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# Living tiny legally

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# Living Tiny Legally

An Honors College Project Presented to

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by James Rollin &

Hollyn Busby

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Accepted by the faculty of the Department of Integrated Science and Technology, James Madison University, in partial fulfillment of the requirements for the Honors College.

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# Living Tiny Legally

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**Senior Capstone Project**

**2017**

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# Abstract

Over the last 40 years, the average new United States house has increased in size by more than 1,000 square feet, from an average size of 1,660 square feet in 1973 (earliest year available from the Census Bureau) to 2,687 square feet last year (Perry, 2016). In that same time period, there was a 91% increase in home square footage per inhabitant and a decrease in average household size. According to the U.S. Census Bureau, the average home in the United States costs approximately $358,000 to build, an increase of roughly $200,000 since 1998. Meanwhile, the average annual income in the U.S. has remained unchanged for the last several years, at approximately $52,000 per year. As costs increased, the U.S. homeownership rate fell to its lowest point in over 50 years. Since 1965, the homeownership rate has decreased to 62.9% as of the second quarter in 2016.

These trends have created a dire need for affordable housing. This project addresses this problem, while proposing tiny houses as a solution, and following the triple bottom line. This is an economic model that focuses on economy, ecology, and equity as the dimensions of success. Tiny homes are sustainable as they are more energy efficient and require less materials, as well as less space. In congruence with less materials and less land required, technology such as passive solar design, high R-value insulation, or energy star appliances can drastically reduce energy costs (Morrison, 2015). Depending on the size, tiny homes use only 10% of the lumber as a traditional home. The cost of a tiny home is comparable to the down payment of a traditional single family home. A typical down payment on an average-sized house is $72,000, whereas the cost of new construction for a 200 square foot tiny house can be as low as $35,000. Socially the tiny house lifestyle promotes a greater sense of community, more socio-economic accessibility, and the benefits of minimalism. This project takes all of these principles and applies them to examine the feasibility of implementing tiny homes within the Harrisonburg area.

# 1.1 National Housing Trends

This section will discuss the national housing trends in the United States, as the size and price of homes increase while the rates of homeownership decrease. With this trend, there has been a surge in renters across the country.

## 1.1.1 Housing as an Economic Indicator

Homeownership rates are the lowest they've been in 51 years, down to 63.7%, which is the lowest rate since Census began tracking the quarterly figure in 1965. The national homeownership rate peaked at around 69% from 2004 through 2006 and has been waning ever since. People are most likely to own homes from ages 25 to 75. The Baby Boomers are entering their post-homeownership years and the Millennials are still in their pre-homeownership years (Sharf, 2016). Figure 1.1.1 below shows the quarterly homeownership rates and seasonally adjusted homeownership rates for the U.S. from 1995 to 2016 (Manja and Jytte, 2016).

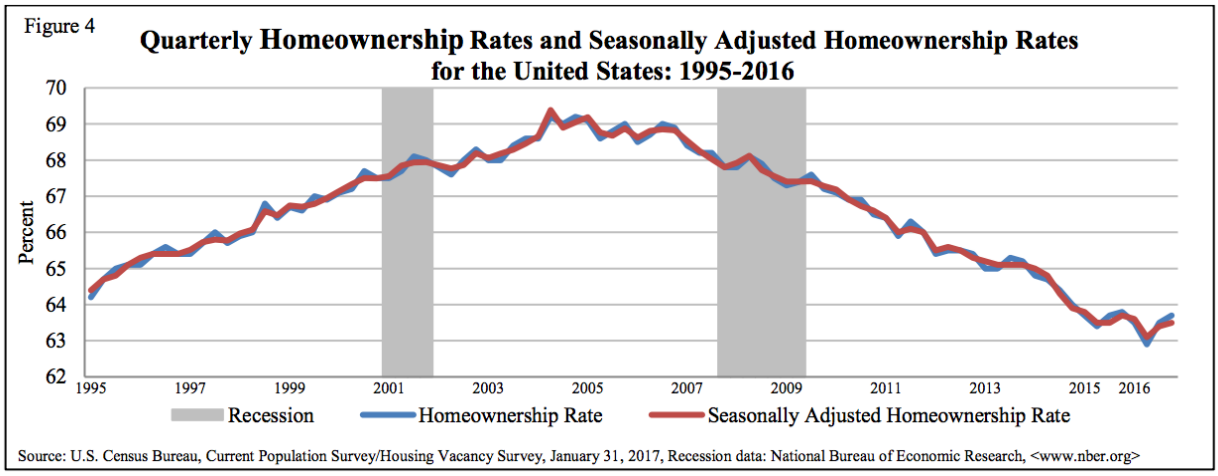


Figure 1.1.1: Homeownership rates from 1995 to 2016 (Manja and Jytte, 2016).

## 1.1.2 Current Rates of Home Ownership

Nationally the trend in homeownership has continued its downward trend from its peak in 2004 at 69.0% to the 2015 level of 63.7%. Most of this has been from those on the younger side of the homeownership demographic; those in the 35-44 age range (JCHS, "Homeownership"). This trend can be attributed to the fact that student loans are taking up a considerable portion of new young potential home buyer's (20-39) income. As indicated in Figure 1.1.2 below, there was an increase in the amount of U.S. households with student debt from 12% in 2001 to 39% in 2013. Many younger renters are devoting most of their income to paying off loans, leaving

less money to save on a down payment for a house. This ripple effect is already putting a significant strain on the rental market and causing this to tighten, this will be discussed more later. With more potential homebuyers being forced to rent and pay loans, they will not have the ability to save the capital for a 20% down payment on a new home (JCHS, “Homeownership”). This effect will result in further decrease in homeownership rates in the US.

Future indicators of the effect of this will be greatly influenced by the market and availability of homes. However, the number of houses that are being foreclosed has steadied and may provide some stability for buyers in the future. One of the biggest variables will be the choice of potential home buyers that believe that homeownership is a future goal and sound investment. According to the 2016 Harvard Joint Center for Housing Studies, this is still the case as long as there is enough market for entry level buyers.

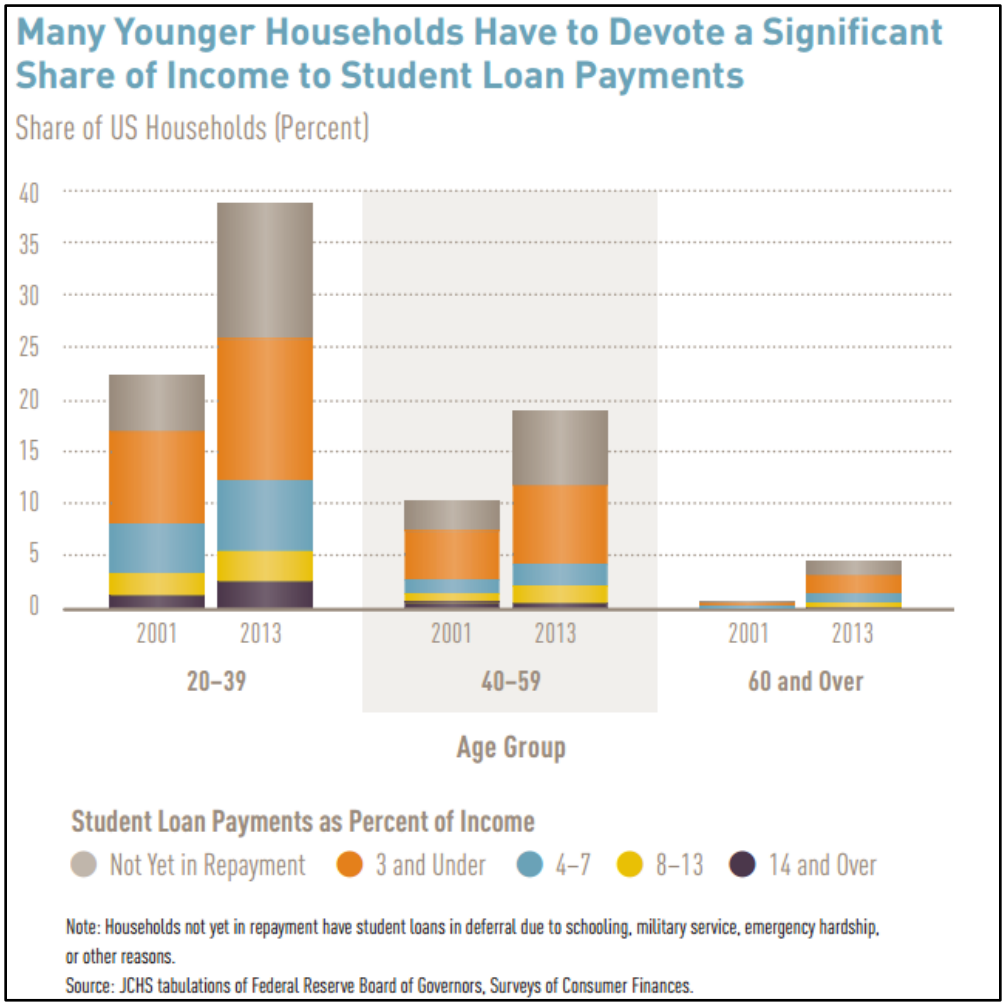


Figure 1.1.2: Showing the increase in a 12 year period of the amount of debt that younger people are having to pay in student loans (JCHS, “Homeownership”).

## 1.1.3 Increase in Home Size

According to the U.S. Census Bureau from 1973 to 2013, the size of the average American home has increased by more than 1,000 square feet. As of 2014, the average size is currently over 2,600 square feet for newly developed homes (Census Bureau, 2017). Meanwhile there has been a subsequent drop in the number of occupants per household, as seen below in Figure 1.1.3. This is led to a 91% rise in the home square footage per inhabitant along with a 61% increase in size (Perry, 2014).

This upward trend for larger homes has not slowed down. However, there is a growing movement of people choosing to downsize their homes as the need for 3,000+ square feet diminish, cost of maintaining the house increases, and rising popularity of new green technologies to increase building efficiencies.

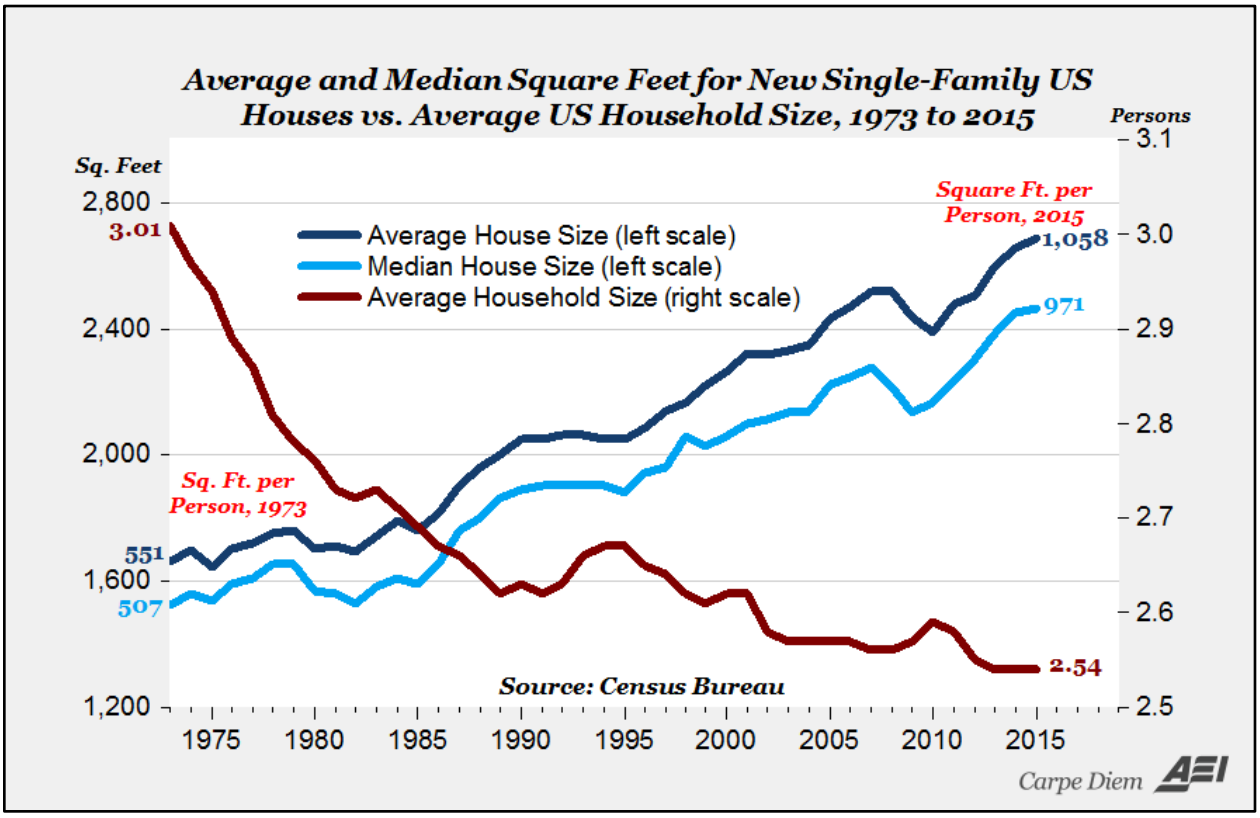


Figure 1.1.3: National trends of increasing size of the average American home, along with declining average household size from 1973 to 2013 (Perry, 2016).

