost of the property being appraised and inform adjustments within the Sales Comparison appraisal. The ability to select appropriate comparables, and to apply adjustments relies on an appraiser trained to understand the ZEM housing type.

Neighborhood Conformity

Additionally, when appraising ZEM Homes, the issue of non-conformance may arise. The ZEM will be unique to the neighborhood in which it is placed. Assessing conformity for ZEM in a MMH park could be related to the type of construction (modular versus manufactured), the renewable energy equipment, or the aesthetics, although some ZEM models look like new manufactured homes. For ZEM as urban infill, the new home may have a different physical appearance than the homes in the surrounding neighborhood. Whether or not this adversely affects the appraisal is a decision of the appraiser. For these reasons it is critical that a competent appraiser, one that has been trained in valuing the unique features of ZEM homes is selected to conduct the appraisal.

For a ZEM pilot to be successful in Colorado, support for the appraisal industry is critical. In Vermont, where stakeholders and advocates have been supporting ZEM since 2013, the cost of ZEM appraisals remains to be \$750-1,000.³⁶ The higher cost compared to \$500-\$600 to a standard appraisal is due in part to the additional data gathering and documentation required for ZEM, as well as the green appraisal process itself being new and simply taking more time. Ideally, Colorado partners in this effort will be able to support the green appraisal industry by offering training and education, direct financial support to appraisers to offset the cost of completing the AI Valuation of Sustainable Buildings Professional Development Program, and potentially offering further incentive to completing a target number of green appraisals annually. Developing a pool of competent green appraisers must also include regional competency.

Strong program support for the appraisal industry, utilizing the many existing resources, must go hand in hand with efforts to launch a ZEM pilot. The Appraisal Institute, in collaboration with the Building Codes Assistance Program (BCAP), the National Association of Home Builders

³⁶ A typical appraisal in the Vermont market is \$500-600, Efficiency Vermont.

(NAHB) and other stakeholders, recently developed a two-page flyer titled, “Appraised Value and Energy Efficiency: Getting it Right.”³⁷ This flyer provides an easy reference for the steps required to help ensure all the pieces are in place help solve the ZEM valuation puzzle.

Modular Factories Serving Colorado

There is currently a lack of in-state modular factory capacity to build ZEM homes. There are entities that build panelized walls, and at least one company starting a 60,000 sq. ft factory in Pueblo: “Goodwin Knight LLC to build pre-fabricated components for single and multi-family buildings.”³⁸ There are 40 factories registered with the Colorado Department of Local Affairs,³⁹ however, some of them are schools or prisons manufacturing only components of houses (e.g. trusses and stairs), or very small scale, and no modular home factories able to build a significant number of homes were identified in Colorado. Numerous dealers located in Colorado offer modular homes but these homes are shipped from out of state.

6. ZEM Cost-Benefit Analysis

In this section we estimate the total cost of owning a ZEM home compared two base cases – a new manufactured home built to HUD code and a new single family ranch home built to the local energy code. We look at three geographic locations and climate zones that represent development models in areas of high housing demand and potential candidates for a ZEM pilot program.

Alamosa County (Climate Zone 6) – Rural

City of Boulder (Climate Zone 5) – Urban

Steamboat Springs (Climate Zone 7)– Mountain ski town

Inputs to the model include financing terms, baseline code parameters, energy costs, net metering payments and rebates or incentives for high performance building practices and equipment. The methodology and detailed inputs to the models is found in Appendix 1. Inputs fall into three general categories: first costs; energy use, generation and cost; and financing terms.

First Costs

First cost estimates include the upfront costs to purchase the home as well as any required site work and permit fees. Available incentives or rebates to buy down the cost of high performance building practices and equipment are included in the model.

The cost estimate for a manufactured home built to HUD is based on 2017-18 U.S. Census average sales price data for the Western region.⁴⁰ To provide a comparable cost comparison to the ZEM home, which comes complete with all finishes, \$20k was added to the average base sales price to account for porches, decks, appliances etc. Construction costs for the single

³⁷ https://www.appraisalinstitute.org/assets/1/29/AI-BCAP_Flyer.pdf

³⁸ <https://www.chieftain-com.cdn.ampproject.org/c/s/www.chieftain.com/ed0e9cb6-cc0e-11e8-b89f-67a86b84a4e6.html?template=ampart>

³⁹ https://dola.colorado.gov/doh_codes/fb.jsf

⁴⁰ <https://www.census.gov/data/tables/time-series/econ/mhs/average-sales-price.html>

family home are based on an average market rate of \$300/square foot obtained from Flatirons Habitat for Humanity. This cost was carried across all scenarios. The ZEM home cost was developed for Colorado by applying labor and material adjustment factors to actual cost data from Vermod, a ZEM factory in Vermont, Beracah Homes, a modular factory in Delaware, and a Portland, Oregon-based modular home factory.

Energy Use, Generation and Costs

Annual energy consumption is modeled using REM/Rate™ energy modeling software.⁴¹ For each location scenario, three models were generated assuming the same ZEM home geometry and footprint:

- Base Case One – Manufactured home built to HUD code
- Base Case Two – Single family ranch home built to local energy code
- Efficient Case – Zero Energy Modular home built to VEIC specification

Energy generation is estimated utilizing NREL's PVWatts® Calculator to meet the estimated consumption value produced by REM/Rate.⁴²

Financing

The cash flow models uses the rates listed in Table 5. The manufactured home terms assumes a chattel loan, which has historically been the most common loan to purchase this housing type. These terms are consistent with the "Tier 2" loan product offered by Impact Development Fund for manufactured homes. Final terms for the manufactured home base case may vary widely. The Credit Union of Colorado has published terms less favorable for manufactured housing than those listed below.^{43, 44} Financing terms for the Single Family Ranch and ZEM scenarios were estimated using the Boulder County Department of Housing and Human Services Quarterly Interest Rate calculation methodology.

Table 6. Financing Term Assumptions.

	Manufactured Home	Single Family Ranch	Zero Energy Modular
Interest Rate	9%	4.18%	4.18%
Term (years)	15	30	30
Down Payment	10%	5%	5%

Homeowner Cash Flow Results

Summary cash flow results for each of the selected cities (Alamosa, Boulder and Steamboat Springs) are shown in Table 7 - Table 9 below. This analysis shows that under the assumed

⁴¹ <http://www.remrate.com/> REM/Rate is a RESNET accredited software tool for Home Energy Ratings System (HERS) and an industry standard for home energy analysis.

⁴² <https://pvwatts.nrel.gov/pvwatts.php>

⁴³ <https://www.cuofco.org/rates/mortgage-rates>

⁴⁴ However, as part of their Duty to Serve efforts, Freddie Mac recently announced a pilot that will offering conventional loan terms to HUD compliant manufactured homes. It will be important to watch these developments as financing has a significant impact on the final monthly mortgage payment.

financing terms and expected incentives, a ZEM home has monthly costs comparable to a new manufactured home. ZEM homes could provide occupants healthier, more efficient homes that would hold their value long-term at essentially the same price as a manufactured home. A new, site-built single family ranch, built to the local code, is almost two-thirds more expensive than the ZEM.

Table 7. Summary Cash Flow Model Inputs for Alamosa County, CO.

Alamosa County			
	Manufactured Home	Single Family Ranch	Zero Energy Modular
Housing Costs			
Base cost	\$73,875	\$294,000	\$149,940
Local sales tax	\$2,615	\$10,408	\$5,308
Site work & delivery	\$8,500	\$8,500	\$15,500
Solar array	\$0	\$0	\$10,575
Permits, fees	\$0	\$660	\$660
Housing Cost Subtotal	\$84,990	\$313,568	\$181,983
Incentives			
Energy efficiency	\$0	\$0	(\$4,088)
Solar PV	\$0	\$0	\$0
Incentives Subtotal	\$0	\$0	(\$4,088)
Financing			
Down payment	\$8,630	\$15,678	\$8,895
Interest rate	9.0%	4.18%	4.18%
Term (years)	15	30	30
Energy Costs and Credits			
Average monthly utility cost	\$89	\$81	\$5
Average monthly credit	\$0	\$0	(\$3)
Average net monthly bill	\$89	\$81	\$2
Total Cost of Ownership			
Mortgage payment	\$776	\$1,453	\$824
Property taxes & Insurance	\$150	\$150	\$150
Energy costs	\$89	\$81	\$2
Total Monthly Housing Cost	\$1,015	\$1,684	\$977

Table 8. Summary Cash Flow Model Inputs for the City of Boulder, CO.

City of Boulder			
	Manufactured Home	Single Family Ranch	Zero Energy Modular
Housing Costs			
Base cost	\$73,875	\$294,000	\$149,940
Local sales tax	\$3,921	\$15,603	\$7,957
Site work & delivery	\$8,500	\$8,500	\$15,500
Solar array	\$0	\$0	\$10,575
Permits, fees ⁴⁵	\$0	\$23,500	\$23,500
Housing Cost Subtotal	\$86,296	\$341,603	\$207,472
Incentives			
Energy efficiency	\$0	\$0	(\$4,088)
Solar PV	\$0	\$0	\$0
Incentives Subtotal	\$0	\$0	(\$4,088)
Financing			
Down payment	\$8,630	\$17,080	\$10,169
Interest rate	9.0%	4.18%	4.18%
Term (years)	15	30	30
Energy Costs and Credits			
Average monthly utility cost	\$82	\$73	\$5
Average monthly credit	\$0	\$0	(\$2)
Average net monthly bill	\$82	\$73	\$3
Total Cost of Ownership			
Mortgage payment	\$788	\$1,583	\$943
Property taxes & Insurance	\$150	\$150	\$150
Energy costs	\$82	\$73	\$3
Total Monthly Housing Cost	\$1,020	\$1,806	\$1,095

⁴⁵ The fees listed for the single family ranch and ZEM scenarios are only city permitting fees. These scenarios assume a one-for-one replacement and exemption from any inclusionary housing fees ((B.R.C. 1981, 9-13-11. Rebuilt Dwelling Units).

Table 9. Summary Cash Flow Model Inputs for Steamboat Springs, CO.

Steamboat Springs			
	Manufactured Home	Single Family Ranch	Zero Energy Modular
Housing Costs			
Base cost	\$73,875	\$294,000	\$149,940
Local sales tax	\$3,723	\$14,818	\$7,557
Site work & delivery	\$8,500	\$8,500	\$15,500
Solar array	\$0	\$0	\$11,750
Permits, fees	\$0	\$9,588	\$9,588
Housing Cost Subtotal	\$86,098	\$326,906	\$194,335
Incentives			
Energy efficiency	\$0	\$0	(\$160)
Solar PV	\$0	\$0	\$0
Incentives Subtotal	\$0	\$0	(\$160)
Financing			
Down payment	\$8,630	\$16,345	\$9,709
Interest rate	9.0%	4.18%	4.18%
Term (years)	15	30	30
Energy Costs and Credits			
Average monthly utility cost	\$127	\$107	\$33
Average monthly credit	\$0	\$0	\$0
Average net monthly bill	\$127	\$107	\$33
Total Cost of Ownership			
Mortgage payment	\$786	\$1,515	\$900
Property taxes & Insurance	\$150	\$150	\$150
Energy costs	\$127	\$107	\$33
Total Monthly Housing Cost	\$1,063	\$1,773	\$1,083

The estimated monthly cash flow, illustrated in Figure 4 - Figure 6, shows that in all location scenarios (Boulder, Steamboat Springs, and Alamosa County), the homeowner cashflow for ZEM is comparable to, or better than, both a new manufactured home built to HUD standards and a traditional site-built home. For each scenario, the cost of owning a ZEM home is approximate one-third less than a new site-built single family ranch home.