## 1.1.4 Overview of the Rental Market

In the U.S., 36% of households' occupants were renters in 2015 according to the Joint Center for Housing Studies at Harvard. This represents approximately 110 million people, and this includes children, who comprise 30 million (27%) of the figure. Rental rates were highest in

urban areas, with over half of central city households being renters. This overall number dropped in the suburbs (28% of the population) and non-metro areas (27% of the population) (JCHS, “Rental Housing”).

### 1.1.4.1 Diversity of the Market

Renters represent a more diverse cross section of the market than homeowners. As seen in figure 1.1.4.1 below, the rental market the distribution of people across age, income, and family composition has more breadth than any other household make up.

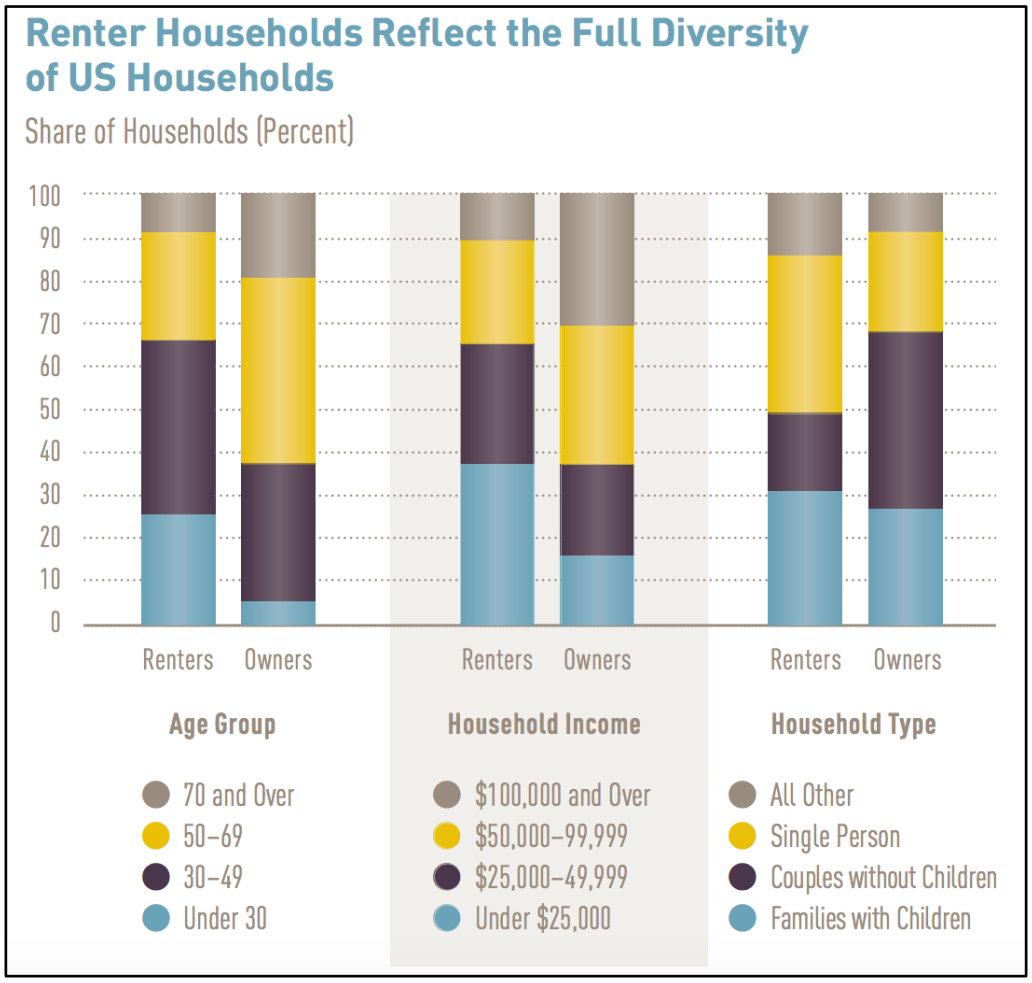


Figure 1.1.4.1: Distribution of U.S. households reflecting the diversity across age, income, and family composition (JCHS, “Rental Housing”).

The most common people to rent are young adults, but this trend is changing. High income households are the fastest growing segment of the market, but only represent 11% of the overall share (JCHS, “Rental Housing”). The great advantage of this is the convenience and flexibility that renting offers. One of the biggest changes has been that families with children, which have been traditionally one of the household groups most likely to own homes, are increasingly becoming renters. This follows the national trends as with families with children representing represent 31% of renters, but only 27% of homeowners (JCHS, “Rental Housing”).

Of these demographics of the market, the niche that is facing the most challenges is the low-income bracket. More than a third of renter households are earning less than $25,000 annually. Policy and housing supply challenges that low income houses in Harrisonburg, Virginia are facing will be further identified in Section 4: Affordable Housing. This trend has been more prevalent in the past decade (2005-2015) with 4 of the nearly 9 million new renters coming from the under $25,000 income bracket (JCHS, “Rental Housing”).

### 1.1.4.2 Surge in Renters

Figure 1.1.4.2 shows how renting has surged over the past 15 years, while homeownership has stalled since 2006. The figure shows the average annual growth in households in millions (JCHS, “Rental Housing”).

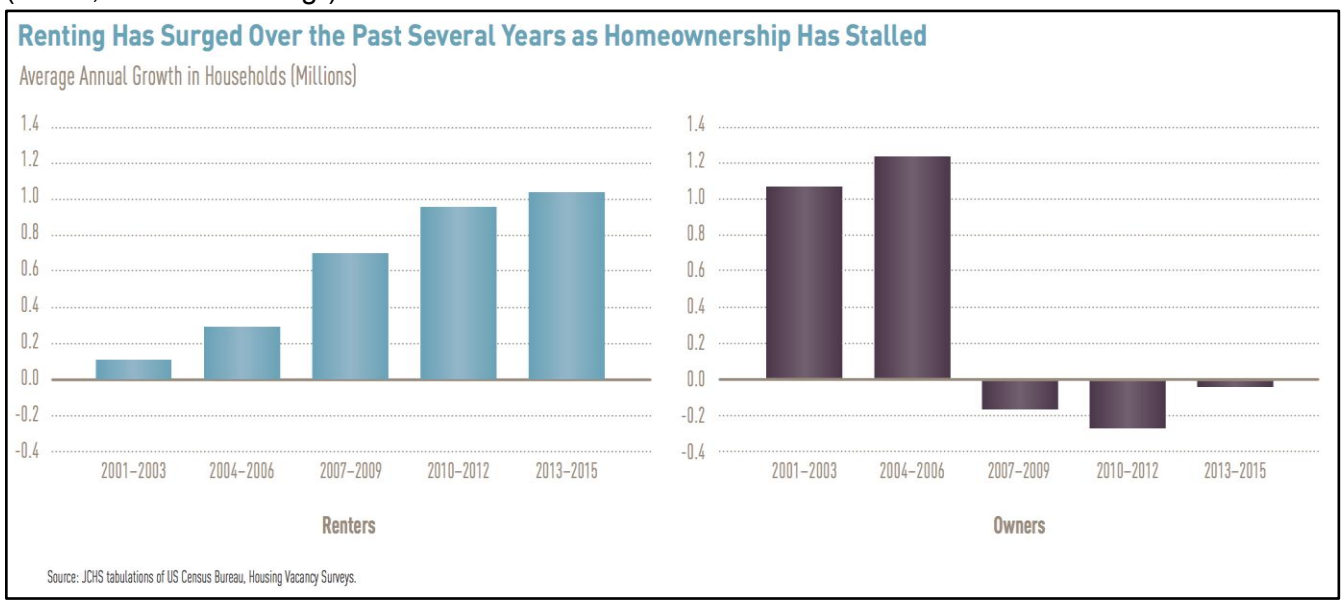


Figure 1.1.4.2: Increasing demand for renting and growth numbers while the overall percentage of home ownership has stalled (JCHS, “Rental Housing”).

# 1.2 Need for Affordable Housing

Today, increases in price, student loans, and number of renters have increased the need for affordable housing.

## 1.2.1 What is Considered Affordable Housing

According to the US Department of Housing and Urban Development, families that are paying more than 30% of their income for housing are cost burdened and may have difficulty paying for necessities such as food, clothing, transportation, and medical care. An estimated 12 million renter and homeowner households now pay more than 50% of their annual incomes on housing. A family with one full-time worker earning the minimum wage cannot afford the local

fair-market rent for a two-bedroom apartment anywhere in the United States (HUD, “Affordable Housing”).

#### 1.2.1.1 Why 30% is the Benchmark for Affordable Housing

Talk of housing affordability is plentiful, but a precise definition of housing affordability is, at best, ambiguous. The conventional public policy indicator of housing affordability in the United States is the percent of income spent on housing, historically this has been set at 30%.

The National Housing Act of 1937 created the public housing program designed to serve those “families in the lowest income group” (Shwartz and Wilson, 2006). Income limits instead of maximum rents were established for family eligibility to live in public housing; that is, a tenant’s income could not exceed five to six times the rent. The Brooke Amendment (1969) to the 1968 Housing and Urban Development Act, established the rent threshold of 25% of family income; that is, a family would be required to pay one-quarter of its income in rent. By 1981, this threshold had been raised to 30%, which today remains the rent standard for most rental housing programs (Shwartz and Wilson, 2006).

The 30% was deemed a rule of thumb for income that a family could spend and still have enough left over for other non-discretionary spending. This rule made its way to homeowner housing.

The mid to late 1990s ushered in many less stringent guidelines. Many households whose housing costs exceed 30% of their incomes started choosing to devote larger shares of their incomes to larger, more amenity-laden homes. These households often still have enough income left over to meet their non-housing expenses. For them, the 30% ratio is not an indicator of a true housing affordability problem, but rather a lifestyle choice. But for those households at the bottom rungs of the income ladder, the use of housing costs more than 30% is an indicator of a housing affordability problem (Shwartz and Wilson, 2006).

### 1.2.2 Defining the Poverty Line

Currently, the federal minimum wage is at $7.25 an hour. Virginia follows this standard, even though 29 of the 50 states have minimum wages higher than the federal minimum. Based on working as a full time a minimum wage employee, the worker will earn $15,080 per year before taxes (Cooper, 2013).

The federal poverty level for 2017 was released on January 31st based on data from the 2015 Census Bureau through the department of Health and Human Services. The thresholds were adjusted based on changes between the 2015 and 2016 Consumer Price Index. Table 1.2.2 below lists the 2017 guidelines for the 48 contiguous states and the District of Columbia. If the household income is at the poverty guideline or less, the household gets federal tax breaks. To be classified as low income housing, the household must be using Housing and Urban

Development (HUD) guidelines. Either the family's income need to be met, or housing needs to represent 30% of the area median income. Spending more than 50% of one's income on housing denotes a 'severe cost burden'.

Table 1.2.2: 2017 Poverty guidelines for the 48 contiguous states and the District of Columbia (ASPE, Poverty Guidelines).

| PERSONS IN FAMILY/HOUSEHOLD | POVERTY GUIDELINE |
|---|---|
| For families/households with more than 8 persons, add $4,180 for each additional person. | |
| 1 | $12,060 |
| 2 | $16,240 |
| 3 | $20,420 |
| 4 | $24,600 |
| 5 | $28,780 |
| 6 | $32,960 |
| 7 | $37,140 |
| 8 | $41,320 |

## 1.2.3 National Trends with the Construction of Low Income Housing

Historically, spending more than 30% of one's income on housing is considered a cost burden. Spending more than 50% of one's income on housing denotes a 'severe cost burden'. According the Harvard Joint Center for Housing, studies on or about the issue of affordable housing has disproportionately affected the rental population and more specifically those who are working near the poverty line (JCHS, "Rental Housing").

More than one in five renter households earned less than $15,000 in 2014. Nearly three-quarters of these 9.6 million households (72%) faced severe housing cost burdens, devoting more than half of their income to housing costs. An additional 13% were moderately cost burdened, spending between 30% and 50% percent of income on housing. Figure 1.2.3 below depicts the cost burdens on a national level (JCHS, "Rental Housing").