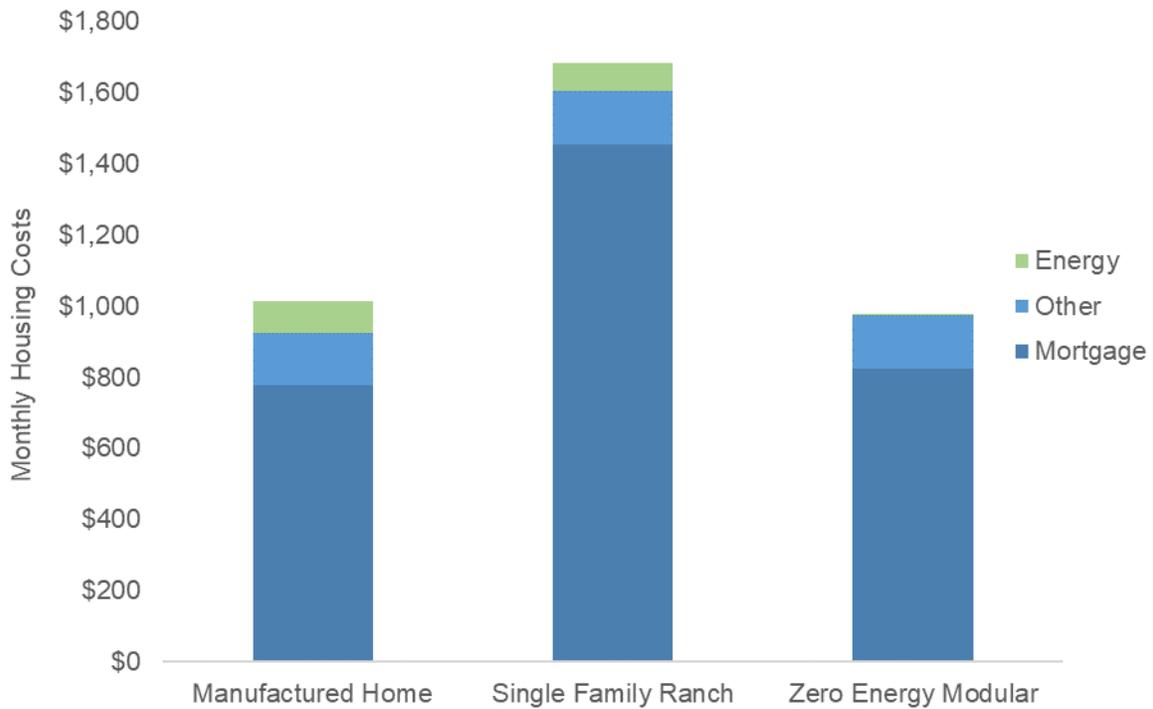


Figure 4. Estimated Monthly Cash Flow by Housing Type for Alamosa County, CO.

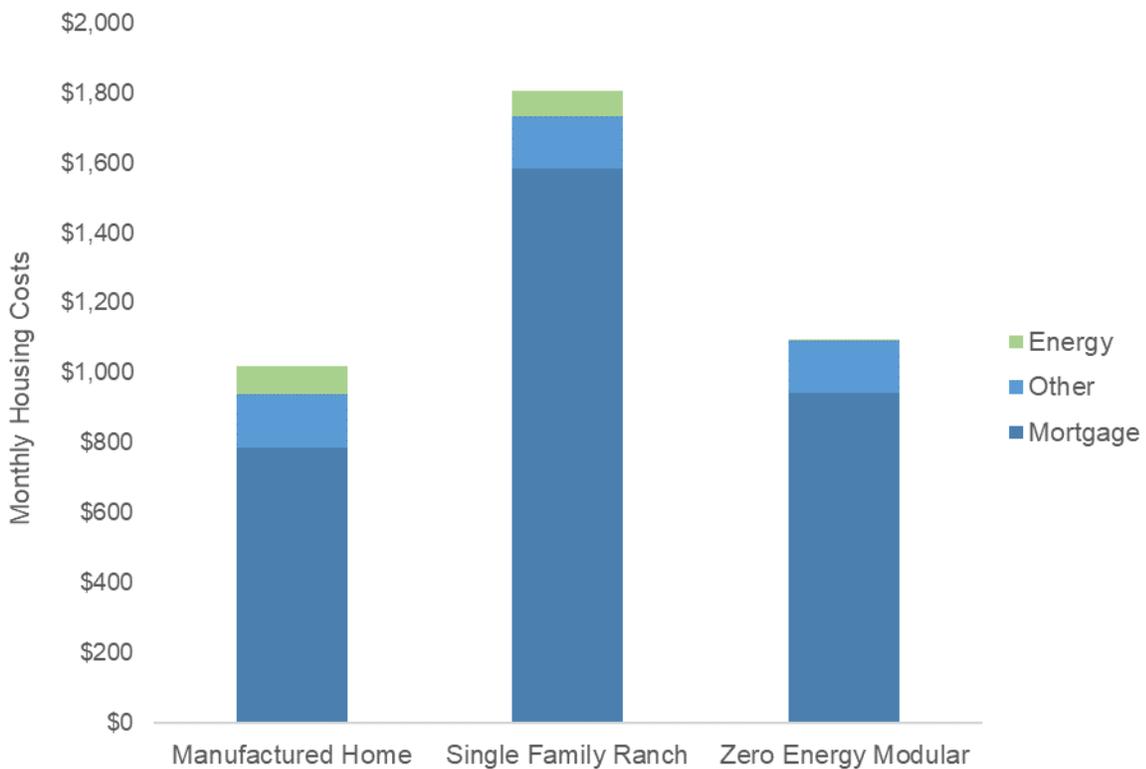


Figure 5. Estimated Monthly Cash Flow by Housing Type for City of Boulder, CO.

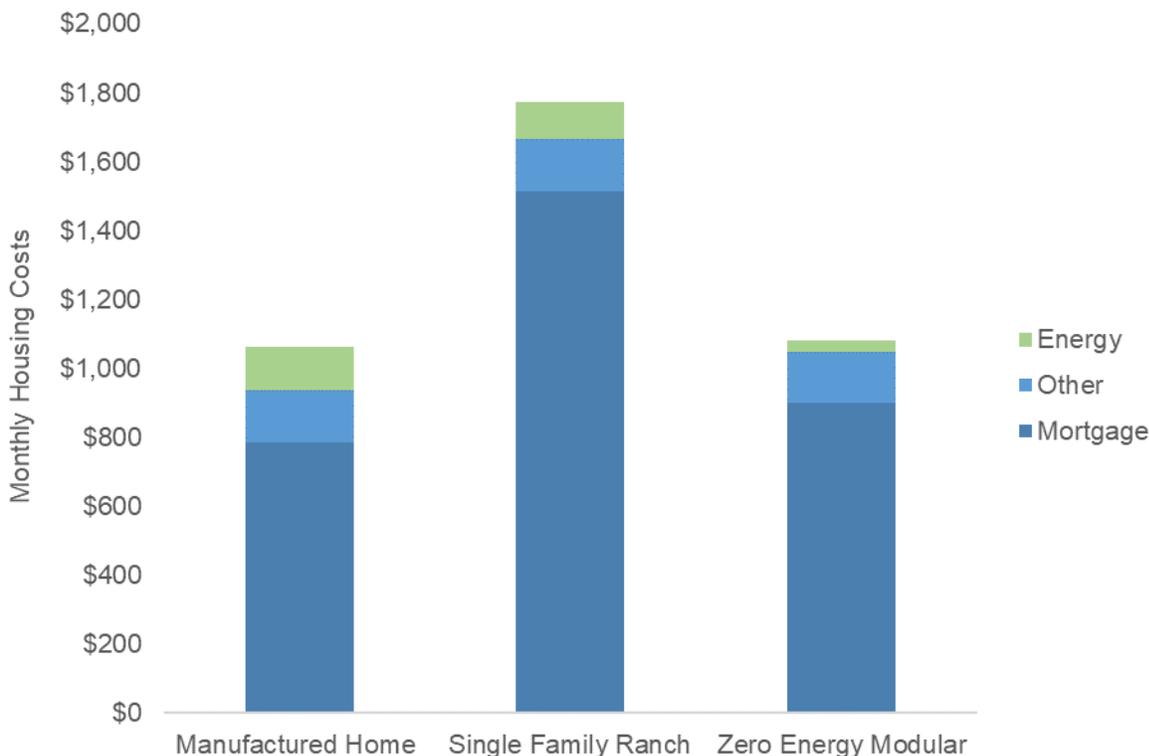


Figure 6. Estimated Monthly Cash Flow by Housing Type for Steamboat Springs, CO.

Non-Energy Benefits

In addition to reduced energy costs, ZEMs also offer non-energy benefits, including improved occupant health and comfort. MMHs are known to have poor indoor air quality and air sealing. Prone to higher levels of mold and indoor volatile organic compounds (VOC), manufactured housing can be particularly harmful to those already vulnerable to respiratory ailments, including children, the elderly, and those who are already ill. A 2017 study based on a decade of data gathered through the National Health and Nutrition Examination Survey found that people living in MMHs were 40 to 50 percent more likely to suffer from respiratory problems than those living in other housing types such as site-built homes and apartments.⁴⁶ In contrast, a survey of ZEM occupants in Vermont found that those who were former occupants of MMH perceived improved air quality and ventilation in their ZEM homes, as well as improved health in themselves and their family members.⁴⁷

⁴⁶ Prevent Medicine Reports. 2017: Different types of housing and respiratory health outcomes: <https://www.sciencedirect.com/science/article/pii/S2211335517300992>.

⁴⁷ University of Vermont Center for Rural Studies. 2017. Assessment of the market of energy efficient factory built homes in Vermont: <https://www.uvm.edu/crs/reports/2017/Market%20assessment%20for%20energy-efficient%20factory-built%20homes%20in%20VT.pdf>

7. Increasing Modular Factory Capacity in Colorado

Introduction to ZEM Factories

The following discussion is an excerpt from *ZEM Factory Initiative: How to Create and Build a Zero Energy Modular (ZEM) Housing Factory Serving Affordable Housing*, available at www.veic.org/resource-library. It provides the background necessary to understand the following sections on potential models to increase ZEM factory capacity in Colorado, and to assist in identifying potential suitable factory structures currently available in the state.

ZEM factory size and necessary workforce can be estimated, recognizing that the exact values will vary depending on production processes and factory set-up (Table 10).

Table 10. Conceptual Factory Size and Required Workforce for Several Production Scenarios.

Module / year	Plant Floorspace	Labor Hours / Module	Labor Annually	FTE, Direct Production
40-50	10-20,000	440-1,200	24,000	20
70	20,000	450	28,000	20
160	45,000	400	56,000	30
260	70,000	350	78,000	35

Ideally, for homes shipped beyond the local market, a factory should be located within a short drive (15 minutes) of a major highway, to reduce transportation time and costs. A start-up can secure a portion of the building and share it with other industries. As the business increases, the modular factory may have the option to occupy a larger part of the building. Factories should have column spacing and height clearances that are compatible with the factory layout. The warehouse can be attached or be delineated space within the factory. Incorporating staging within the factory is generally more efficient than in a separate warehouse.

Generally, about 70% of the factory's square footage should be dedicated to the production line, and 30% to receiving, staging, and shipping.

A number of layouts are possible for setting up a factory plan. The plan will depend on whether the units are built in place (bay or crib construction), whether they are built in a set production line and moved along fixed rollers or rails, or whether they are on air pads (Figure 7) or casters on the modules and moved along a more or less set flow. Tracks are generally not a recommended choice because debris tend to accumulate in the tracks and cause problems. Casters and air pads are the most flexible options for moving modules around the factory floor, with air pads being more expensive. Flexibility in moving the modules is helpful as the factory expands or contracts and the layout of the factory line is changed to accommodate for the



Figure 7. Air pads Utilized to Move Modules Throughout Factory.

change in demand. The following figures illustrate various layout options for a modular factory. Line production (e.g. shotgun, sidesaddle, or horseshoe) are better suited to larger factories, and crib construction works best with small factories.

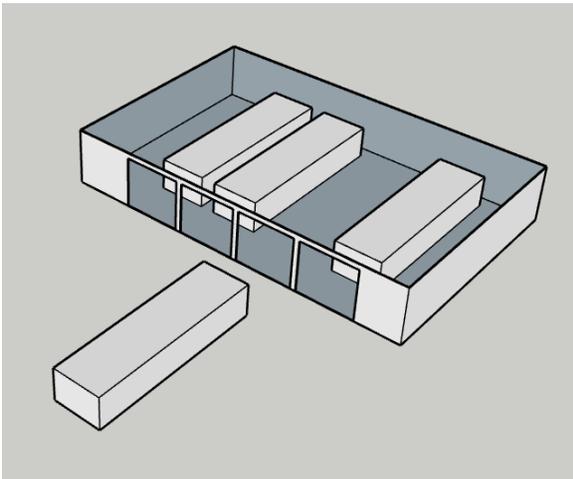


Figure 8. “Crib” or “Bay” Construction (10,000 sq. ft).

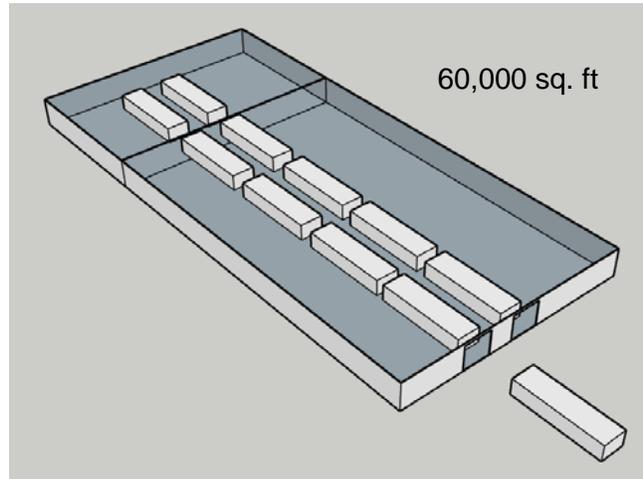


Figure 9. Shotgun Line Layout (60,000sq, ft) .

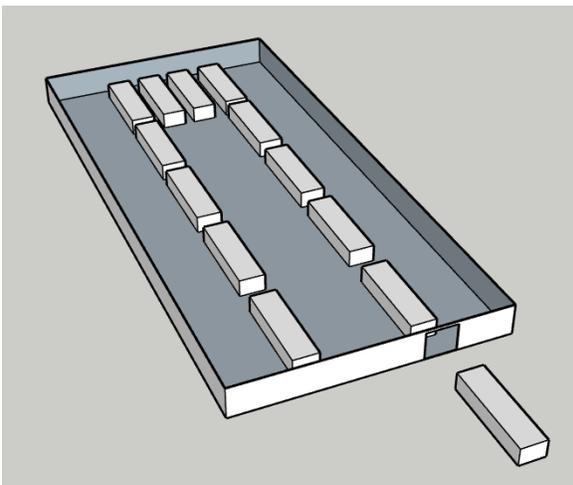


Figure 10. Horseshoe Line Layout (60,000 sq. ft).

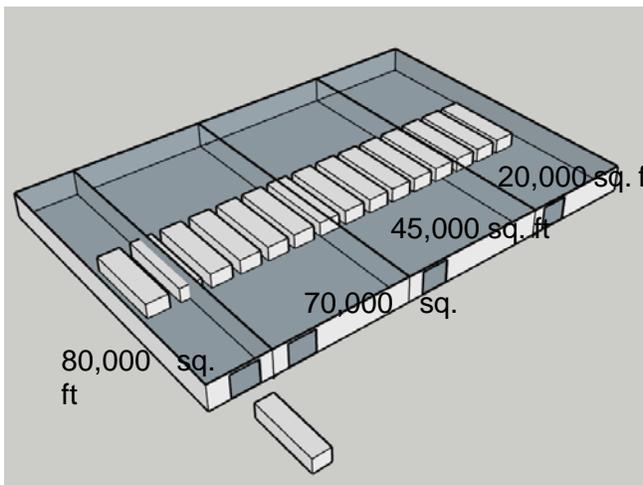


Figure 11. Sidesaddle Line Layout.

Small Factory

“Crib”, or “Bay” construction (Figure 8) works well for a start-up because it requires less equipment and does not require equipment and space to move the modules other than loading them on the carrier upon completion. Crib construction also works well if each module is highly customized or if the volume of production is relatively low. However, crib construction allows for limited capacity to expand, without a major investment into an additional building space.

We envision three types of small ZEM factories:

A community college or vocational school providing a few ZEM homes per year and hands-on trainings for the students, developing the workforce necessary for future projects.

Small factories run by Habitat for humanity affiliates. Chapters are located throughout Colorado and would be ideally suited to start small, crib-construction factories with capacity to produce 2-6 modules simultaneously.

Privately-owned factory selling directly to land trusts, affordable housing developers, Habitat chapters, private home-owners.

Medium and Large Factories

If the volume of production is higher, a line production can allow for shorter production time, and a relatively lower cost per module, with more specialized crews at each station performing a limited number of tasks each. The shotgun line layout (Figure 9) is often used for line production. It can be modified into a T or an L or a horseshoe shape (e.g., Figure 10), depending on factory layout and volume of production. A sidesaddle layout may be preferred depending on building layout and construction processes (Figure 11).

Whether the construction line is sidesaddle or shotgun, the amount of work done at each station can vary to adapt to the facility size and layout. If space allows, a module can be pulled out of the construction line to customize or add additional features that would create a bottleneck if the module stayed in the line. From an efficiency standpoint, factories should strive to construct mostly standard modules as customization reduces production efficiency.

The number of stations in the construction line are determined by starting with two basic models that the factory is expecting to produce, determining the steps to construct those modules, and then consolidating the steps to fit the factory. If demand increases, the number of stations can be consolidated, and more work done at each station, to allow for higher volume production.

For a 20- 40,000 sq. ft factory, an example would be to have two sidesaddles with bay station pull-outs for customization or floor construction. This would allow the production to take place in a compact facility.

If the production line starts as a linear sidesaddle, and if space allows, the production line can be modified to L-shaped, or U-shaped for increased production. Similarly, a shotgun production could be modified to a sidesaddle production line to increase the number of stations and scale up production.

Larger factories could be run by affordable housing organizations or private entities that sell directly to affordable housing developers and homeowners. Colorado has an active network of affordable housing developers. With in-house staff skilled at managing construction projects, permitting and site work, these developers are good candidates to manage a factory. A former modular factory in Walsenburg, CO, now vacant could be re-purposed in to a ZEM factory.

With time, as the ZEM pilot program expands into a full-scale emerging market, additional factories would be established, and existing factories could expand within their existing footprint, and into larger facilities able to produce more homes. Using conceptual factory sizes, to ramp up production to 75 homes annually in Colorado as part of a pilot project, there would need to be two to three small, start-up factories in the state.

Expanding the pilot to meet the actual affordable housing demand in Colorado, assuming a demand increasing from 75 to 200 ZEM homes per year statewide, some of the start-ups would need to increase production and a few additional start-ups could be built in different areas of the state. However, to meet that level of demand, at least one larger factory (e.g., 45,000 sq. ft.) would likely be necessary. The cost of the homes would likely decrease due to greater efficiency of production in the larger factories.

By 2025, the ZEM market could be served by two larger ZEM factories and a number of local, small ZEM factories associated with specific organizations or local market demand. Deciding on whether to favor several smaller local factories over one larger one will depend on a balance of several factors:

- **Factory developer's** capacity, vision, aspirations, and funding.
- **Production costs:** larger factories generally produce less expensive modules.
- **Transportation costs:** several regional factories can generally transport modules shorter distances than one large factory.
- **Labor availability:** one larger factory may have difficulties hiring the necessary workforce, depending on location.
- **Local economic development:** benefits of a small factory supporting the local housing demand and need for jobs vs. a larger, centralized factory serving a larger region.

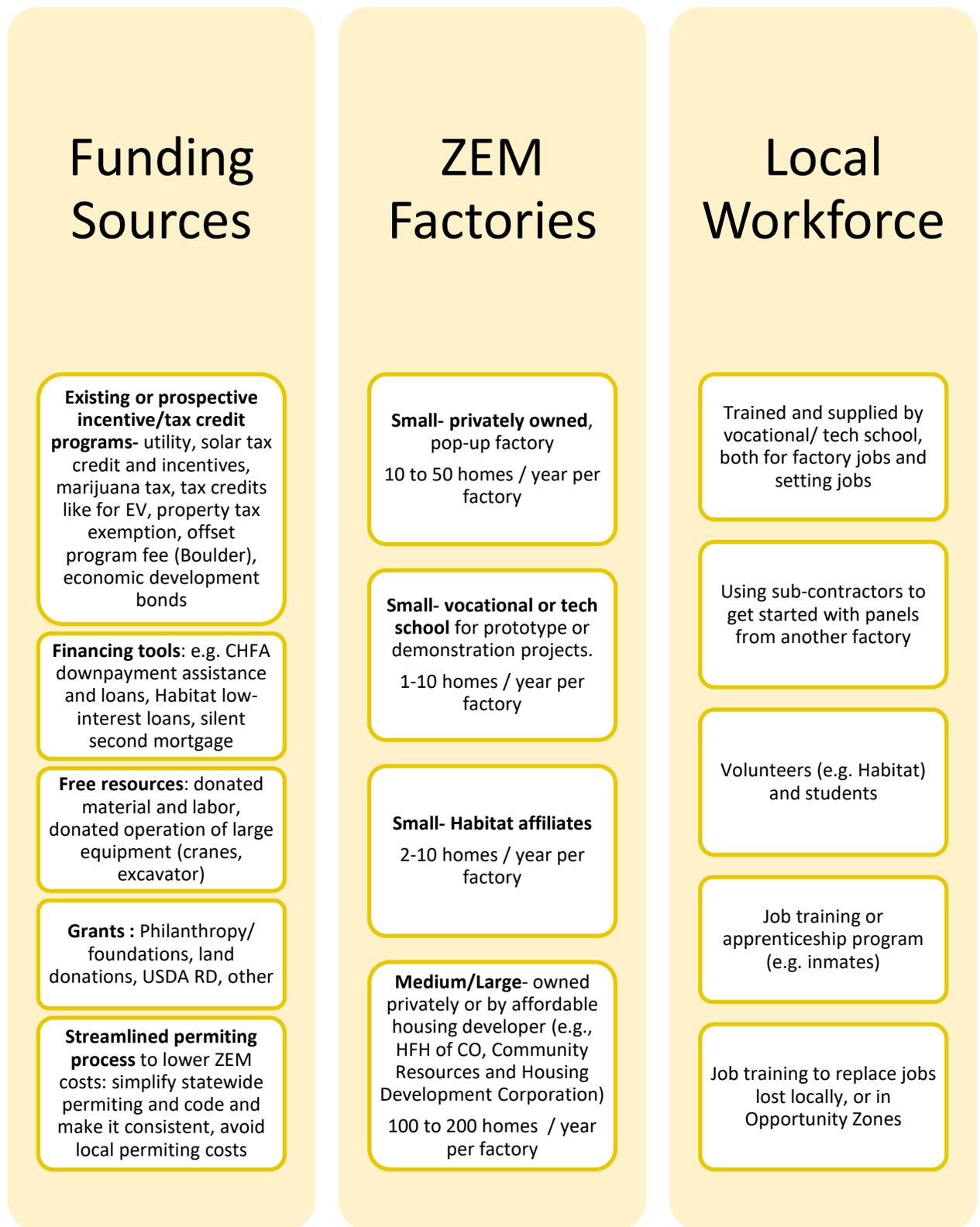


Figure 12. Increasing ZEM Manufacturing Capacity in Colorado.