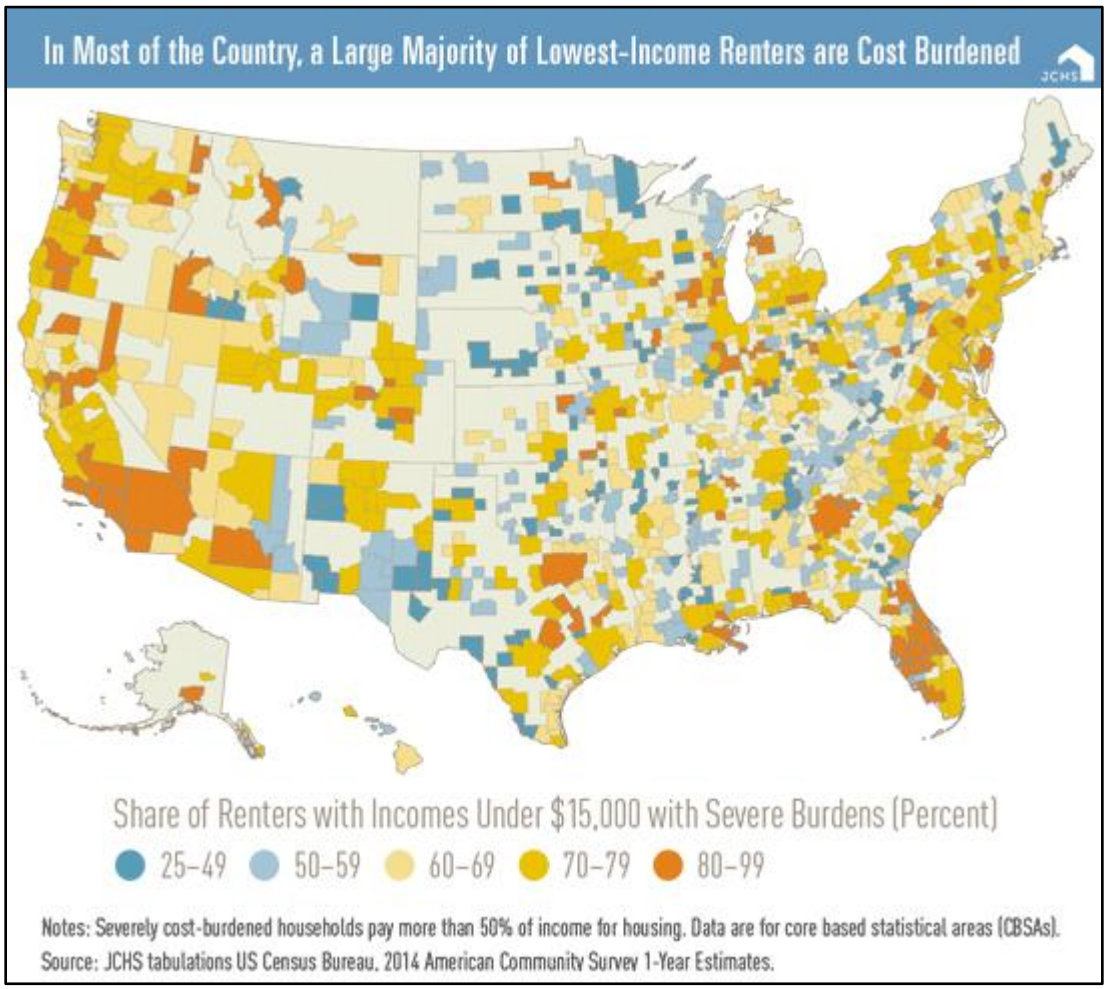


Figure 1.2.3 National map of most of the cost burdened renters are low income (JCHS, “Rental Housing”).

### 1.2.3.1 Rental Supply Gap

There are two main factors at play with the supply gap in affordable housing. First, the crash in 2008 made many single-family homes (that were previously owners) become renters. This took up the brunt of the supply for the single-family rentals on the market. Secondly, when the economic situation improved, there was a disconnect between the needs of the renters and what was being built. More than half of all new construction was a studio or 1 bedroom apartment, which was well above the 36% that was typical of that in the 1990s and early 2000s. This construction was focused in urban areas representing 57% of the total construction (JCHS, “Rental Housing”).

Because of these factors, many of the older units that were traditionally for low income housing were upgraded, which demanded a higher price. With this increase, there were federal cuts to HUD, and policy makers did not mandate that new construction of homes would remain in the affordable price range. The price range increased to $800/month for a single family, when

adjusted for inflation. With the private market failing to meet supply, the result is rising prices for low income renters. A National Low Income Housing Coalition study found that, in 2014, there were only 31 rental units affordable and available for every 100 extremely low-income renters, and 57 rental units affordable and available for every 100 very low-income renters. These statistics and the losses in affordable housing are demonstrated in Figure 1.2.3.1 (JCHS, “Rental Housing”).

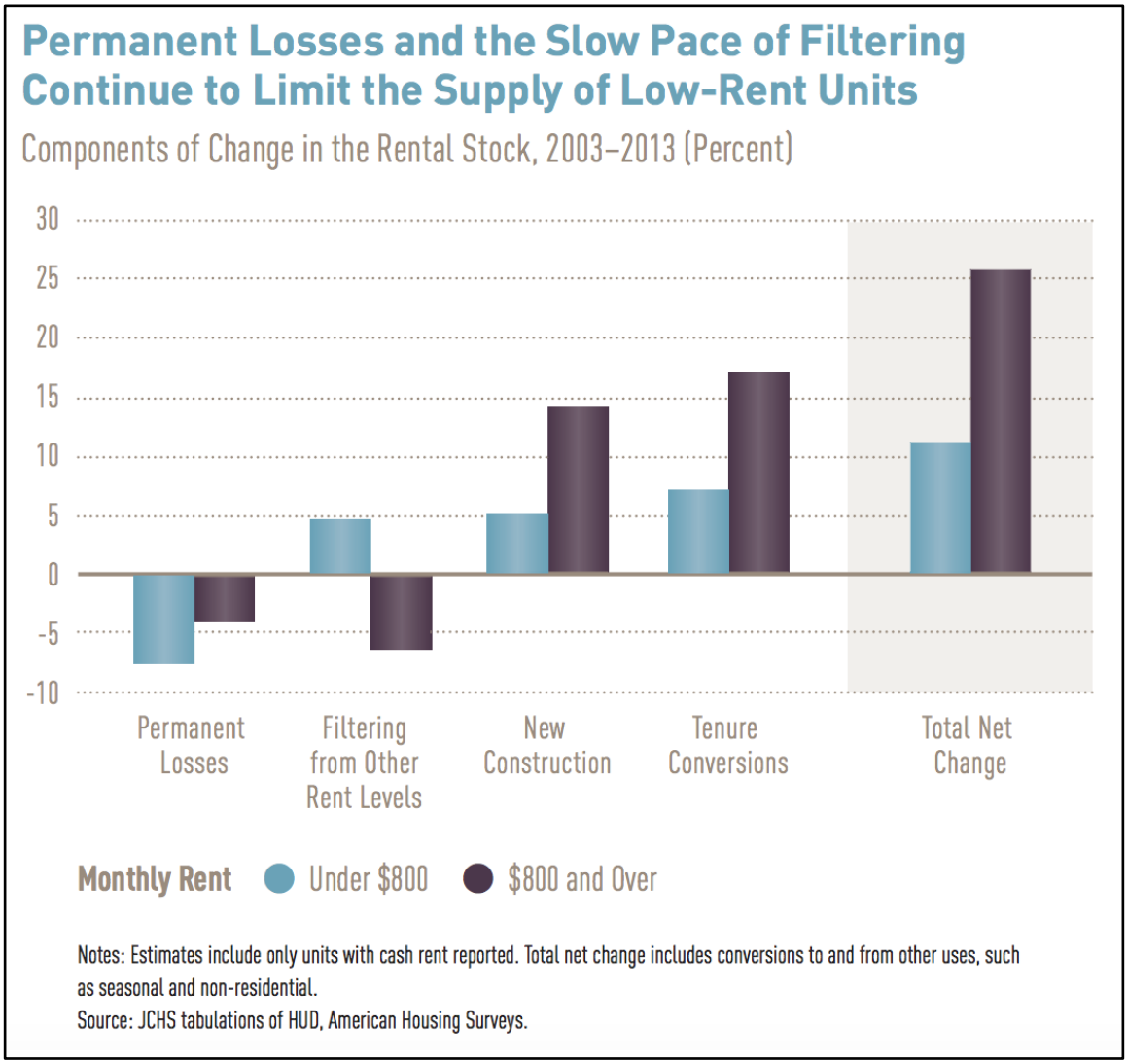


Figure 1.2.3.1. Diagram showing permanent loss and slow pace of filtering, limiting supply of low-rent units (JCHS, “Rental Housing”).

## 1.2.4 Local Trends with the Existing Affordable Housing Market in Harrisonburg

The figures below show a graphic of renter households in the Harrisonburg, VA Metro Area that make incomes less than $30,000 annually. Figure 1.2.4.1 shows where renter households are

located with incomes under $15,000 and Figure 1.2.4.2 shows where renter households are located with incomes between $15,000 and $30,000 annually.
A large percentage (80%) of renters' households with incomes below $15,000 a year in the concentrated Metro Area are labeled with severe cost burdens. 5,000 people in this area are renters with severe cost burdens, with the median housing cost at $670/month, meaning that above 50% of their income is going to housing (JCHS, "Rental Housing").

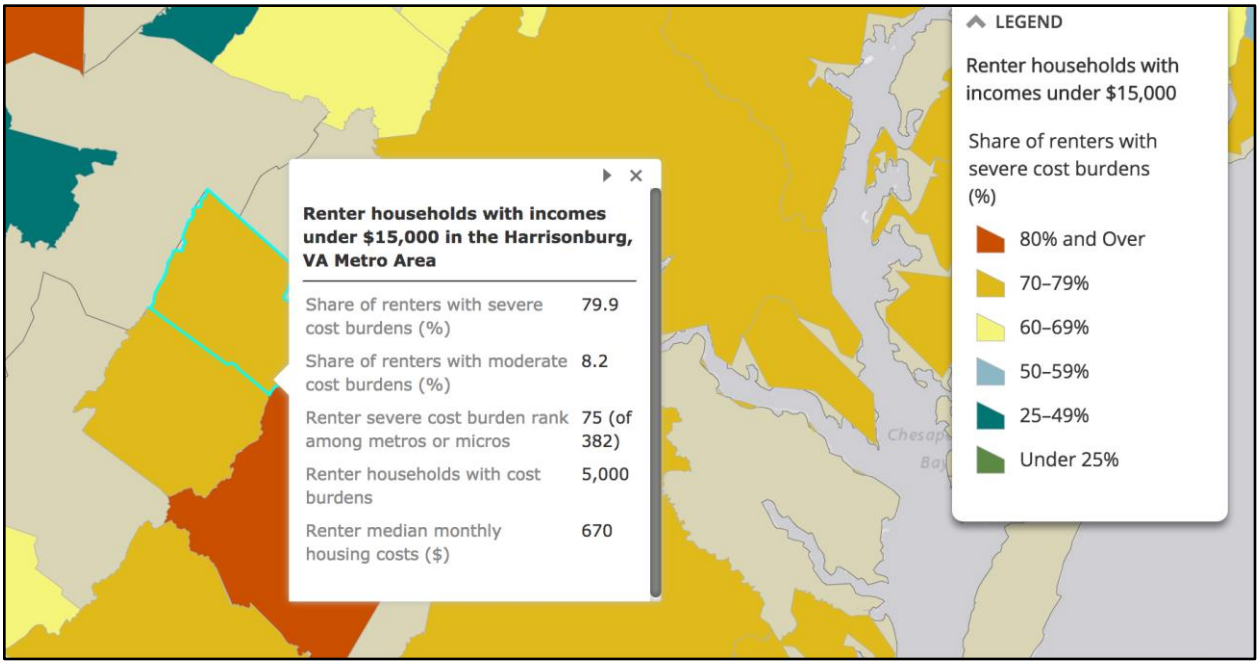


Figure 1.2.4.1. Renter households in the Harrisonburg Metro Area making below the federal minimum and moderate to severe cost burdens (JCHS, "Rental Housing").

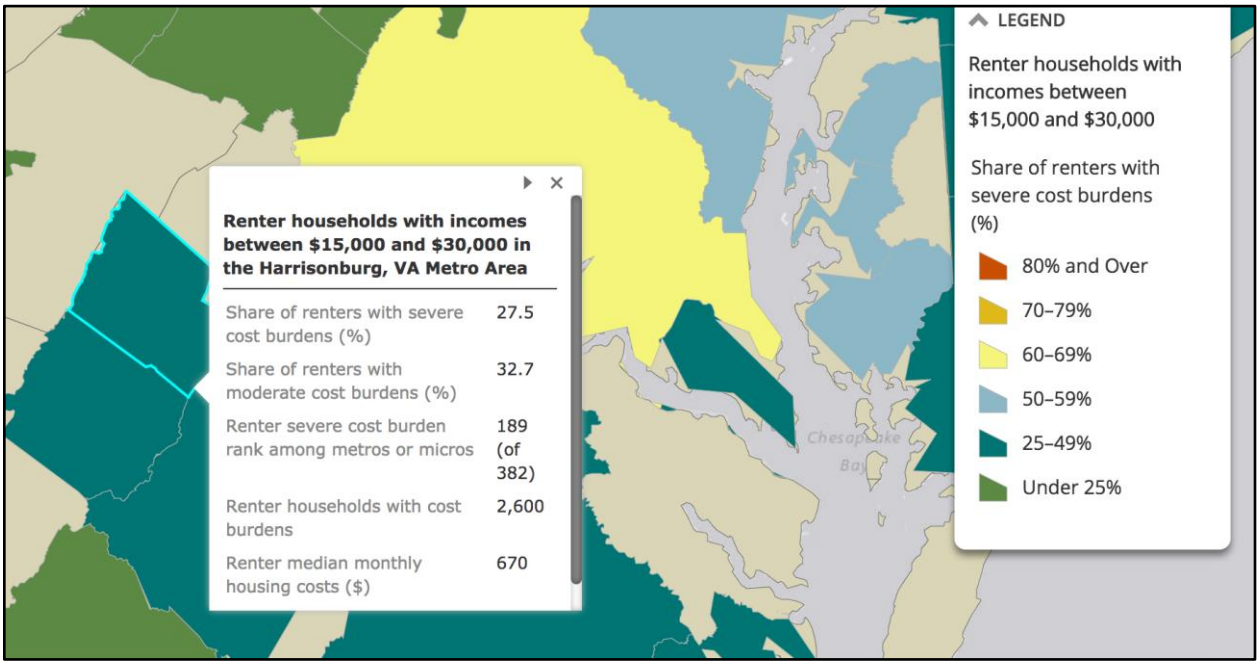


Figure 1.2.4.2 Rental households with incomes between $15,000 and $30,000 (JCHS, “Rental Housing”).

## 1.2.5 Consequences of Severe Cost Burdened Housing

The lack of affordable housing options forces cost-burdened renters to sacrifice other basic needs, settle for inadequate living conditions, and possibly face housing instability. The most significant cutback low-income households make is on basic sustenance, which is food and healthcare. Compared with households that can afford their housing, severely burdened households in the bottom expenditure quartile spend $150 (41%) less on food each month. They also spend substantially less on healthcare and put aside less for retirement (JCHS, “Rental Housing”).

Another tradeoff is between housing that is affordable and housing that is adequate. In 2013, 10% of low-income renters lived in units that lacked complete plumbing or kitchen facilities, experienced frequent breakdowns in major systems, or had other physical defects (JCHS, “Rental Housing”).

Housing quality issues are prevalent in non-metro and rural areas, where housing options are more likely to be substandard. Housing cost burdens also expose renters to the risk of eviction, strained household finances, diminished employment prospects, and lower school performance. In 2013, 2.1 million low-income renters reported that they had missed a rent payment in the previous three months, and a similar number stated they believed they were likely to face eviction in the next two months. Meanwhile, about 710,000 renters had been threatened with

eviction in the previous three months, with eight of ten of these threats associated with a failure to pay rent or other lease violations (JCHS, “Rental Housing”).

The costs of housing instability are also high for the government programs in place to support homeless families as well. Recent research has found that aiding for permanent housing for homeless families can help reduce domestic violence and substance abuse, keep families together, and limit the number of school moves for children. Importantly, the provision of permanent housing is more cost-effective than helping these families through the shelter system. Adding sustainability as a design element could also reduce the carbon footprint in transitional housing, make the houses more energy efficient, and increase the longevity of the household. Most importantly, this will help to reduce the utility bill for low income housing. In 2014, renter households paid 17% of their income in utilities, and owner households of the same measure paid 22% (JCHS, “Rental Housing”).

# 2 Affordable Housing

## 2.1 Affordable Housing in Harrisonburg

The 2016 Assessment of Fair Housing (AFH) also shows a map of the estimated median gross rents in Harrisonburg between 2010-2014. The areas with estimated rents at $700/mo. or lower are assumed to be low-income housing in the city. These areas are important targets for providing affordable housing. South and north of E. Market Street, south and north of W. Market Street, and west of S. High Street are areas where the median gross rents are estimated to be the lowest.

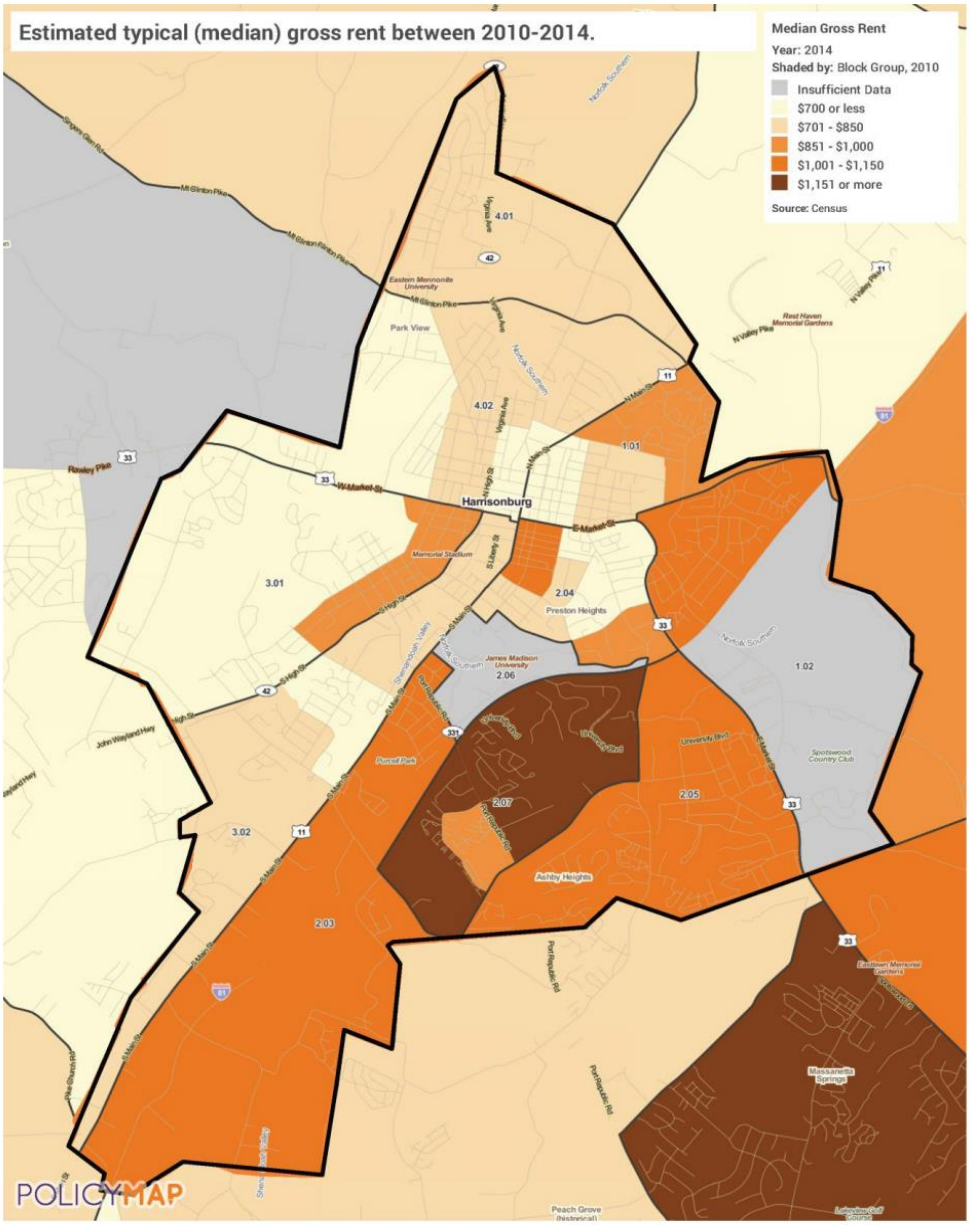


Figure 2.1: Estimates for 2010-2014 median gross rents in Harrisonburg (AFH, 2016).

The 2016 AFH also presents a combination of quantitative data analysis and qualitative research identified a series of factors that significantly contribute to fair housing issues in Harrisonburg. Contributing factors were assigned three priority levels based on the amount and strength of the supporting evidence that initially identified the factor: High – factors that limit or deny fair housing choice or access to opportunity, as well as other factors that are urgent or establish a foundation for future actions; Medium – moderately urgent or building on prior actions; Low – limited impact on fair housing issues (2016 Assessment of Fair Housing).

The contributing factors are organized into groups that align with the issues discussed in the Fair Housing Analysis section of the AFH:

- Segregation/Integration
- Racially or Ethnically Concentrated Areas of Poverty (R/ECAPs)
- Disparities in Access to Opportunity
- Disproportionate Housing Needs
- Publicly Supported
- Housing
- Disability and Access
- Fair Housing Enforcement, Outreach Capacity, and Resources (2016 Assessment of Fair Housing).

Table 2.1. Showing the list and priority of the contributing factors to the affordable housing stock in Harrisonburg (2016 Assessment of Fair Housing).

| Contributing Factor | Priority | Discussion |
|---|---|---|
| **(B)(i) Segregation/Integration** | | |
| Community Opposition | **Medium** | HRHA faced vocal community opposition during the planning phase of a new project-based development. This opposition caused HRHA to find an alternate location for the project, which is now called Commerce Village and serves homeless people with mental and physical disabilities. The fact that strong community opposition, although uncommon to this degree in Harrisonburg, can derail an affordable housing project makes addressing this factor moderately urgent. |
| Lack of private investments in specific neighborhoods | Low | For the most part, new private, multi-family development in the City caters to JMU students. This means that some neighborhoods, particularly those close to JMU and other amenities sought by students, see a lot of private investment, while others do not. This private developer preference has not risen to the level of outright discrimination, but is a housing market trend of which the City and HRHA should be aware. |
| Location and type of affordable housing | **High** | In addition to the type of affordable housing mentioned above, the location of affordable housing is a major influence citywide. Harrisonburg's most segregated neighborhood (tract 2.04) and the neighborhoods adjacent to it contain some of the more affordable rental options in the City. In addition, around half of HRHA's Housing Choice Vouchers are used outside the City in Rockingham County due to the increased affordability of units there. |
| **(B)(ii) R/ECAPs** | | |
| Lack of private investments in specific neighborhoods | Low | See above. |
| Location and type of affordable housing | **High** | See above. |
| **(B)(iii) Disparities in Access to Opportunity** | | |
| The availability, type, frequency, and reliability of public transportation | **High** | According to local stakeholders, Harrisonburg's transit system does not provide access to employment centers or certain critical community amenities such as the central post office in |

| Contributing Factor | Priority | Discussion |
|---|---|---|
| | | the City's southern area or the poultry processing facilities in the County. The Harrisonburg Department of Public Transportation's decision-making ability regarding hours and coverage are limited and tied heavily to the needs of the University, which are frequently mismatched with those of the protected classes in the community. |
| Lack of private investments in specific neighborhoods | Low | See above. |
| Location of employers | **High** | This contributing factor is closely tied to others concerning public transportation. Numerous major employers are located outside the City limits, or are located within the City but outside the reach or convenience of the current bus routes. Access to decent employment is one of the most effective pathways to increased opportunities for low-income families. |
| Location and type of affordable housing | **High** | See above. |
| **(B)(vi) Disproportionate Housing Needs** | | |
| The availability of affordable units in a range of sizes | **Medium** | Small families with fewer than five members are much less likely to have housing problems than large families and non- families, with a rate of problems a full 35 percentage points lower than large families within the City. Of the 115 households on HRHA's waiting list, 75 (or 65%) are families with children. Non-families experience the most severe cost burden. They are more than twice as likely to be severely cost-burdened as large families, and almost four times as likely as small families.<br>These facts indicate a significant disproportionate need for housing assistance for both large families with children and small (i.e. single person) households compared to other household types. |
| Lack of private investments in specific neighborhoods | Low | See above. |
| **(C) Publicly Supported Housing** | | |
| Community opposition | **Medium** | See above. |
| **(D) Disability and Access** | | |
| Access to transportation for persons with disabilities | **Medium** | All the issues regarding transit in Harrisonburg already discussed apply to persons with disabilities, although individuals with disabilities are disproportionately |