Economic Development Support for ZEM Factories in Colorado

Colorado Economic Development Commission (EDC) offers programs supporting economic development and job growth in Colorado.⁴⁸ EDC develops incentive packages for projects that create or retain local jobs. These incentives may be available to new ZEM factories considering locating a factory in Colorado.⁴⁹ A non-profit organization looking to start a factory will likely not have enough state tax liability to be eligible for tax credits and may need to partner with a private factory developer to access these incentives.

The economic development incentives offered in Colorado can be grouped into two categories. The first category includes incentives and tax credits and are restricted to businesses where Colorado is competing with other states for the factory development, as demonstrated by submitting a cost differential spreadsheet as part of the application process:

The Strategic Fund Incentive is a cash incentive that supports economic growth and job development in the state. It is available for projects where Colorado is competing with other states for the project. A one-to-one local incentive match is required to access the cash grant. The Job Growth Incentive Tax Credit (JGITC) is a performance-based job creation incentive program for net job growth in a given calendar year. It is restricted to businesses creating at least 20 jobs, except for businesses located in Enterprise Zones where at least 5 jobs have to be created. To be eligible, the mean wage for all jobs created must be equal to or higher than the average median wage for the county.

Job Growth Incentive Tax Credit-Higher Education Partnership: A program for businesses partnering with State Higher Institutions to support job growth, academic development and economic expansion.

The second category are incentives and tax credits that do not require demonstration that the factory is being considered in other states:

Colorado FIRST: a job training program for companies relocating to or expanding in Colorado. The program offers up to \$1,200 per full-time job.

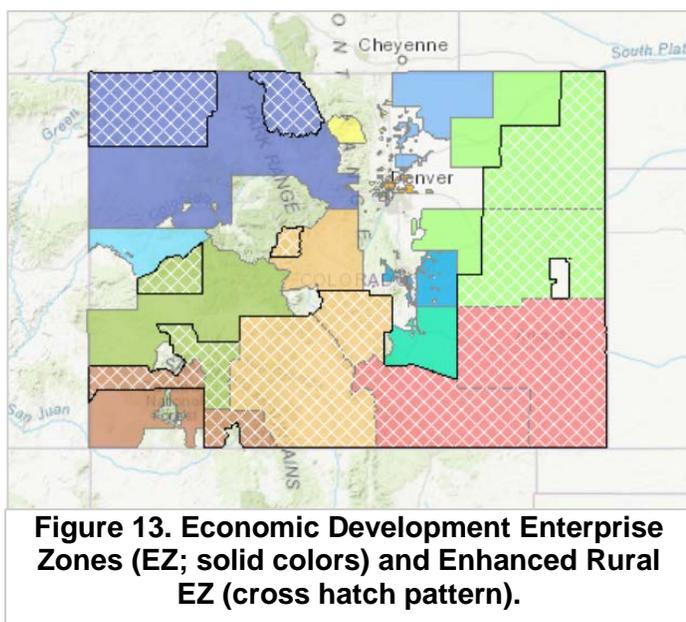
Enterprise Zone (EZ) program: offers state income tax credits for private investments in economically distressed areas.

Among the tax credits offered, some are directly applicable to new ZEM factories, including:

Investment: a 3% tax credit is available for businesses investing in EZs.

Job Training: a 12% credit is available for qualifying job-training programs.

New Employee: a per-employee tax credit for businesses increasing their workforce.



⁴⁸ <https://choosecolorado.com/doing-business/incentives-financing/economic-development-commission/>

⁴⁹ <https://choosecolorado.com/doing-business/incentives-financing/businesses-considering-colorado-site-selectors/>

Vacant Commercial Building Rehabilitation: a 25% credit for the cost of rehabilitating an older, vacant building; limited to \$50,000 per building.

Contribution Projects: a 25% credit for private-public partnerships that have the support of the community.⁵⁰

The New Opportunity Zone office manages a federally-funded regional opportunity zones program, which is location-specific. The EDC will assist prospective factory developers connect with that program. Another potential source of funding for factory development is the Colorado C-PACE program, run by the Energy Office. C-PACE is a financing tool that allows property owners to finance qualifying energy efficiency, water conservation, and other clean energy improvements on existing and newly constructed commercial properties, with repayment of the financing through a voluntary assessment on their property tax bill.⁵¹

8. Conclusions and Recommendations

There is a strong need for new affordable housing solutions in Colorado and ZEM homes provides an excellent opportunity to meet that demand in a way that also advances the State's clean energy goals. VEIC recommends that Colorado proceed to the design and implementation of a ZEM pilot program, which will be the first step in a long term market transformation effort to bring clean energy to Colorado's affordable housing market. VEIC is actively supporting ZEM programming in Vermont, Delaware, Oregon and Massachusetts and would be pleased to support Colorado as well should it decide to proceed to design and launch a ZEM pilot program.

ZEM homes could have an incredible impact on Colorado. If ten thousand ZEM homes were installed over the next decade, we estimate that low and moderate income households would save \$9.5 million in reduced energy costs relative to traditional MMH and new, site-built homes. In addition, the state would avoid an estimated 137 million pounds of greenhouse gas emissions. If we assume medium-sized factories come on line to meet the demand, 18 new factories would be created with over 500 jobs.

Table 11. Projected ZEM Energy and GHG Benefits for Colorado, 2019-2030.⁵²

Projected Benefits, 2019-2030	
Number of ZEM Homes installed	10,000
Electric Savings (kWh)	52,400,000
Natural Gas (therms)	5,000,000
Energy Cost Savings	\$9,500,000
Avoided Emissions (lbs. CO ₂)	137,200,000

⁵⁰ <https://choosecolorado.com/doing-business/incentives-financing/ez/>

⁵¹ <https://copace.com/>

⁵² Detailed calculations found in Appendix C Estimated Benefits of ZEM.

Next Steps

1. Provide Adequate Resources for Program Launch

VEIC has learned through our experiences in Vermont, Delaware and Massachusetts, that program design, launch, and maintenance takes dedicated resources in the form of staff, time, and budget. The early years need adequate supply of all of these to ensure the program pieces come together seamlessly and that when barriers arise, there is support available to quickly find solutions. This support can come through effective collaboration and partnerships with other interested parties, but it also should include a clear articulation of the program roles and responsibilities to ensure a positive and uncomplicated experience for homeowners and the general market.

VEIC's experience has shown that approximately six months should be dedicated to the program design effort and that program launch and early implementation can take about three years. Confirmed support for the program – both financial and staffing – will be necessary to bring this new product into the market. The level of program implementation staffing and other supports may be able to begin ramping down after the initial three years depending on market adoption.

2. Design a ZEM Program with Strong Partnerships and Clear Roles

For a pilot program to be successful, strong partnerships will be needed between market players in the state. Through one-on-one phone calls and the in-person stakeholder meeting, it is clear there is interest and willingness from Colorado housing, energy and construction groups to partner on a ZEM pilot program. The roles described in Table 12 will need to be fulfilled for a ZEM pilot program to roll out.

For the current phase of work, VEIC did not reach out to potential homebuyers. During ZEM pilot program design, we recommend talking with potential single family homebuyers and residents of MMH communities to understand their needs, perceptions of zero energy homes, and attitudes towards taking on debt. This is a critical step to designing outreach and homebuyer marketing campaigns.

Table 12. ZEM Pilot Program Roles.

Role	Description	Example of Potential Partner
Fiscal sponsor	Provides funding for ZEM pilot program and provides oversight of program implementation and progress toward goals.	Financing authority or Investor Owned Utilities (IOU)
Program manager	Responsible for day to day implementation and success of program if providing turnkey implementation. Potentially oversees subcontractors and partners who could be subcontracted to fill various roles. Determine home certification such as DOE zero energy ready homes.	Statewide energy efficiency provider or consultant
Homebuyer Recruitment	As ZEM is a new product, a dedicated and multi-pronged effort needs to be made to attract new	Affordable housing development organization

Role	Description	Example of Potential Partner
	homebuyers. An important recruitment tool is a ZEM model home that can be toured by potential homeowners and partners and allows interested parties to experience the quality and comfort of the home. Partnerships with homebuyer counseling services offered by affordable housing and community action agencies, could be a way to leverage existing services to promote ZEM and recruit homebuyers.	
Financing Partners	Helps income qualified customers become mortgage ready. Identify and coordinate affordable financing package. Installments according to factory payment schedule. Partners willing to lend for ZEMs placed on lots with long term leases.	Financing authority- state or federal
Land Acquisition	For single family homes, obtain funding and purchase land. For mobile home replacement in a community, secure a lot in a coop community.	Land Trusts, Municipalities, Resident-Owned Communities (ROC)
Developer	Work with modular factory and homeowner to order the home, finalize unit layout, finish, paint colors and sign contract. Potentially cover costs of and coordinate permitting /zoning, utility tie-in, GC coordination/foundation/ site grading and landscaping.	Affordable housing development organization
Factory Builder	Build the home; Ensure it meets codes and obtain ZERH certification; Provides warranty; Designs and installs foundation; Obtain road permits; Coordinate timing with GC.	Private, affordable housing development organization, technical schools,
General Contractor	For each ZEM home installed, an organization will need to be responsible for construction oversight and completion. This will include securing permits, compliance with zoning, site prep, foundation installation, utility connection and completing site cleanup and landscaping. This general contracting role could be filled by the factory if they provide turn key services. It could also be filled by an affordable housing developer.	Private, affordable housing development organization
Building Science and Technical Assistance	As existing modular factories transition from standard building practices to meet the ZEM specification and new modular factories emerge to meet increasing demand for ZEM homes, building science and construction support should be provided to factories during early years of the ZEM pilot program to ensure homes are built to operate as zero energy.	Consultant
Homebuyer education	Homebuyer education on the operation and maintenance of their ZEM home is a key ingredient to ensuring that the program meets its goals for energy savings, affordability, and comfort. The ZEM pilot program should deliver post-occupancy training and technical assistance to answer	CHFA-approved homebuyer education provider

Role	Description	Example of Potential Partner
	homeowner questions Conducting post occupancy customer satisfaction surveys and feedback can inform future program offerings.	
Post-Occupancy Monitoring	Monitor energy use and generation. Compare to modeling, utility data, homeowner education.	Consultant

3. Support ZEM Factories in Colorado

Our research and feedback from multiple stakeholders has highlighted that Colorado needs hundreds of affordable units built every year. To date, Colorado's affordable housing developers have had limited success working with out-of-state modular factories to bring in high performance homes. Manufacturing ZEM in-state could help to meet the demand for affordable housing through a mix of small and larger factories.

Establishment of ZEM factories in Colorado will require three key ingredients:

- Funding source to invest in factories and lower the costs of ZEM homes
- Factories that are able to build to ZEM specifications
- Locally available, stable, trained workforce

4. Launch ZEM Pilot Program in “Shovel-Ready” Markets

The ZEM pilot program should be launched in areas that are primed for this opportunity. Demonstrating success in communities with the most existing supports and least program barriers will increase the scale of adoption and provide an example for other communities to follow. For example, the pilot program will need to be offered only in cities and towns that offer net metering and EE/RE incentives to bring down the first cost of the home. The pilot program should also target areas with financially stable coops, infill opportunities, or planned Habitat developments. And finally, consideration needs to be given to the location of modular building resources, with a focus on targeting communities that meet the above criteria and are located within a reasonable distance from the builder.

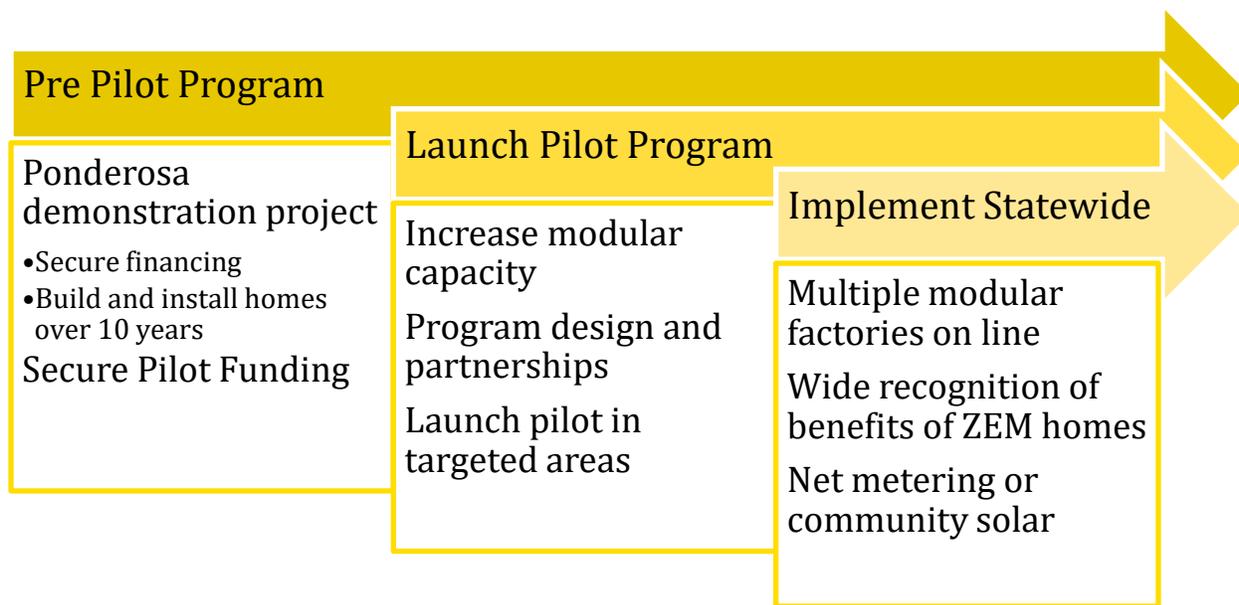


Figure 14. Suggested Rollout of a Colorado ZEM Pilot Program.

It is well known in affordable housing circles that development is slow. Encouraging multiple paths in parallel will accelerate the adoption of ZEM, and this is well aligned with stakeholder feedback. Ideally, a number of different development options will be explored simultaneously. Developing a single site from beginning to end can take a year or more. This type of program needs to have continuous learning integrated into the process and partnerships that can help leverage outside resources to be successful.

Several stakeholders noted the large demand for affordable housing in northeastern Colorado (e.g., Brush, Yuma, Sterling). Stakeholders also highlighted that there is a need for affordable workforce housing and large employers may be willing to enter in a partnership to provide housing that will lead to better employee retention. These considerations should be taken into account when selecting communities for a pilot. Pilot towns and communities will be those that are willing to site ZEM homes. There are generally few zoning hurdles for modular construction of single family homes on owned land. However, for mobile home replacement located on a lot in a coop or nonprofit park, the program will need to understand local zoning in that community and whether modular homes are allowed in MMH communities.

Appendix A – Energy Modeling

Reference files:

- CO ZEM_Cash Flow-Modeling_Alamosa.xls
- CO ZEM_Cash Flow-Modeling_Boulder.xls
- CO ZEM_Cash Flow-Modeling_Steamboat.xls

All energy modeling was completed using REM/Rate™ software version 15.7. Utilizing detailed building inputs including component areas, framing factors, insulation and mechanical efficiency levels, REM/Rate generates end use consumption estimates for heating, cooling, hot water and lights and appliances. Climate locations are selected for each model to reflect the heating and cooling requirements for the selected scenarios. Energy generation is estimated utilizing NREL's PVWatts® Calculator⁵³ to meet the estimated consumption value produced by REM/Rate. A total of nine scenarios were run to represent ZEM, HUD and a single family ranch home built to local code in three Colorado climate zones. The three climate zones also represented three ownership scenarios:

- Alamosa County – Rural, owned land
- City of Boulder – Urban, mobile home park
- Steamboat Springs – Mountain ski town, owned land

Each model assumes the same geometry and footprint. Geometry for all models is based on the size and configuration of a standard two bedroom, two bath 14'x70' single-wide manufactured home. To avoid differences in energy consumption due to factors other than prescribed efficiency values, all cases were modeled on the same foundation type – open ventilated crawl space. The team recognizes that this foundation type may not be typical of single family ranch new construction, however the choice was made in order to produce the best 'apples to apples' comparisons across the models. Heating system and fuel types for the base cases were informed by 2015 U.S. Census American Housing Survey data for Colorado. All base case scenarios assume natural gas as the primary heating fuel whereas the ZEM is an all-electric home.

The HUD baseline home was modeled to the standard prescribed by the Code of Federal Regulations (CFR) Title 24 – Housing and Urban Development (HUD) Part 3280 Manufactured Home Construction and Safety Standards, Subpart F Thermal Protection. Unlike the International Energy Conservation Code (IECC), which provides prescriptive R-values and U-factors for individual assemblies, the HUD Code prescribes an overall coefficient of heat transmission (Uo) that the manufactured home must not exceed. Therefore, the level of efficiency for individual assemblies in the home may vary as long as combined they meet the (Uo) standard for the region in which the home is installed. Component assemblies modeled for the HUD home meet the requirement for Uo Value Zone 3.

A natural gas furnace was assumed for the baseline heating fuel/system type.

⁵³ <https://pvwatts.nrel.gov/pvwatts.php>

The single family ranch scenarios were modeled to the prevailing local code in each jurisdiction. The three locations represented a wide range of baseline efficiency levels with Alamosa County having to least efficient code (IECC 2009) and Steamboat Springs the most efficient code (IECC 2015). The City of Boulder's code, 2017 COBECC, falls in the middle in terms of efficiency. These homes also assumed a natural gas furnace for the baseline heating fuel/system type.

All ZEM homes were modeled to the same efficiency specification using an electric Cold Climate Air Source Heat Pump (ccASHP) for the primary heating fuel/system. ZEM specifications vary only in the Photovoltaic (PV) system capacity. ZEM models were constructed to approximate zero net energy, therefore the PV system size varied by location.

Energy cost data was calculated using current energy prices for the utilities serving each location. Alamosa County and the City of Boulder are served by Xcel Energy for both electricity and natural gas. Steamboat Springs is served by Yampa Valley Electric Association and Atmos Energy. The electric rate utilized for Xcel Energy is an average of winter and summer Tier 1 rates. Regulated Colorado utilities utilize the Percentage of Income Payment (PIPP) program to provide energy assistance to low income customers. This program can be implemented in different ways by utilities. To simplify the scenarios, the standard residential rate is utilized for all cases. Table A 1 documents the utility rate assumptions utilized in the cash flow model.

Table A 1. Utility Rate Assumptions.

	Alamosa County	City of Boulder	Steamboat Springs
Electric Utility	Xcel Energy		Yampa Valley Electric Association
\$/kWh	\$0.09772		\$0.09330
Monthly service fee	\$5.29		\$32.25
Net Meter Credit	\$0.09772		\$0.0330
REC	\$0.005		n/a
Gas Utility	Xcel Energy		Atmos Energy
\$/therm	\$0.44000		\$0.68829
Monthly service fee	\$14.46		\$11.60

Detailed inputs for the REM/Rate energy modeling analysis are provided in the tables that follow. The only inputs that vary for the HUD and ZEM models are the REM/Rate Location climate data, therefore only the City of Boulder tables are included here for the HUD and ZEM models (Table A 2 and Table A 6). Detailed inputs for the Single Family Ranch baseline scenario are shown for each location (Table A 3 - Table A 5).

Table A 2. REM/Rate Inputs for New MH modeled to HUD Specification.

Detailed Modeling Inputs			
		Manufactured Home (HUD Region 3 Uo-0.079)	
		Value	Description
ModelingTool		Rem/Rate version 15.7	
Climate Zone(1)		5B Boulder HDD 6103, CDH 7211	
General	Dimensions	14x70'	
	Conditioned Floor Area	980	
	Volume	7840	
	Housing Type	Mobile Home	
	Number Bedrooms	2	
	Foundation Type	Open crawl space	
Envelope	Floor	R-22	2x6, 16oc, Grade III, carpet
	Wall	R-19	Standard wood frame, 2x6, 16oc, Grade III
	Windows	U-0.35; SHGC: 0.50	170 sf, 17% WFR
	Door	R-6	Two 21sf steel doors
	Ceiling	R-30	2x10, 16oc, Grade III
	Mechanical Systems	Heating	Electric
Natural Gas			80 AFUE⁽²⁾ Furnace, 100kBtuh (100%)
Oil			
Cooling		13 SEER	Central Air Conditioner, 2 ton
Hot Water		0.56 EF	Natural Gas, 50 gal, Med draw, Fed Std (=0.6483 - (0.0017 × Vr))
Duct Insulation		90% @ R22; 10% @ R8	Location: MH belly, assumes surrounded R value except for crossover trunk at R8 (consistent w PNNL analysis); Supply @ 264; return @ 49 (est per REM), PNNL assumed 210sf supply for 924 sf single wide
Duct Leakage		12 CFM25/100 sf CFA	
Low Flow (<-2 gmp)		None	
Infiltration	8.0 ACH50	Consistent w PNNL analysis	
Ventilation	Exhaust Ventilation	50 cfm, 12 hr/day, 50 watts	
Lights & Appliances	CFL/LED	34%	Consistent w PNNL analysis
	Refrigerator	413 kWh/yr	ENERGY STAR Calculator value for 'conventional model' top mounted freezer
	Dishwasher	307 kWh/yr	ENERGY STAR Calculator value for 'conventional model'
	Range/Oven	n/a	Natural Gas (per EIA)
	Washer	Medium Efficiency	REM preset (LER 487 kWh/yr)
	Dryer	3.11 CEF	Federal Std (per ES appliance savings calculator)
PV System		n/a	
Comments			
(1)	REM Locations represent a range in heating and cooling load in CO with potential for ZEM placement		
(2)	The standard for manufactured home furnaces manufactured before November 19, 2015 is 75 AFUE.		
	For purposes of this analysis, the current standard is used to represent a new MH.		
	If looking at a replacement scenario, the older standard should be utilized.		

Table A 3. REM/Rate Inputs for Alamosa County Single Family Ranch Home Modeled to 2009 IECC.

Detailed Modeling Inputs			
		Single Family Ranch (2009 IECC)	
		Value	Description
ModelingTool		Rem/Rate version 15.7	
Climate Zone(1)		6B Alamosa HDD 8435, CDH 2924	
General	Dimensions	14x70'	
	Conditioned Floor Area	980	
	Volume	7840	
	Housing Type	Single Family Detached	
	Number Bedrooms	2	
	Foundation Type	Open crawl space	
Envelope	Floor	R-30	2x10, 16 oc, Grade II, hardwood
	Wall	R-20	Standard wood frame, 2x6, 16oc, Grade II
	Windows	U-0.35; SHGC: 0.40	170 sf, 17% WFR
	Door	R-6	Two 21sf steel doors
	Ceiling	R-49	2x8, 16oc, Blown Cellulose, Grade II
Mechanical Systems	Heating	Electric	
		Natural Gas Oil	80 AFUE Furnace, 100kBtuh (100%), Fed Min Std
	Cooling	13 SEER	Central Air Conditioner, 2 ton
	Hot Water	0.56 EF	Natural Gas, 50 gal, Med draw, Fed Min Std (=0.6483 - (0.0017 × Vr))
	Duct Insulation	Supply (attic) R-8; All other R-6	90% Attic; 10% Conditioned space
	Duct Leakage	8/12 CFM25/100 sf CFA	Leakage to outdoors/total leakage
	Low Flow (<-2 gmp)	None	
	Infiltration	7 ACH50	
Ventilation	Exhaust Ventilation	50 cfm, 12 hr/day, 50 watts	
Lights & Appliances	CFL/LED	50%	
	Refrigerator	413 kWh/yr	ENERGY STAR Calculator value for 'conventional model' top mounted freezer
	Dishwasher	307 kWh/yr	ENERGY STAR Calculator value for 'conventional model'
	Range/Oven	n/a	Electric (per EIA)
	Washer	Medium Efficiency	REM preset (LER 487 kWh/yr)
	Dryer	3.11 CEF	Federal Std (per ES appliance savings calculator)
PV System		n/a	

Table A 4. REM/Rate Inputs for Boulder Single Family Ranch Home Modeled to 2017 COBECC.