| | | |
|---|---|---|
| | | affected by the limited transportation options as they tend to rely heavily on public transit due to an inability to drive, walk, or bike to destinations or a lack of income to purchase a personal vehicle. Because all City buses are wheelchair accessible and paratransit services are available, this factor as it specifically applies to persons with disabilities involves building on prior actions to address transit needs at a more basic level. |
| Inaccessible sidewalks, pedestrian crossings, or other infrastructure | Low | Currently, many areas of the City lack sidewalks, handicap accessible curb cuts, and APS signals. However, the City is gradually installing sidewalks and curb cuts in older neighborhoods where they were not previously required, and traffic signals are replaced with APS signals when repairs are required. Additionally, the City is currently updating its Bicycle and Pedestrian Plan with the goal of ensuring that improvements are accessible to all users. Given that resources are already being devoted to mitigating this factor, the urgency to address it is low. |

| Contributing Factor | Priority | Discussion |
|---|---|---|
| Lack of affordable, accessible housing in range of unit sizes | **Medium** | Similar to transportation issues, persons with disabilities share a basic need for affordable housing with other low-income households. For the most part, the greatest difficulty faced by a person with a physical disability looking to buy or rent a home is finding a unit that is already accessible or easily modified. Things like no-step entries, bathrooms on the first floor, curb cuts, etc. are not always common features in Harrisonburg's housing stock. |
| **(E) Fair Housing Enforcement, Outreach Capacity, and Resources** | | |
| Lack of resources for fair housing agencies and organizations | **High** | Just as funding for CPD programs around the country have been decreasing, there is a chronic underfunding of enforcement, investigation, and outreach agencies in Harrisonburg. Without sufficient enforcement resources, progress in affirmatively furthering fair housing will be extremely difficult. |

The list of priorities was created to inform the Harrisonburg Redevelopment and Housing Authority (HRHA) future planning processes and funding decisions. The strategic goals will be made based on the priority rating each item was ranked.

Table 2.1.1 Showing all of the Strategic Goals in the city in addressing affordable housing (2016 Assessment of Fair Housing).

| Goal | Contributing Factors | Fair Housing Issues | Metrics, Milestones, and Timeframe for Achievement | Responsible Program Participant(s) |
|---|---|---|---|---|
| **Expand housing choice and access to opportunity** | Location and type of affordable housing<br><br>The availability of affordable units in a range of sizes<br><br>Lack of affordable, accessible housing in range of unit sizes | Segregation/Integration R/ECAPs<br><br>Disparities in Access to Opportunity<br><br>Disproportionate Housing Needs<br><br>Disability and Access | Continue to maintain a list of local publicly supported developments with expiring subsidies in order to identify partners and potential sources of funding for preservation.<br><br>Work with City planning staff to institute an evaluation of the impact on fair housing choice for every residential development proposal. Restructure existing incentives to encourage proposals that increase the supply of affordable housing in high opportunity areas and/or outside of “concentration areas.”<br><br>HRHA will attempt to reach out to private landlords, particularly those in higher opportunity neighborhoods, to increase participation in the Housing Choice Voucher program. HRHA will maintain a list of "friendly" landlords who have accepted HCVs in the past. HRHA will contact these and other known, non-participating landlords with information about | City of Harrisonburg<br><br>Harrisonburg Redevelopment and Housing Authority |

| | | | | |
|---|---|---|---|---|
| | | | the program, invitations to and public meetings and educational events, direct inquiries about unit availability, etc. | |

**Discussion:** Fair housing is distinct from affordable housing. However, there is a great deal of overlap between the two issues. Fair housing experts and advocates, including those consulted in Harrisonburg, know that the most prevalent barrier to fair housing is unaffordability. To address the contributing factors related to the type and location of affordable housing, the City and HRHA will partner with the private market and other public organizations to increase the supply and variety of affordable housing in high opportunity neighborhoods. Development incentive programs that are already in place or that can be easily implemented at little to no cost, such as fee waivers, expedited review, zoning variances, etc., will be a primary tool for achieving this goal.

| Goal | Contributing Factors | Fair Housing Issues | Metrics, Milestones, and Timeframe for Achievement | Responsible Program Participant(s) |
|---|---|---|---|---|
| **Increase homeownership among low-income households and members of the protected classes** | Location and type of affordable housing<br><br>The availability of affordable units in a range of sizes<br><br>Lack of affordable, accessible housing in range of unit sizes | Segregation/Integration R/ECAPs<br><br>Disparities in Access to Opportunity<br><br>Disproportionate Housing Needs<br><br>Disability and Access | Within the next five-year planning cycle, create a framework for providing down payment assistance through CDBG and/or HRHA for qualified first time homebuyers.<br><br>Within the next three years, begin holding annual homebuyer education and financial literacy workshops. | City of Harrisonburg<br><br>Harrisonburg Redevelopment and Housing Authority |
| **Discussion:** The City of Harrisonburg has a relatively low homeownership rate, especially among certain racial and ethnic groups. Particularly, Black and Hispanic households have at least two times lower homeownership rates than other racial/ethnic groups. Persons with physical disabilities looking to buy a home also face difficulty in finding a unit that is already accessible or easily modified. Increasing homeownership for protected classes not only helps these households build wealth and access opportunity, it relieves pressure from the rental market. The City and HRHA will coordinate to help qualifying HRHA residents and other low-income households in the City responsibly achieve homeownership. | | | | |
| **Improve the utility of public transit for low-income and disabled persons** | The availability, type, frequency, and reliability of public transportation<br><br>Location of employers<br><br>Access to transportation for persons with disabilities | Disparities in Access to Opportunity<br><br>Disability and Access | Within one year, identify any key community asset or major employer currently underserved by transit service.<br><br>Within three to five years, adjust transit routes and schedules to provide improved access to underserved locations within the City, as identified by the Harrisonburg Department of Public Transportation and other City staff.<br><br>Within three to five years, work with | City of Harrisonburg |

| | | | | |
|---|---|---|---|---|
| | | | Rockingham County and key businesses that employ a large number of low income individuals to attempt to establish improved transportation for these individuals. | |

**Discussion:** Practical, economical transportation is an essential element of daily city life. For many low-income households and members of the protected classes, the available transportation options in Harrisonburg are inconvenient or costly enough to be unreasonable choices. The City will work together with the transportation department, JMU, Rockingham County, and local employers to assess the current effectiveness of public buses in addressing the needs of the low-income and protected classes, and attempt to adjust service accordingly to better reach key community assets. Because of the nature of independent cities in Virginia, the actions Harrisonburg can take outside of its borders are limited and will require the full cooperation of Rockingham County.

| Goal | Contributing Factors | Fair Housing Issues | Metrics, Milestones, and Timeframe for Achievement | Responsible Program Participant(s) |
|---|---|---|---|---|
| **Strengthen anti-discrimination investigation, enforcement, and operations** | Lack of resources for fair housing agencies and organizations | Fair Housing Enforcement, Outreach Capacity, and Resources | Within two years, contract with a HUD-certified organization to conduct paired discrimination testing in the local rental market.<br><br>Within one year, conduct the four-factor analysis to determine the extent to which document translation is needed. Prepare a Language Access Plan if it is determined to be necessary.<br><br>Annually train City and HRHA staff to refer callers about fair housing to the designated staff person. In addition, train all staff that interact with the public in techniques to communicate with those with language and/or cultural barriers. | City of Harrisonburg<br><br>Harrisonburg Redevelopment and Housing Authority |
| **Discussion:** Any effort to affirmatively further fair housing can only go so far without effective and efficient investigation and enforcement of discriminatory actions. However, resources for these activities are already limited and are only becoming more so. HRHA and the City will ensure that discriminatory activity is properly investigated by a trained agency. In addition, HRHA and the City will evaluate and strive to improve the way they interact with the public in order to prevent unintentional barriers from occurring. | | | | |
| **Increase the level of fair housing knowledge and** | Community opposition | Segregation/Integration | Within six months, create a page on the City's website | City of Harrisonburg |

| | | | | |
|---|---|---|---|---|
| **understanding among housing developers, real estate professionals, elected officials, and the general public** | | Publicly Supported Housing | for fair housing resources.<br><br>Partner with local organizations such as lending institutions, attorneys, realtors, etc. to host a fair housing community forum annually.<br><br>Hold an annual fair housing training for elected officials, appointed boards, and department staff. | Harrisonburg Redevelopment and Housing Authority |
| **Discussion:** While fair housing education and outreach are constant needs in any jurisdiction, the City and HRHA will work to improve the level of fair housing knowledge and understanding among local housing developers, real estate professionals, local elected officials, design and construction professionals, and the general public with a focus on members of the protected classes. In particular, HRHA and the City will focus on internal education and training to reduce the chances of creating impediments to fair housing within their own organizations. The City and HRHA will also partner with local organizations whose clients are hard to reach protected classes, such as NewBridges and Church World Services, to help citizens better understand their rights. | | | | |

## 2.2 Housing Demographic Needs in Harrisonburg

The 2016 Assessment of Fair Housing presents a housing demographic needs list in Harrisonburg. This broken down by the number of bedrooms, children, and housing type.

Table 2.2 Publicly Supported Housing by Program Category (2016 Assessment of Fair Housing).

| Publicly Supported Housing by Program Category: Units by Number of Bedrooms and Number of Children | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (Harrisonburg, VA CDBG) Jurisdiction | | | | | | | |
| | Households in 0-1 Bedroom Units | | Households in 2 Bedroom Units | | Households in 3+ Bedroom Units | | Households with Children | |
| **Housing Type** | **#** | **%** | **#** | **%** | **#** | **%** | **#** | **%** |
| **Public Housing** | | | | | | | | |
| **Project-Based Section 8** | 219 | 53.16 | 127 | 30.83 | 62 | 15.05 | 111 | 26.94 |
| **Other Multi Family** | | | | | | | | |
| **HCV Program** | 179 | 31.08 | 176 | 30.56 | 216 | 37.50 | 301 | 52.26 |

Large families comprise about 7% of the households accounted for in Table 2.2, and about 10% of within affordable housing. Even given their small relative numbers, nearly 65% of large families, or roughly 720 households, experience at least one housing problem.

Households with children are more than half of those with a Housing Choice Voucher and more than one-quarter of those in project-based development. Even so, there are more large family households with housing problems in the community than those currently receiving public assistance. This illustrates a greater need among families with children than HRHA can address (2016 Assessment of Fair Housing). Single families are an important target group that desperately need better housing options.

## 2.3 Harrisonburg Affordable Housing Qualifications

The table below provides 1-4 bedroom Fair Market Rates (FMRs) for each county and city in Virginia (Federal Fair Market Rents, VHDA 2017).

Table 2.3.1: Listing the 2017 Local Fair Market Housing Rates ($/month) (VHDA, 2017).

| City/County | Locations | 1 Bedroom | 2 Bedroom | 3 Bedroom | 4 Bedroom |
|---|---|---|---|---|---|
| Harrisonburg city | Harrisonburg, VA MSA | $630 | $803 | $1,082 | $1,415 |
| Rockingham County | Harrisonburg, VA MSA | $630 | $803 | $1,082 | $1,415 |

The table below provides the HUD median income for families with 1-8 children (VHDA, 2017).

Table 2.3.2: HUD Median Income for 2016 Fiscal Year (“HUD Median”, VHDA 2017).

| Percentage | One | Two | Three | Four | Five | Six | Seven | Eight |
|---|---|---|---|---|---|---|---|---|
| 30% | $12,350.00 | $16,020.00 | $20,160.00 | $24,300.00 | $28,440.00 | $32,580.00 | $36,400.00 | $38,750.00 |
| 40% | $16,440.00 | $18,800.00 | $21,160.00 | $23,480.00 | $25,360.00 | $27,240.00 | $29,120.00 | $31,000.00 |
| 50% | $20,550.00 | $23,500.00 | $26,450.00 | $29,350.00 | $31,700.00 | $34,050.00 | $36,400.00 | $38,750.00 |
| 60% | $24,660.00 | $28,200.00 | $31,740.00 | $35,220.00 | $38,040.00 | $40,860.00 | $43,680.00 | $46,500.00 |
| 80% | $32,900.00 | $37,600.00 | $42,300.00 | $46,950.00 | $50,750.00 | $54,500.00 | $58,250.00 | $62,000.00 |

| Non-Adjusted Income Limits for Harrisonburg city | | | | |
|---|---|---|---|---|
| **Percentage:** | 50% | 80% | 100% | 150% |
| **Income:** | $29,200.00 | $46,720.00 | $58,400.00 | $87,600.00 |

MSA: Harrisonburg, VA MSA
Median Income: $58,400.00
Virginia State Median Income: $77,500.00 (“HUD Median”, VHDA 2017).