Detailed Modeling Inputs			Single Family Ranch (2017 COBECC)		
			Value	Description	COBECC Comments (VEIC)
	ModelingTool		Rem/Rate version 15.7		
	Climate Zone(1)	5B	Boulder HDD 6103, CDH 7211		
General	Dimensions		14x70'		
	Conditioned Floor Area		980		
	Volume		7840		
	Housing Type		Single Family Detached		
	Number Bedrooms		2		
	Foundation Type		Open crawl space		
Envelope	Floor		R-30	2x10, 16 oc, Grade II, hardwood	Code req is R30 or fill cavity R19 min - find
	Wall		R-20	Standard wood frame, 2x6, 16oc, Grade II	
	Windows		U-0.30; SHGC: 0.40	170 sf, 17% WFR	
	Door		R-6	Two 21sf steel doors	
	Ceiling		R-49	2x8, 16oc, Blown Cellulose, Grade II	Better U than req
Mechanical Systems	Heating	Electric			
		Natural Gas Oil	80 AFUE	Furnace, 100kBtuh (100%), Fed Min Std	
	Cooling		13 SEER	Central Air Conditioner, 2 ton	
	Hot Water		0.56 EF	Natural Gas, 50 gal, Med draw, Fed Min Std (=0.6483 - (0.0017 × Vr))	
	Duct Insulation		Supply (attic) R-8; All other R-6	90% Attic; 10% Conditioned space	
	Duct Leakage		4 CFM25/100 sf CFA	total	
	Low Flow (<-2 gmp)		None		
	Infiltration		3 ACH50		
Ventilation		Exhaust Ventilation	70 cfm, 14 hr/day, 50 watts	COBECC 1.4cfm/watt for <90 cfm bath fan	
Lights & Appliances	CFL/LED		75%		
	Refrigerator		413 kWh/yr	ENERGY STAR Calculator value for 'conventional model' top mounted freezer	
	Dishwasher		307 kWh/yr	ENERGY STAR Calculator value for 'conventional model'	
	Range/Oven		n/a	Electric (per EIA)	
	Washer		Medium Efficiency	REM preset (LER 487 kWh/yr)	
	Dryer		3.11 CEF	Federal Std (per ES appliance savings calculator)	
PV System			n/a		

Table A 5. REM/Rate Inputs for Steamboat Springs Single Family Ranch Home Modeled to 2015 IECC.

Detailed Modeling Inputs			Single Family Ranch (2015 IECC)	
			Value	Description
ModelingTool			Rem/Rate version 15.7	
Climate Zone(1)		7B	Steamboat Springs HDD 8209, CDH 3718	
General	Dimensions		14x70'	
	Conditioned Floor Area		980	
	Volume		7840	
	Housing Type		Single Family Detached	
	Number Bedrooms		2	
	Foundation Type		Open crawl space	
Envelope	Floor		R-38	2x12, 16 oc, Grade II, hardwood
	Wall		R-20+5	Standard wood frame, 2x6, 16oc, Grade II
	Windows		U-0.32; SHGC: 0.40	170 sf, 17% WFR
	Door		R-6	Two 21sf steel doors
	Ceiling		R-49	2x8, 16oc, Blown Cellulose, Grade II
Mechanical Systems	Heating	Electric		
		Natural Gas Oil	80 AFUE	Furnace, 100kBtuh (100%), Fed Min Std
	Cooling		13 SEER	Central Air Conditioner, 2 ton
	Hot Water		0.56 EF	Natural Gas, 50 gal, Med draw, Fed Min Std (=0.6483 - (0.0017 × Vr))
	Duct Insulation		Supply & Return (attic) R-8; All other R-6	90% Attic; 10% Conditioned space
	Duct Leakage		4 CFM25/100 sf CFA	Total
	Low Flow (<-2 gmp)		None	
	Infiltration		3 ACH50	Testing not required in Routt Co unincorporated areas and Oak Creek
	Ventilation		Exhaust Ventilation	50 cfm, 19 hr/day, 50 watts
Lights & Appliances	CFL/LED		75%	
	Refrigerator		413 kWh/yr	ENERGY STAR Calculator value for 'conventional model' top mounted freezer
	Dishwasher		307 kWh/yr	ENERGY STAR Calculator value for 'conventional model'
	Range/Oven		n/a	Electric (per EIA)
	Washer		Medium Efficiency	REM preset (LER 487 kWh/yr)
	Dryer		3.11 CEF	Federal Std (per ES appliance savings calculator)
PV System			n/a	

Table A 6. REM/Rate Inputs for ZEM Home Modeled to VEIC Specification.

Detailed Modeling Inputs			Zero Energy Modular (VEIC Specification)	
			Value	Description
	ModelingTool		Rem/Rate version 15.7	
	Climate Zone(1)	5B	Boulder HDD 6103, CDH 7211	
General	Dimensions		14x70'	
	Conditioned Floor Area		980	
	Volume		7840	
	Housing Type		Single Family Detached	
	Number Bedrooms		2	
	Foundation Type		Open crawl space	
Envelope	Floor		R-40	2x10 , 16oc, Grade I, hardwood
	Wall		R-43	Double stud wood, 2x7, 24oc, Grade I
	Windows		U-0.21; SHGC: 0.27	170 sf, 17% WFR
	Door		see window entry	Two 21sf glazed
	Ceiling		R-60	SIPS, Grade I
Mechanical Systems	Heating	Electric	13.5 HSPF/2.3 COP	Ductless Minisplit (90%)/CERV (10%)
		Natural Gas		
		Oil		
	Cooling		30.5 SEER/2.3 COP	Ductless Minisplit (50%)/CERV (50%)
	Hot Water		2.75 EF	HPWH, 50 gal
	Duct Insulation		none	
	Duct Leakage		none	
	Low Flow (<-2 gmp)		yes	
	Infiltration		1 ACH50	
Ventilation		Balanced (CERV)	100% SRE/TRE; 50 cfm, 24 hr/day, 62w	
Lights & Appliances	CFL/LED		100%	
	Refrigerator		371 kWh/yr	ENERGY STAR Calculator value for ENERGY STAR top mounted freezer
	Dishwasher		270 kWh/yr	ENERGY STAR Calculator value for ENERGY STAR
	Range/Oven			Electric
	Washer		ENERGY STAR	REM preset (LER 96 kWh/yr)
	Dryer		4.5 CEF	Electric; Ventless Heat Pump
PV System			4.5 kW	5842 kWh/yr (PV Watts)

Energy consumption and cost results are presented in Table A 7 - Table A 9 below. The values presented in Table A 9 represent VEIC’s current understanding of how Yampa Valley Electric Association (YVEA) handles net energy generation credits on a monthly basis versus the end of year avoided cost rate payment for annual net generation.

Table A 7. REM/Rate and PVWatts Modeling Outputs – Alamosa County (Xcel Energy).

REM/Rate Model Results										
		Annual Fuel Consumption			Annual MMBtu			Annual Fuel Costs		
Home Type		Manufactured Home	Single Family Ranch	Zero Energy Modular (ZEM)	Manufactured Home	Single Family Ranch	Zero Energy Modular (ZEM)	Manufactured Home	Single Family Ranch	Zero Energy Modular (ZEM)
(Energy Specification)		(HUD)	(2009 IECC)	(VEIC)	(HUD)	(2009 IECC)	(VEIC)	(HUD)	(2009 IECC)	(VEIC)
Heating	(therms)	560	394	0	58.4	40.9	7.4	\$246.40	\$173.36	\$0.00
	(kWh)	701	439	2168				\$68.50	\$42.90	\$211.86
Cooling	(kWh)	556	471	289	1.9	1.6	1	\$54.33	\$46.03	\$28.24
Hot Water	(therms)	156	156	0				\$68.64	\$68.64	\$0.00
	(kWh)	0	0	784	15.6	15.6	2.7	\$0.00	\$0.00	\$76.61
Lights & Appliances	(therms)	28	0	0				\$12.32	\$0.00	\$0.00
	(kWh)	3902	4136	3562	16.1	14.1	12.2	\$381.30	\$404.17	\$348.08
Photovoltaics NMC	(kWh)	0	0	-7,092	0	0	-24.2	\$0.00	\$0.00	-\$693.03
Annual Fuel Costs	(therms)	744	550	0				\$327.36	\$242.00	\$0.00
	(kWh)	5159	5046	-289	92	72	-0.9	\$504.14	\$493.10	-\$28.24
Annual Service Fees & Credits	(therms)							\$173.52	\$173.52	\$0.00
	(kWh)							\$63.42	\$63.42	\$63.42
	RECS							\$0.00	\$0.00	-\$35.46
Annual Total								\$1,068.44	\$972.04	\$27.96
Monthly Average								\$89.04	\$81.00	\$2.33

*Net meter credits roll-over in Solar Bank but do not apply to monthly service fees. Therefore, annual total calculation for ZEM includes Annual Service Fees and Credits only, not net negative annual energy costs

Table A 8. REM/Rate and PVWatts Modeling Outputs – City of Boulder (Xcel Energy).

REM/Rate Model Results										
		Annual Fuel Consumption			Annual MMBtu			Annual Fuel Costs		
Home Type		Manufactured Home	Single Family Ranch	Zero Energy Modular (ZEM)	Manufactured Home	Single Family Ranch	Zero Energy Modular (ZEM)	Manufactured Home	Single Family Ranch	Zero Energy Modular (ZEM)
(Energy Specification)		(HUD)	(2017 COBECC)	(VEIC)	(HUD)	(2017 COBECC)	(VEIC)	(HUD)	(2017 COBECC)	(VEIC)
Heating	(therms)	290	177	-	31	19	3	\$127.60	\$77.88	\$0.00
	(kWh)	543	277	886				\$53.06	\$27.07	\$86.58
Cooling	(kWh)	1,199	984	614	4	3	2	\$117.17	\$96.16	\$60.00
Hot Water	(therms)	132	132	-				\$58.08	\$58.08	\$0.00
	(kWh)	-	-	623	13	13	2	\$0.00	\$0.00	\$60.88
Lights & Appliances	(therms)	28	-	-				\$12.32	\$0.00	\$0.00
	(kWh)	3,902	3,921	3,562	16	13	12	\$381.30	\$383.16	\$348.08
Photovoltaics NMC	(kWh)	-	-	(5,842)	-	-	(20)	\$0.00	\$0.00	-\$570.88
Annual Fuel Costs	(therms)	450	309	-				\$198.00	\$135.96	\$0.00
	(kWh)	5,644	5,182	(157)	64	49	(1)	\$551.53	\$506.39	-\$15.34
Annual Service Fees & Credits	(therms)							\$173.52	\$173.52	\$0.00
	(kWh)							\$63.42	\$63.42	\$63.42
	RECS							\$0.00	\$0.00	-\$29.21
Annual Total								\$986.47	\$879.29	\$34.21
Monthly Average								\$82.21	\$73.27	\$2.85

*Net meter credits roll-over in Solar Bank but do not apply to monthly service fees. Therefore, annual total calculation for ZEM includes Annual Service Fees and Credits only, not net negative annual energy costs

Table A 9. REM/Rate and PVWatts Modeling Outputs – Steamboat Springs (YVEA, Atmos Energy).