## 2.4 VA Building Development Codes

Currently, all new construction related to the Virginia Housing Development Authority (VHDA) housing construction is subjected to the “Virginia Housing Development Authority: 2016 Minimum Design and Construction Requirements”.

The requirements address issues related to the design, construction, maintenance, marketing, life cycle costs and aesthetic concerns for developments utilizing low income housing tax credits (LIHTC), and/or developments financed by the VHDA. Drawings, specifications and scope of work are expected to comply with the latest applicable issue of the Virginia Uniform Statewide Building Code (USBC), construction practices, and the minimum design of VHDA. An expanded text of these requirements covering all new construction can be found in the Appendix of this document under the “Virginia Housing Development Authority: 2016 Minimum Design and Construction Requirements”. Within the state, all affordable housing will fall under the USBC. Since this code is above the federal standard of the 2009 IBC, Virginia law will be followed.

## 2.5 Affordable Housing Grants and Funding Available

One of the biggest challenges facing affordable housing is determining where the money will be coming from. There are infinite factors to consider, but the cost of a new community will certainly cost millions. This is including the startup costs, and not ongoing or maintenance costs. The list below comprises all of the relevant sources of funding for affordable housing projects. Most of these are awarded at the federal level, but some grants are offered through the individual state (Abarbanel, 2016).

### 2.5.1 Federal Grants

- Community Development Block Grants (CDBG)
    - Community Development Block Grants can fund a number of activities, including job creation, providing services to vulnerable populations, and providing affordable housing. Although new housing construction cannot be funded through CDBG, CDBG can fund land acquisition and infrastructure improvements for tiny home villages (Abarbanel, 2016).
- Emergency Services Grants
    - Emergency Services Grants are used primarily for the renovation of homeless shelters. If a tiny home developer could successfully make the case that transitional tiny home villages are a shelter, funds from this program could be used for operating costs, such as utilities, repairs, and food (Abarbanel, 2016).
- HOME Investments Partnership Program (HOME)
    - distributes grants to cities and states to fund affordable housing projects and provide direct housing assistance to low-income renters. Under this program, tiny home villages constructed with HOME funding would have to meet HUD's housing quality standards, which means each unit would need to include a full bathroom and kitchen. However, local housing ordinances supersede the HUD standards (Abarbanel, 2016).
- HUD Federal Housing Administration (FHA) Multifamily Mortgage Insurance
    - The HUD Federal Housing Administration (FHA) Multifamily Mortgage Insurance Program requires that loans be allocated to the "construction or rehabilitation of detached, semi-detached, row, walkup, or elevator-type rental or cooperative housing containing five or more units." The program is offered to any rental housing at market rate, or for properties that accept rental assistance (project-based or tenant-based vouchers) (Abarbanel, 2016).
- Low Income Housing Tax Credits (LIHTC)
    - The goal of the LIHTC program is to encourage individual and corporate investors to fund and build affordable rental housing. The tax credits can either be 9 percent or 4 percent— meaning that the LIHTC either provides equity equal to the present value or either 30 percent or 70 percent, respectively. The process for accessing the funds, however, is both time intensive and costly. It is not uncommon for developers to undergo this process multiple times before being accepted. For smaller organizations or non-profits this represents a major barrier (Abarbanel, 2016).
- Section 8 Project Vouchers
    - Section 8 Project-Based Vouchers are distributed by public housing agencies (PHAs). PHAs release project-based vouchers to private owners to rent some or all of the units in their housing developments to low-income families. Vouchers are contingent on multi-year housing contracts between the private owner and HUD. To fund the vouchers, Congress appropriates annual funding. These vouchers differ slightly from Housing Choice Vouchers. Specifically, vouchers do

not have transferability, as rental assistance does; they are tied to one specific housing development or unit (Abarbanel, 2016).

- Section 8 Housing Choice Vouchers
    - Housing Choice Vouchers, are distributed by PHAs, and extended to individuals with incomes not exceeding 80 percent of the poverty line. Under the voucher, the recipient has at least 60 days to find housing. Recipients are free to choose housing of their choice and the voucher is connected to them, rather than the property in which they live. But their housing choice must meet the habitability requirements of the program. The subsidy is paid by the PHA directly to the landlord, and the family pays the difference not covered by the subsidy. The voucher is then put towards rent, with the recipient paying the difference not covered by the subsidy or at least a “minimum rent” (Abarbanel, 2016).
- Self-Help Homeownership Opportunity Program (SHOP)
    - The goal of Self-Help Homeownership Opportunity Program funds is to create a sense of pride and community through “sweat equity”—wherein the future homeowners themselves, in partnership with nonprofit organizations and volunteer labor from the community, build the home. Funds are provided to the non-profit organizations administering this kind of model, and are considered to be start-up funds, because they can only be used for either site acquisition or on-site development. Annually, there is approximately $25 million available, granting between $450,000 and $13 million to three to six of the applicants. National or regional organizations qualify for funding, as do consortia (two or more non-profit organizations that are located in at least two states). Those organizations then must choose future homebuyers who would qualify for low-income housing under HUD’s definitions of low income households. Members of the household must contribute a minimum of 100 hours of sweat equity. Moreover, SHOP funding requires that physical construction involve community participation. Once the house is built, HUD standards of safety and durability apply. This funding source may be a good option for tiny home village developers because of the ability to use volunteer labor, which would cut building costs. Also, because the grant is not tied to minimum house size requirements. In addition, by involving community participation in the building, this type of grant is likely to help build support from local residents (Abarbanel, 2016).

### 2.5.2 Energy Efficiency Initiatives

There are efforts at the state and federal level to increase energy efficiency measures. DSIRE (database of state incentives for renewable and efficiency) has a complete collection of all grants and incentives promoting green technologies. Below is the most prominent program that is being implemented in the state. This program provides low-cost financing options for residents, non-profits, local governments, or businesses to take advantage of energy efficiency technologies (Shrestha, 2015).

Table 2.5.2: Grant Overview Virginia SAVES Green Community Loan Program (Shrestha, 2015).

| | |
|---|---|
| Implementing Sector: | State |
| Category: | Financial Incentive |
| State: | Virginia |
| Incentive Type: | Loan Program |
| Website: | http://www.vasavesgcp.com/ |
| Funding Source: | Qualified Energy Conservation Bonds (QECBs) |
| Budget: | $20 million (2015) |
| Start Date: | 09/02/2015 |
| Eligible Renewable/Other Technologies: | Solar - Passive, Solar Water Heat, Geothermal Electric, Solar Photovoltaics, Wind (All), Biomass, Geothermal Heat Pumps, Municipal Solid Waste, Combined Heat & Power, Landfill Gas, Tidal, Wave, Ocean Thermal, Hydroelectric (Small), Anaerobic Digestion, Other Distributed Generation Technologies |
| Eligible Efficiency Technologies: | Clothes Washers, Dehumidifiers, Ceiling Fan, Chillers, Furnaces, Boilers, Heat pumps, Air conditioners, Combined Heat & Power, Compressed air, Caulking/Weather-stripping, Building Insulation, Agricultural Equipment, Comprehensive Measures/Whole Building, Custom/Others pending approval, Yes; specific technologies not identified, Insulation, Food Service Equipment, Commercial Cooking Equipment, Data Center Equipment, Commercial Refrigeration Equipment |
| Applicable Sectors: | Commercial, Industrial, Local Government, Nonprofit, Schools, State Government, Agricultural, Institutional |
| Maximum Loan: | Minimum Loan size: $500,000 to $ 1 million<br>Maximum Loan size: $5 million |

| | |
|---|---|
| Loan Term: | As negotiated with the Funding Party per transaction, with the expectation that the blended useful of the improvement up to a maximum of 10 years, but may be longer in Energy Performance Contracting |
| Interest Rate: | As negotiated with the Funding Party per transaction |

## 2.6 HUD Energy Efficiency Commitments

In conjunction with the USDA, the U.S. Department of Housing and Urban Development recently raised the overall minimum standards of energy efficiency. Announced May 6, 2015 all states are required to have their minimum energy efficiency standards compliant with the International Energy Conservation Code (IECC) 2009 code. This will serve to update the requirements of the Energy Independence and Security Act of 2007. The IECC will be the new minimum standard for new construction of certain HOME-financed and FHA-insured properties (both multifamily and single family) as well as USDA-guaranteed single family homes, this includes energy star appliances (Huang, 2011).

This affected 16 states that were previously below this standard. The reasons given were purely economic, where the measures will require saving money on housing in the long term. The actual numbers are location specific, but all represent sizeable savings. It is estimated that HUD's annual utility expenditure for public and multifamily assisted housing is $6.4 billion, 22% of public housing operating budget. Virginia is already operating under the IECC 2012 version with several performance standards that were changed and will be discussed later (Huang, 2011).

### 2.6.1. HUD Energy Efficiency Programs

On October 16, 2009, HUD released a notice, PIH-2009-43 (HA), encouraging the use of renewable energy and green construction practices in public housing. Through the notice, HUD "strongly encourages Public Housing Agencies (PHAs) to use solar, wind, geothermal/ground coupled heat pumps and other renewable energy sources, and other 'green' construction and rehabilitation techniques whenever they procure for maintenance, construction, or modernization." (PIH Green Initiative).

### 2.6.2 Renew300:

President Barack Obama's Climate Action Plan calls for a target of 300 megawatts (300 MW) of installed capacity of renewable energy on-site at federally subsidized housing by 2020. Federally assisted housing includes HUD's rental housing portfolio (Public Housing, Multifamily Assisted) and USDA's Rural Development Multifamily Programs, as well as rental housing

supported through the Low Income Housing Tax Credit (LIHTC) program. LIHTC is the primary tool of the federal government for developing and rehabilitating affordable rental housing and is administered by state agencies with guidance from the Treasury Department and the Internal Revenue Service.

The 300 MW target aims to make use of millions of federally subsidized roofs with on-site generation potential. Due to the nature of the target, solar photovoltaic (PV) generation is the primary renewable energy source utilized under this initiative. However, other types of renewable energy, including solar thermal, wind, geothermal, biomass, combined heat and power, and small-hydro projects, are also included (High Performance Buildings).

### 2.6.3 HUD Green Building guide

In 2011, HUD published guidance entitled “Enhancing Energy Efficiency and Green Building Design in Section 202 and Section 811 Programs”. This was designed to provide technical assistance during the fiscal year 2010 to 2015 strategic plan. With further implementation of energy efficient technologies becoming prominent in the market, this is a guide showing developers what is available, federal assistance, and case studies of what has been done successfully (Wollos, 2017).

### 2.6.4 2014-2018 Goals

HUD recognizes the importance of increasing energy efficiency in the low income housing stock. Improving the energy efficiency of these buildings would save taxpayer money from utility bills and increase the standard of living for residents. This standard would be reflected in improving health conditions such as respiratory infections, asthma, injuries, and other related health hazards. These goals, as outlined below, are part of the Obama Administration's plan to cut energy waste in half before 2030 (Wollos, 2017). The top 3 goals stated were:

- Strengthen HUD’s programs and policies to meet the President Obama’s goal of cutting energy waste in half by 2030 in new and existing HUD-assisted housing.
    - This can be done through raising some of the energy standards in construction and voluntary commitments with DOE funded research.
- Implement national partnerships to triple the amount of onsite renewable energy across the federally assisted housing stock by 2020.
    - Such as the USDA, HUD, and department of the treasury all working with towards installing renewable energy with federally assisted housing.
- Overcome barriers to leverage private sector and other innovative sources of capital for energy efficiency and renewable energy investments (Wollos, 2017).

## 2.7 HUD Tiny House feasibility study

The Department of Housing and Urban Development has actively been exploring solutions to address affordable housing. Two model tiny house communities were established in Oregon,

utilizing the concepts of shared resources with private living spaces to test the feasibility of tiny homes as a viable option for low-income housing (Abarbanel, 2016).
Each community had a focus, one being transitional housing and the other as a permanent residence. The respective properties will be discussed in more detail below. The goal of this study was to answer questions surrounding tiny home communities such as (Abarbanel, 2016):

- To be successful, how much community support is needed?
- Length of time to build a village and how durable the homes are?
- Looking at the land use and some of the zoning and building codes with tiny homes?
- Did this village increase the quality of life for low income individuals?

### 2.7.1 Comparison Transitional v Permanent Housing

Two very different model tiny house communities were established. Opportunity Village in Oregon was focused on developing temporary housing whereas Emerald Village also in Oregon was a permanent model. These differences in approach are expressed in Table 2.7.1. The main application of each community is where there is a change in design (Abarbanel, 2016).

In the temporary model, the focus is on homelessness. This offers better protection than a shelter and provides some amenities such as showers and the ability to cook. However, this is not a long term solution, it simply provides for an immediate need and can be built cheaply and quickly.

With a permanent model, the focus is more on people who are in temporary models and looking to move into something more permanent or for marginalized low-income groups who may be facing eviction. This model does not address chronic homelessness, rather working individuals that are excessively burdened by rents or mortgages.

Table 2.7.1: Comparison of Opportunity Village and Emerald Village, by Evaluation Criteria (Abarbanel, 2016).

| | **Opportunity Village (Temporary Model)** | **Emerald Village (Permanent Model)** |
|---|---|---|
| Description | Temporary, simple rooms without private bathrooms or kitchens | Permanent homes with private bathrooms and kitchens |
| Residents | Formerly homeless individuals | Marginally housed and previously homeless individuals who have completed some transitional program (such as living in Opportunity Village) |
| Size | 60 to 80 sq. ft. | 150 to 250 sq. ft. |

| | | |
|---|---|---|
| Zoning Challenges | Springfield: Homes must be 120 sq. ft. (excepting manufactured homes); Shared kitchens must go through an application process<br>Eugene: Apply for a conditional use permit | Springfield: Homes must be 120 sq. ft. (excepting manufactured homes); Shared kitchens must go through an application process<br><br>Eugene: No particular barriers |
| Cost to Build | $7,300 per unit | $60,000 per unit, and possibly higher |
| Funding | $98,000 cash, $114,000 in-kind (donations of goods/services instead of cash) | ● $1.5 million total costs<br>● In-kind donations<br>● Possible mortgage |
| Operational Costs per Unit | $90/month | $250 to 300/month |
| Rent | $30/month | $250 to 300/month |
| Possible HUD involvement (not currently being used) | -Emergency Services Grants | -Section 8 Housing Choice or Project vouchers (limited)<br>-CDBG<br>-HOME<br>-SHOP |
| Units | 29 | 22 |
| Effectiveness measures | Homelessness reduction | Increase in affordable housing stock |

## 2.7.2 Pros and Cons of Tiny Homes as Transitional Housing

Using the resources and data from this section, we were able to generate a chart comparing pros and cons of tiny homes as transitional housing.

Table 2.7.2.1: Comparing the Pros and Cons of Using Tiny Houses as Transitional Housing (Abarbanel, 2016).

| Pros | Cons |
|---|---|
| Requires Less funding to build | Difficult to use public funding sources |
| Less professional expertise necessary; simple and quick to build once approved | More ‘nontraditional’ project; harder to get community and political support |

| | |
|---|---|
| Can utilize temporary sites with short-term leases | Lack of site control poses a design constraint |
| Lower operating costs; better accommodates people with little to no income | Very basic infrastructure and amenities |

### 2.7.3 Pros and Cons of Tiny Homes as Affordable Housing

Using the resources and data from this section, we were able to generate a chart comparing pros and cons of tiny homes as affordable housing. All of the solutions are highly localized, but if municipalities have the resources to allocate then developing a permanent model is more effective.

Table 2.7.3: Comparing the Pros and Cons of Using Tiny Houses as Affordable housing (Abarbanel, 2016).

| Pros | Cons |
|---|---|
| Easy to utilize public funding sources | Requires more funding to build |
| More advanced infrastructure; easier to build community and public support | More professional expertise necessary, leading to more complex development process |
| long term site control | Finding a long term site can be difficult |
| Can provide affordable housing to people with extremely low incomes, without depending on public subsidies | Requires residents to have a stable source of income, unless subsidies are obtained |

# 3 Literature Review

This document presents Tiny Houses as a key solution to affordable housing in the city of Harrisonburg, while also making a large-scale, sustainable social and environmental impact on the Harrisonburg community. It describes social movement where people are choosing to downsize the space they live in.

Cities benefit from tiny house ordinances. With significant need for affordable housing, cities are hard-pressed to find solutions that quickly expand their low-income housing stock without burdening an already burdened system. Tiny houses can be quickly installed in municipalities and set up at little to the cities (Morrison, 2015).

Although not addressed in the proposed code language of this public comment, it is important to recognize the need for codes pertaining specifically to movable tiny houses. For some people, homeownership is heavily impacted by the cost of land and even the construction of a fixed tiny house. For those individuals, the presence of movable tiny houses in the building code may create their only path to homeownership. The flexibility of a movable tiny house allows individuals to locate their homes in areas of community living or on ancillary home sites, without the burdensome cost of a single-family lot. It also allows them to take their home with them should they need to relocate, thus eliminating many typical costs of moving.

## 3.1 Tiny House Definitions

The typical size of a tiny house seldom exceeds 500 square feet. The typical tiny house on wheels is usually less than 8 ft. by 20 ft., with livable space totaling 120 square feet or less for ease of towing and to exempt it from the need for a building permit. The typical American home is around 2,600 square feet, whereas the typical small home is between 100 and 400 square feet (Parrott, 2015). A common trend in the U.S. and westernized countries is that home size often increases with the owners' prosperity (Tiny Revolution, 2011).

Since size in tiny homes is subjective, they are typically 400 square feet homes on wheels and up to 1000 square feet on foundation. The smallest house you can build to Uniform State Building Code (USBC) is 120 square feet. Especially in homes as small as these, tiny houses emphasize design over size, encouraging people to choose multifunctional space saving appliances and equipment, and in general, less "stuff". Their small footprints and square footage make them inherently affordable as well as typically more sustainable environmentally. Permitting tiny houses will allow individuals who may not otherwise be able to afford to own their own homes the opportunity to do so, and may further permit a better mixing of differing socioeconomic classes.

### 3.1.1 Tiny House on Wheels

A tiny house on wheels (THOW), for the purposes of the following DMV guidelines, is a structure which is intended as a full time residence or year-round rental property. THOWs must meet these five conditions adapted from the Tiny House Community website (Guidelines, Tiny House Community):

1. Built on a trailer that is registered with the builder's local DMV.
2. Towable by a bumper hitch, frame-towing hitch, or fifth-wheel connection. Cannot move (and was not designed to be moved) under its own power.
3. Is no larger than allowed by applicable state law. (The typical THOW is no more than 8'6" wide, 30' long, and 13'6" high. Larger tiny houses may require special a commercial driver's license and/or special permits when being towed.) Important to note:

- Roof height is from bottom of tires to the top of the highest exterior point on the house, including any protrusions. The roof height may be taller when stationary, as long as it is collapsible for towing of the THOW.
- Chimney piping may need to be removed for travel and then reinstalled to meet clearance requirements for use.
- If slide-outs are included, the plans should be reviewed and approved by a structural engineer licensed in the state in which the THOW is built.

4. Has at least 70 square feet of first floor interior living space, and no more than 400 square feet (excludes any lofts).
5. Includes basic functional areas that support normal daily routines (such as cooking, sleeping, and toiletry).

### 3.1.2 Manufactured Home

A manufactured home is any home that is factory-built in the U.S. to the HUD Title 6 construction standards (commonly known as 'the HUD-code'). The HUD-code took effect June 15, 1976. A HUD-code home will display documentation called the Certification Label and the Data Plate. The red Certification Label (sometimes referred to as the HUD Label) can be located on the tail end of each transportable section of the home. The Data Plate will be located inside of the home. Regulation states that the Data Plate be affixed inside the home on or near the main electrical breaker box, or other readily visible/accessible location. These documents are extremely important. The HUD Title 6 regulation removal is illegal, which could hinder the buying, selling, financing, or insuring of a manufactured home. A manufactured home is built on a permanent frame to ensure transportability. However, typically a manufactured home is not moved from its initial installed site (NADA Guides, 2017).

### 3.1.3 Modular Home

Modular homes are factory-built to a local state code. In some cases, a state may have adopted one of the uniform construction codes (i.e. UBC, IRC, etc.). Modular homes do not have the Red Certification Label, but do have a label attached to the home stating the code it was built to. The appropriate State Modular Code Agency will be able to assist you in locating the modular label.

A modular home can be built as an "on-frame" or "off-frame" modular. On-frame will be built on a permanent chassis, whereas, the off-frame modular will be built with removal of the chassis frame in mind. An off-frame modular will usually require additional cranes to assist with home placement. Modular homes are, more often than not, attached to private land (NADA Guides, 2017).

### 3.1.4 Park Model RV

Park models are "tiny homes on steroids". Park models are under 400 square feet and are usually built to ANSI code (RV) as well. They are generally single story 1 bedroom/1 bathroom

structures. Many park models offer a loft option as well, which provides some additional space for storage, guest sleeping area, kids' room, etc. The loft space is not included in the total square footage of the home as it cannot legally be considered 'livable' space due to the ceiling height. Many people ask if the ceiling height can be raised and the simple answer to that is no. The maximum loft height for a park model is 5'. Anything over 5' must be counted in the square footage, thus exceeding the 400 square feet maximum. You cannot move a park model with a 1 ton truck. Park models must be professionally moved with a tower truck, acquire proper permitting, and require the driver to have a CDL ("Park Models vs Tiny Homes", 2016).

### 3.1.5 "Home" According to the Building Code

A tiny home is loosely defined as a home under 200 square feet Tiny homes are most often built on a trailer and are generally road legal. This means that anyone can tow a tiny home and no permits or CDL are required. Tiny homes built to ANSI code do not go on a foundation and remain permanently on the trailer they were built on. Tiny homes can be built in a variety of lengths, from a super short 4' to a luxurious 48', but must always remain under 8'6" in width in order to be road legal. In addition, the height of a tiny home should not exceed 13'6" (the legal maximum height most states allow without a permit). Most states also have a maximum total length (truck and trailer) of 65'. The larger the home, the larger the vehicle needed to tow it. These restrictions are important when planning to build a tiny home intended to move ("Park Models vs Tiny Homes", 2016).

### 3.1.6 Micro Apartments

A micro apartment might be 300 square feet in New York City or 500 square feet in Dallas. This study learned that no standard definition exists. A micro apartment is a somewhat ambiguous term that covers anything from a relatively small studio or one-bedroom apartment to a short-term lease, Single Room Occupancy unit with communal kitchen and common room areas.

The size of what qualifies as a micro apartment is determined by the market in which it exists. An average micro apartment on the East and West Coasts, such as those proposed in the adAPT NYC competition, can be around 300 square feet. In some Midwestern and Texas markets, units, such as those designed by Urban Studio, can range between 400 and 500 square feet (Milenkovic, 2014).

### 3.1.7 Our Proposal

The homes we are looking to implement in the city of Harrisonburg will have enough functional space for a single family to comfortably live in. We propose a maximum of two bedrooms, for the parents and children, and a separate living space. The importance of separating bedroom space from workspace is emphasized, and can still be achieved with a smaller square footage through careful design and planning. This in addition to being a fully self-contained unit including kitchen, bath, and living space.

## 3.2 Who is Living Tiny

Figure 3.2 below illustrates the tiny house market segments of the people who are adopting the tiny life, what motivations are, and the means by which they are making the transition (Frazier Presentation, 2017). This figure is more comprehensive that strictly tiny houses. Many of the extensions here extend to ecovillages, homes on permanent foundations, and even business owners who are innovators in the housing market.