REM/Rate Model Results										
		Annual Fuel Consumption			Annual MMBtu			Annual Fuel Costs		
Home Type		Manufactured Home	Single Family Ranch	Zero Energy Modular (ZEM)	Manufactured Home	Single Family Ranch	Zero Energy Modular (ZEM)	Manufactured Home	Single Family Ranch	Zero Energy Modular (ZEM)
(Energy Specification)		(HUD)	(2015 IECC)	(VEIC)	(HUD)	(2015 IECC)	(VEIC)	(HUD)	(2015 IECC)	(VEIC)
Heating	(therms)	565	301	0	58.9	31.3	6.4	\$388.88	\$207.18	\$0.00
	(kWh)	705	334	1863				\$65.78	\$31.16	\$173.82
Cooling	(kWh)	639	537	330	2.2	1.8	1.1	\$59.62	\$50.10	\$30.79
Hot Water	(therms)	154	154	0	15.4	15.4	2.6	\$106.00	\$106.00	\$0.00
	(kWh)	0	0	767				\$0.00	\$0.00	\$71.56
Lights & Appliances	(therms)	28	0	0	16.1	13.7	12.2	\$19.27	\$0.00	\$0.00
	(kWh)	3902	4006	3562				\$364.06	\$373.76	\$332.33
Photovoltaics NMC	(kWh)	0	0	-6,398	0	0	-21.8	\$0.00	\$0.00	-\$596.93
Annual Fuel Costs	(therms)	747	455	0	93	62	0.5	\$514.15	\$313.17	\$0.00
	(kWh)	5246	4877	124				\$489.45	\$455.02	\$11.57
Annual Service Fees & Credits	(therms)							\$139.20	\$139.20	\$0.00
	(kWh)							\$387.00	\$387.00	\$387.00
	NMC							\$0.00	\$0.00	\$0.00
Annual Total								\$1,529.80	\$1,294.40	\$398.57
Monthly Average								\$127.48	\$107.87	\$33.21

Appendix B – Cash Flow Model Analysis

A cash flow analysis was conducted to compare the monthly cost of ownership of a ZEM home with a typical new manufactured home built to HUD standards as well as to a new single family ranch home built to local code. For this report, a single typical baseline heating fuel/system was selected for comparison to ZEM: natural gas furnace. The three home models, HUD, single family ranch, and ZEM, were each modeled in three Colorado IECC Climate Zones: 5B (City of Boulder), 6B (Alamosa County), and 7B (Steamboat Springs).

For this analysis we assumed the ZEM buyer qualifies for an affordable housing mortgage. Mortgage terms were developed using the Boulder County Department of Housing and Human Services Quarterly Interest Rate calculation methodology. The HUD manufactured home assumes a typical personal property, or chattel loan, commonly used for manufactured home purchases.

Table B 1 and Table B 2 below show detailed inputs and assumptions for the City of Boulder Cash Flow Model. Figure B 1 and Figure B 2 provide an illustration of expected monthly utility bills over a three year period for a ZEM home in Xcel Energy service territory. Modeling assumes average winter and summer Tier 1 electric rates, net meter credits at the same prevailing total energy rate, and REC payments of \$0.005/kWh. Expected utility bills vary greatly depending on whether the 'start' month is a net energy consumption month (e.g. November) or a net energy producing month (e.g. April).

Table B 1. Monthly Cash Flow for HUD MH, Single Family Ranch, and ZEM Homes, Boulder.

Monthly Cash Flow Comparison for Zero Energy Modular (ZEM) in Boulder, Colorado				
<i>ZEM Model Home assumes 980sf 2 bedroom/2 bath 14'x70'</i>				
Economic Analysis Scenario: Low Income Homeowner				
		Manufactured Home (HUD)	Single Family Ranch (2017 COBECC)	Zero Energy Modular (VEIC Specification)
	Utility Rate Class	R (Residential General Service)	R (Residential General Service)	R (Residential General Service)
	REM Model	CO-HUD-Single-NatGasFHA-cz5-Boulder-.blg	CO-COBECC-SFD-NatGas-cz5-Boulder.blg	CO-ZEM-Single-ElectricHP-cz5-Boulder.blg
Housing Costs				
1	Base Factory Cost	\$73,875	\$294,000	\$149,940
2	Sales Tax	\$3,921	\$15,603	\$7,957
3	Foundation/Site Work	\$8,500	\$8,500	\$8,500
4	Delivery and Set	\$0	\$0	\$7,000
5	Solar Array	\$0	\$0	\$10,575
6	Permits Fees	\$0	\$23,500	\$23,500
	Housing Cost Subtotal	\$86,296	\$341,603	\$207,472
Incentives				
7	Xcel Energy Heat Pump Water Heater	\$0	\$0	\$450
	Xcel Energy Ductless Mini-split Heat Pump	\$0	\$0	\$300
8	Xcel Energy Existing Home Low Income Rebates	\$0	\$0	\$3,338
9	Xcel Energy Solar Rebate	\$0	\$0	\$0
10	City of Boulder Solar Rebate	\$0	\$0	\$0
	City of Boulder Solar Grant	\$0	\$0	\$0
11	GRID Alternatives Incentive	\$0	\$0	\$0
12	Other Financial Incentives (CO ZEM)	\$0	\$0	\$0
	Incentive Subtotal	\$0	\$0	(\$4,088)
Financing				
	Total cost to finance	\$86,296	\$341,603	\$203,384
13	Down payment/Closing costs	\$8,630	\$17,080	\$10,169
	Interest rate	9%	4.18%	4.18%
	Term (years)	15	30	30
	Monthly Mortgage Cost	\$788	\$1,583	\$943
Energy Costs				
14	Average annual utility costs (usage + fees)	\$986	\$879	\$63
	Average annual RECS payment	\$0	\$0	-\$29
	Average annual utility bill	\$986	\$879	\$34
	Average monthly utility bill	\$82	\$73	\$3
	Average Monthly Energy Bill	\$82	\$73	\$3
Total Cost of Ownership				
	Mortgage payment	\$788	\$1,583	\$943
	Co-op fee	\$0	\$0	\$0
	Property taxes (after adjustment)	\$120	\$120	\$120
	Insurance	\$30	\$30	\$30
	Energy	\$82	\$73	\$3
	Total monthly housing cost	\$1,020	\$1,806	\$1,095
	Upfront out of pocket cost	\$8,630	\$17,080	\$10,169
	Annual Income Required (housing cost as 30% of income)	\$40,798	\$72,258	\$43,818

Table B 2. References and Assumptions for Boulder Monthly Cash Flow Model.

Assumptions & References	
1	HUD Manufactured home cost estimate based on 2017-18 census data for Western region. \$20k was added to this base cost est for comparable finishes to ZEM (porches, appliances etc.). https://www.census.gov/data/tables/time-series/econ/mhs/average-sales-price.html
	Single Family Ranch cost estimate assumes \$300/sf market rate construction cost Based on 11/30/2018 conversation with Susan Lythgoe Executive Director, Flatirons Habitat For Humanity ZEM cost based on Vermont 2018 pricing (valid through 10/1/18) and Portland, OR factory estimate - adjusted for CO material and labor costs. ZEM base factory costs include full appliance package, stairs, deck and porch and utility hook-up.
	60% Manufactured/modular homes only pay sales tax on materials. 60% is the portion of material cost based on VEIC research. https://boulder.colorado.gov/finance/tax-rates-3
2	8.85% Boulder has separate sales and use tax rates. This analysis utilizes the sales tax rate.
3	Foundation and site work based on VEIC research adjusted for CO. Assumes frost protected foundation per HUD requirements, helical piers for ZEM. Final costs highly site specific. Flatirons Habitat provided an analysis that included \$6000 for foundation. Maintaining \$8000 as assumption for all home types including site work.
	4
5	\$2.35 Average installed cost per watt for 2018 WAP projects. Based on 12/11/2018 conversation with Luke Ilderton (Energy Outreach Colorado).
	4.5 kW Solar array size (kW) based on PV Watts data for Boulder, CO. System sized to approximate net zero modeled energy consumption from REM/Rate.
6	Estimated City of Boulder permitting fees based on 11/30/2018 conversation with Susan Lythgoe, Executive Director, Flatirons Habitat For Humanity These scenarios assume a one-for-one replacement and exempt from any inclusionary housing fees ((B.R.C. 1981, 9-13-11. Rebuilt Dwelling Units).
	7
8	Data on Existing home low income rebate provided by Luke Ilderton (EOC) 12/4/2018, updated 12/5/2018.
	\$4 Aerators - Bathroom Primary
	\$5 Aerators - Kitchen
	\$300 Air Sealing & Weather-stripping T2
	\$850 Attic Insulation-LI-SFW
	\$40 A-Style LEDs
	\$64 BR-Style LEDs
	\$500 Crawlspace Wall Insulation LI-SFW
	\$630 Refrigerator Replacement
	\$10 Showerhead Primary
	\$10 Showerhead Secondary
	\$850 Wall Insulation
\$75 Water Heater Blanket LI-SFW	
9	New incentive outcome of settlement for State Energy Office and WAP (~\$2/watt). Unclear whether ZEM could qualify for this incentive but should engage City of Boulder Energy Management team and EOC to explore potential
	10
11	GRID alternatives is frequently utilized by Flatirons Habitat. Recent projects have received ~30% incentive of total project cost. Luke Ilderton (EOC) indicated that the GRID program has typically been a higher cost for WAP homeowners.
12	Other incentive(s) - TBD
13	10% HUD MH assumes 10% closing costs. Financing term based on chattel loan data provided by CHFA.
	5% Boulder County Dept. of Housing and Human Services Quarterly Interest Rate calculation methodology for zip code 80301
14	Xcel utility costs documented on tab 'Utility Rates-Xcel'
	Monthly utility cost calculation documented on tab 'Model_Outputs'

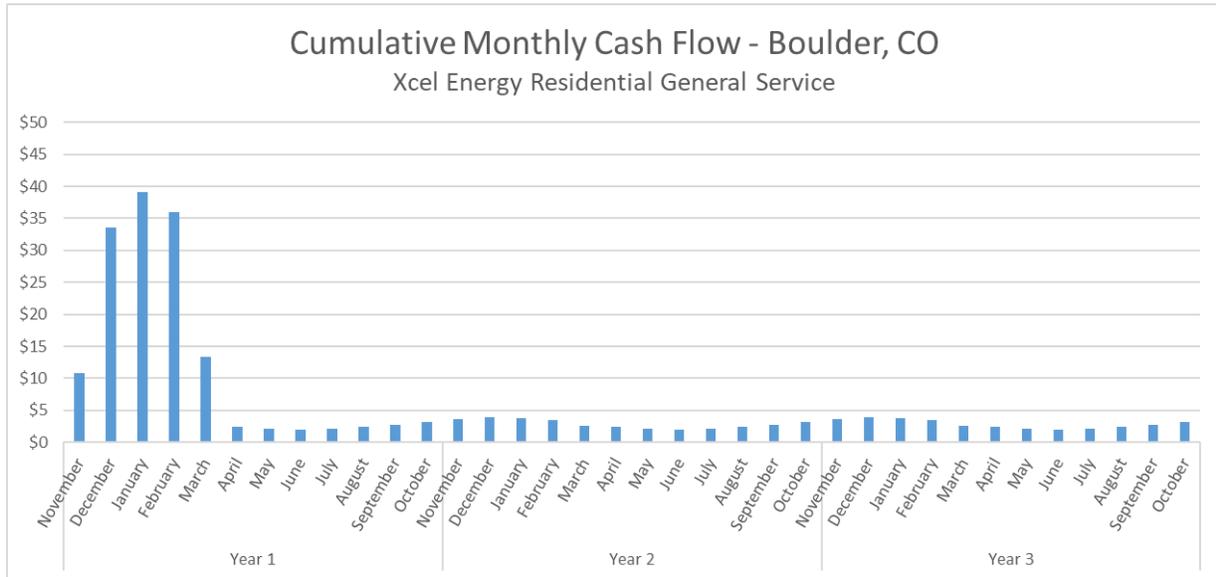


Figure B 1. Estimated ZEM Monthly Utility Bills for Three Years with Occupancy Starting in November.

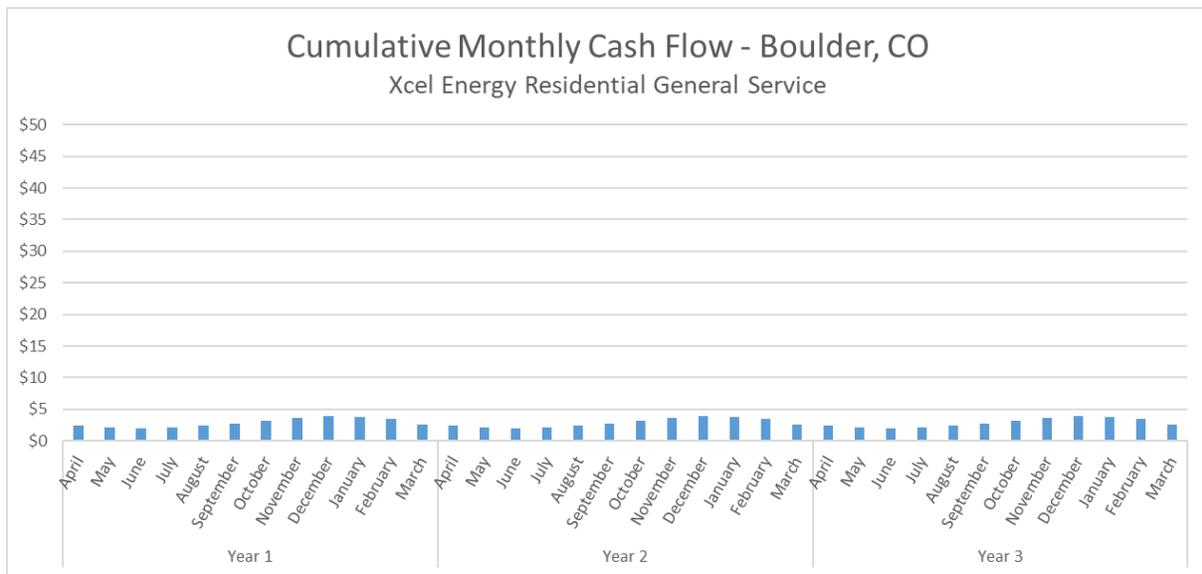


Figure B 2. Estimated ZEM Monthly Utility Bills for Three Years with Occupancy Starting in April.

Appendix C – Estimated Benefits of ZEM

Reference files:

Estimated Benefits of ZEM.xls

Appendix D –Stakeholder Meeting on January 18, 2019 Summary Notes

Topic #1 ZEM pilot programs leverage existing affordable mortgage products and incentives and grants to buy down and finance first cost of the home.

What funding sources do you currently use/know of that could be applied to new ZEM Homes?
E.g. mortgage products, down payment assistance, utility incentives, other affordable housing grants

What ideas do you have to repurpose existing funding for ZEM homes, even if it would require a policy change? E.g. weatherization, emergency repair, health care funding.

Group 1 – Funding

Utility rebates- not specific to residential new construction

Existing “smart watt” money through electric coop. State mandate for rebates lack of performance credit

CHFA down payment assistance and loans

Habitat volunteer assistance and donated materials

Business partnerships (employers) in woodland park include casinos in teller city. \$150 sf unknown transportation costs. \$6000 delivery and set up boulder county

MHC resident owned communities. Possible land donations

Silent second mortgage (from housing agency)

Group 2 – Funding

Habitat Low interest mortgages

Leasing solar panels thru SunRun solar developer and other solar partnerships

Grid Solar city of boulder grant, free solar panels to HFH

Holy cross utility pilot program

Marijuana tax, Boulder uses for RE. Anyone that gets federal money could not use marijuana tax money. But a third party developer could build a solar field and donate the energy produced.

Utility PUC docket Demand side management or resource management plans- Xcel recovers RE fund

State funds for pilot programs (this has been done before)

Weatherization funds, leftover of ARRA

Volunteer hours, donated material

Future tax credits (like what has been done for EV)

Donated materials to plant

Boulder affordable housing fund

Smart MH (KY), Next step MFR housing, working with coops

Save \$25k to avoid city permits (need policy change)

Streamlining inspection process to cut down the costs

Energy resource center (Loveland) using weatherization contracts (fee for service)

Old age person fund (for an assisted living ZEM project)

Rental programs yes, need homeownership

Exemption of affordable housing from property taxes

Neighborhood (EOC rebate only)

Accessory dwelling unit free land in back yard

Policy modification depends on local regulations, zoning

Simplifies permitting process - overheard lowers

Pilot to gather resources and stream line process

Group 3 - Funding

Community solar instead of individual rooftops, lower interconnection fees because no individual fees.

Xcel has Energy Star new homes program, ZEM would likely qualify

Utility incentives for energy improvements might be adaptable for factory homes

Health foundations, health care providers

First time homebuyer incentives

On-bill financing (would be hard with Xcel but maybe others)

CHFA down payment assistance

Fort Collins EPIC program solar

Offset programs fees in lieu of meeting code requirements form builders and developers. E.g. boulder requires RNC home >5,000 sq ft to be net zero (>3,000 sq ft in the future), or pay offset. That revenue could be used for ZEM program

Full Group

Individual donors, this is a huge source of funds for Habitat. Going to donors with a coalition of coordinated NGOs is more powerful

Housing + healthcare make life unaffordable in Colorado. Healthcare is significantly less affordable in Western Colorado. Health care providers want to keep workers there, they may provide funds to make housing affordable and retain workers. Tapping larger employers: employee home ownership funds may lead to employee retention solution, where employees can live where they work (e.g. resort communities)

Lower costs through bulk purchasing, e.g. HVAC

Tax credits (for development, 3rd party financier) and solar + storage, Solar tax product tool

Coordination of people who can do the work for you; Partner with other businesses constructing large projects: e.g. crane time, mine digging the foundation.

Topic #2 - There are no modular factories located in Colorado. What actionable ideas do you have that could increase modular capacity in Colorado?

Who would be interested in starting a factory or expand existing efforts?

What resources exist to help an organization/ entrepreneur start a new factory

Which regulatory barriers will be most difficult for a new factory to meet.

What assistance do you think each type of potential factory developer may need to develop a factory in Colorado

What are your thoughts on ideal factory size and implications e.g. small local factory may not achieve lowest cost vs. large factory with optimized cost

Are there financial resources available such as grant and tax credits for industrial development? Are there size limitations to these financial assistance programs?

What are the permitting requirements to start a factory in CO? What are the permitting requirements to build and sell homes to customers? are the requirements different for rental units?

Are there logistical resource (help with business plan, permitting, etc.)

How does this vary by regions in Colorado. Are there special industrial areas with tax breaks for factories?

Are specific areas of the state in great need of factory job, due to the recent loss of a large employer for example? Do these regions offer incentives for starting a factory?

Group 1- Increasing modular capacity

Small temporary/pop up factory – set up near a project. Hire crews to come to factory like site built (e.g. drywall, framers, electricians, plumbers), but using the same crews once they are trained

Utilize community college or even high school students, at-risk youth (building habitat homes), apprenticeship program: the trades are aging and there is a deficit in workforce. Habitat is taking this nationwide with Habitat international for a national model.

Ship panels to local factories. Lots of factories do pre-fab panels. A temporary factory could take the panels, make modules. They would train local people. Because of panels the first hurdle is smaller, once demand is higher, factory can grow

Group 2 – Factories

Rhino cubed – interested in starting a factory. Building out of state now b/c of costs and labor higher in CO, labor availability is low, and shipping is not that expensive.

Opportunity zones are very proactive

Coal plants are closing, jobs going away, there is a need for economic development

Many small marijuana growers will likely go out of business soon, leading to space and workforce availability

Homes could come from out of state

Setting a home leads to job creation as well

Potential site is *the Farm* in Buena vista

Bill to allow economic development bonds

Explore affordable utility rates for factories

City owned space for a factory

Permitting for new buildings

Want a consistent building code/ permitting process throughout CO, it's too complicated now CO market sufficient for a large factory

There is very little new zoning for small homes, need a change in zoning to create demand

Group 3 - Factories

Current state law requires CO factories to build to CO standards. Can't compete out of state. RMHA is running a bill this season to remediate this.⁵⁴

In the Front Range there is workforce competition, elsewhere in the state, there are not many trained workers.

Current backlog is 3-6 months- benefit of time savings in CO

Workforce development

Factories can design to local codes, or could maybe design to strictest code in the state

Efficiencies in building same approved design over and over

Need to understand municipal cost requirements across state

Topic #3 - Zero energy modular is an affordable housing solution that can be used for mobile home replacement, single family ownership, infill or rental.

Under which scenario do you see the most potential for early adoption in a pilot program?

What barriers to you see or are experiencing within each development scenarios?

How can those barriers be removed?

Full group

Ponderosa is a pilot program- MFR housing replacement (e.g. ponderosa)

Municipal utilities can integrates resources and streamlines process by having all codes requirements in one place, and limit bureaucracy

⁵⁴ Note: HB-19-1238 passed 3/20/19 and has since removed this barrier: <https://leg.colorado.gov/bills/hb19-1238>

Habitat model: they are a developer with expertise from the grounds up, incl. education and financing. Habitat is interested in the pop-up factory idea

The rental market is softening, any resources available as a result?

Market rate and affordable offered in parallel

To make affordable housing happen need a leader with a strong vision that also works hard to collaborate

Collaboration to create concepts, and evolve the model as partners come on board. Ensure all partners feel ownership. Coalition can provide vision and leadership, with clear definitions to the vision.

At risk MMH communities (at risk of closing)

MMH communities and Habitat have the most potential

Replacement on existing lots

Resident owned communities movement: there is one, maybe soon two ROC in Colorado. Several more coming soon.

Will have to be land trust owner or non-profit owner. Private is not interested.

Permanent affordability is a big draw.

Workshop Attendees	Company
Pamm Gibson	City of Boulder
Andy Cordova	Colorado Energy Office
Scott Gilbert	HFH Roaring Fork Valley
Susan Lythgoe	Flatirons HFH
Jonah Kinchy	Flatirons HFH
Michelle Alexander	Boulder County Housing
David Ogunsanya	Elevation Community Land Trust
Kurt Firnhaber	City of Boulder
Darren Hinton	Millender White
Ryan Harry	Colorado Energy Office
Stacey Rothgeb	NREL
Jan Burton	Rhino Cubed
Cheri Witt Brown	Greely Weld HFH
Megan Ferguson	Impact Development Fund
Norrie Boyd	Boulder County Housing
Kory Whitaker	Habitat Metro Denver
Gary Dominguez	CHFA
Carolyn Elam	City of Boulder
Jessica Kenney	Boulder Housing Partners

Workshop Attendees	Company
Tawny Peyton	Rocky Mountain Home Association
Jay Sugnet	City of Boulder
Jane Harrington	Colorado Community Land Trust
Kristin Hyser	City of Boulder
Jennifer Gremmert	EOC
Crystal Launder	City of Boulder
Paige Omohundro	CHFA
Bill Maly	Catalyst Development
Susan Cummings	HFH Teller County
Jamie Caperton	HFH Teller County
Beth Truby	CHFA
Juliette Juillerat	VEIC
Alison Donovan	VEIC