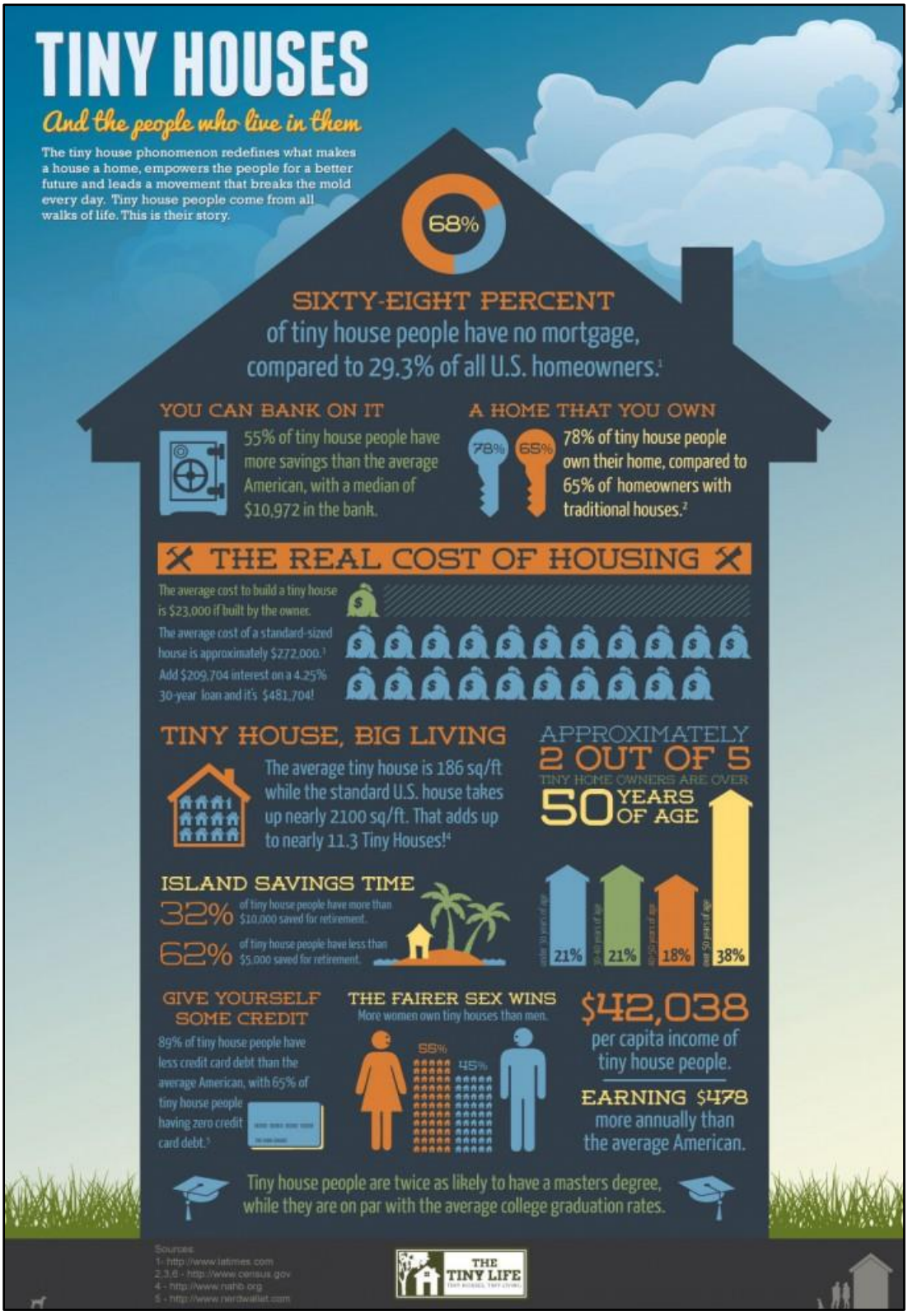
TINY HOUSES
And the people who live in them
The tiny house phonomenon redefines what makes a house a home, empowers the people for a better future and leads a movement that breaks the mold every day. Tiny house people come from all walks of life. This is their story.
68%
SIXTY-EIGHT PERCENT
of tiny house people have no mortgage, compared to 29.3% of all U.S. homeowners.[1]
YOU CAN BANK ON IT
55% of tiny house people have more savings than the average American, with a median of $10,972 in the bank.
A HOME THAT YOU OWN
78%
65%
78% of tiny house people own their home, compared to 65% of homeowners with traditional houses.[2]
THE REAL COST OF HOUSING
The average cost to build a tiny house is $23,000 if built by the owner.
The average cost of a standard-sized house is approximately $272,000.[3]
Add $209,704 interest on a 4.25% 30-year loan and it's $481,704!
TINY HOUSE, BIG LIVING
The average tiny house is 186 sq/ft while the standard U.S. house takes up nearly 2100 sq/ft. That adds up to nearly 11.3 Tiny Houses![4]
APPROXIMATELY
2 OUT OF 5
TINY HOME OWNERS ARE OVER
50 YEARS OF AGE
ISLAND SAVINGS TIME
32% of tiny house people have more than $10,000 saved for retirement.
62% of tiny house people have less than $5,000 saved for retirement.
21%
21%
18%
38%
GIVE YOURSELF SOME CREDIT
89% of tiny house people have less credit card debt than the average American, with 65% of tiny house people having zero credit card debt.[5]
THE FAIRER SEX WINS
More women own tiny houses than men.
55%
45%
$42,038
per capita income of tiny house people.
EARNING $478
more annually than the average American.
Tiny house people are twice as likely to have a masters degree, while they are on par with the average college graduation rates.
Sources:
1- http://www.latimes.com
2,3,6 - http://www.census.gov
4 - http://www.nahb.org
5 - http://www.nerdwallet.com
THE TINY LIFE

Figure 3.2.1: Giving a profile of the individuals who are choosing to live in tiny houses. Note that this graph was created in 2013, and some of the numbers may have changed in the past 4 years.

### 3.2.1 Millennials

Millennials refer to the young adults and professionals of this generation who are first time home buyers. Due to the lack of affordability, many do not have the financial means to save for a down payment on a typical single-family home. Their ages range from 18-24, with an income average of 50,000 annually. Many are currently in transitional stages of housing, where they are looking for affordability and often choose to rent over purchasing a home.

### 3.2.2 Retirees

The empty nesters are also a large group of those interested in living tiny. These are the people looking to downsize their overall living space after so many years of having so much of it. They are often looking to let go of objects and clutter. These people are on average 62 years old in order to collect social security and often are looking at retirement plans (Social Security, 2017). At this stage of life, they often are looking at homes that “age in place”, also known as homes that have functionality for seniors to easily get around the house. They’re going to look for smart designs that make home mobility easier even for a senior, and design and appliances that have a longer life cycle.

### 3.2.3 Environmental Advocates

The environmental advocates are those who want to reduce their overall impact on the Earth. Living in a tiny house is an efficient and sustainable way to design an entire lifestyle that can reduce their overall environmental impact.

### 3.2.4 Low Income Housing

Families who pay more than 30 percent of their income for housing are considered cost burdened and may have difficulty affording necessities such as food, clothing, transportation and medical care. An estimated 12 million renter and homeowner households now pay more than 50 percent of their annual incomes for housing. A family with one full-time worker earning the minimum wage cannot afford the local fair-market rent for a two-bedroom apartment anywhere in the United States (Affordable Housing, 2017).

Section 8 of HUD housing is a target market for tiny homes, being that they can be built with smart design and can age in place at an affordable price. The city of Harrisonburg seeks to help renters transition to a homeowner status, and tiny homes and their communities could be the most viable solution to increasing homeowners in the area.

## 3.3 Advantages of Living Tiny

A growing movement of downsizing homes is trending. The typical American home is around 2600 square feet. Tiny or small houses are around 100 - 900 square feet. Popular reasons cited are environmental and financial as well as owners seeking more time and freedom (Morrison, 2015). These micro-homes are also making a large-scale social impact on communities.

Adding tiny house community that provides affordable, sustainable housing and a supportive community would be a big advantage for the disabled, chronically homeless in Harrisonburg. We will address affordability and sustainability in the urban core, and how that will benefit potential home buyers in need of affordable homes.

### 3.3.1 Economics

The best reason for going tiny is strictly economics. Tiny homes are inherently cheaper than traditional developments. This cost difference is reflected below in their construction costs below. Table 3.3.1 compares the cost of the typical housing developments used for low income housing, excluding land cost. In urban areas, high rises are the norm as they provide the greatest density. But these require greater upfront capital investment, management, and maintenance for the development. This in contrast to tiny homes that are cheaper and allows for greater flexibility with energy implementation measures.

Table 3.3.1: Comparing the cost of construction and 30 year cost of energy among various low income housing solutions.

| **Comparing the Lifetime Costs of Housing Options** | | | | |
|---|---|---|---|---|
| Housing Type | Total Unit Building Cost ($) | Square Footage | 30 Year Energy Cost ($) | **Total Cost ($)** |
| 50 Apartment Complex | 210,614 | 350 | 10,920 | **221,534** |
| 100 Apartment Complex | 156,723 | 350 | 10,920 | **170,643** |
| Tiny Home on E. Johnson St. | 99,400 | 456 | 14,911 | **114,311** |
| Tiny House on Wheels | 62,950 | 200 | 6,240 | **69,190** |

Below, Table 3.3.2 compares the lifetime cost of ownership of a traditional single family home. The U.S. Census Bureau shows data for the median cost of all U.S. homes sold (Cost of Affordable Housing, n.d.).

Figure 3.3.2: Lifetime cost of ownership of a tiny house for a conventional single family home, including the cost of energy (Krisch, 2017).

| Comparing the Lifetime Cost of Ownership of a Home | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Housing Type** | **Manufacturer** | **Sq. Ft** | **20% Down ($)** | **List price ($)** | **Interest + loan ($)** | **30yr Energy Cost ($)** | **30 Year Total ($)** |
| Tiny House on Wheels | Tumbleweed | 200 | 0 | 62,950 | 0 | 6,240 | **69,190** |
| Tiny Home on E. Johnson St. | Gaines Group/ Beck Builders | 456 | 0 | 99,400 | 0 | 14,911 | **114,311** |
| Single Family National Average | U.S. Census Bureau | 2600 | 53,780 | 268,900 | 373,755.17 | 70,980 | **498,515** |
| Single Family Harrisonburg | On the Market | 2275 | 45,200 | 226,000 | 314,126.7 | 69,615 | **383,742** |
| Single Family Harrisonburg new Construction | Based 2016 on Real estate data | 1893 | 42,800 | 214,000 | 297, 447.4 | 68,148 | **365,595** |

## 3.3.2 List of Assumptions with the Cost of Ownership

Listed below are assumptions with the lifetime cost of ownership of a tiny house for a conventional single family home, including the cost of energy.

### 3.3.2.1 Tiny House on Wheels

Due to the high variance with the overall spectrum of tiny homes that exist today, finding a suitable sample proved difficult. Many of the people who choose to live tiny build their own

homes from scratch. But the individual's skill set, amount of capital, time they are willing to invest (labor, finding parts, meetings), and willingness to hire a contractor all can push that number up or down tens of thousands of dollars (Cypress, 2017).

For example, a builder who specialized in energy efficient construction was able to build their personal home for $10,500. This included donated materials, knowledge of ecological design, donations of materials from friends in the industry, and performing most of the labor by hand (Tiny House blog, 2016).

Most individuals looking to live tiny have ambition and are willing to learn in the process and help with the labor, but lack much of the specific technical knowledge. Many of the costs will be in buying the materials (great variance depending on end goals) and hiring a contractor for guidance on the more technical measures. This can include sealing a roof properly, demonstrating how to install drywall, and completing the electrical and plumbing work. This category will have the greatest range but $25,000 to $40,000 is a realistic number (Spesard, 2017).

Finally, one seeking to live tiny has the option to hire a contractor and choose from either a prefab or custom model. There are many tiny house construction companies springing up all over the country, Tumbleweed is one of the largest and for our estimates we choose their most popular model.

Due to the high degree of variability with tiny house construction, we assumed hiring a contractor to be the best option. This way, there is no guess work in the quality of construction, sourcing of the materials, or registering the tiny house as an RV (Cypress, 2017). Additionally, it is challenging to find accurate numbers on expenses for the amount of labour and materials necessary. Within this estimate, all of the tradeoffs between individual details including heating elements, finishes, or stove selection are beyond the scope of this project. A prefabricated model gives answers to these variables and a hard number for the end cost.

#### 3.3.2.2 Local Properties

Considering some of the real estate locally, our research found the median price of homes listed in the area is in the $225,000 to $240,000 range (Zillow, 2017). Our project presents two local models. The first is a house which is currently on the market with an asking price on par with the local median property values.

#### 3.3.2.3 E. Johnson St. House

To bring real world perspective to the argument, the house on E. Johnson Street was designed by the Gaines Group (Personal Communication with Hendricks, 2017). The Gaines Group are a local architecture firm that specializes in sustainable design. This house was made by an Eastern Mennonite University student two years back for her graduate thesis, and is currently on the market.

#### 3.3.2.4 Single Family Harrisonburg

Listing Details (HotPad.com):
Location: 3027 Cross Keys Rd, Rockingham County VA 22801
Units: Single family, 4 bed, 2 bath
Size: 2,275 square feet
Price: $226,000
Acreage: 1.6 acres

Loan calculation: This was based on taking out a loan for the remainder of the mortgage of the house, after first paying the 20% down payment of $45,200. The loan was based on the rates at the time of calculation for a 30-year fixed mortgage, which was a 4.09% interest rate (Bankrate, 2017).

#### 3.3.2.5 New Local Construction

Scott Rogers is a local realtor with Funkhouser real estate. He compiles housing data from the Harrisonburg and Rockingham county area on the state of the housing market. The monthly reports he published cover a wide array of the local housing market. This includes everything from homes sales, market value trends, what is available the housing stock, cost of homes, and lot sizes among other data. Figure 3.3.1 below was used to calculate the average size of a new local home based on the current market. Taking the median sales price over the median price per square foot we can estimate a theoretical ‘median’ house made today would be

approximately 1893 square feet, not including land costs (Rodgers, 2017).

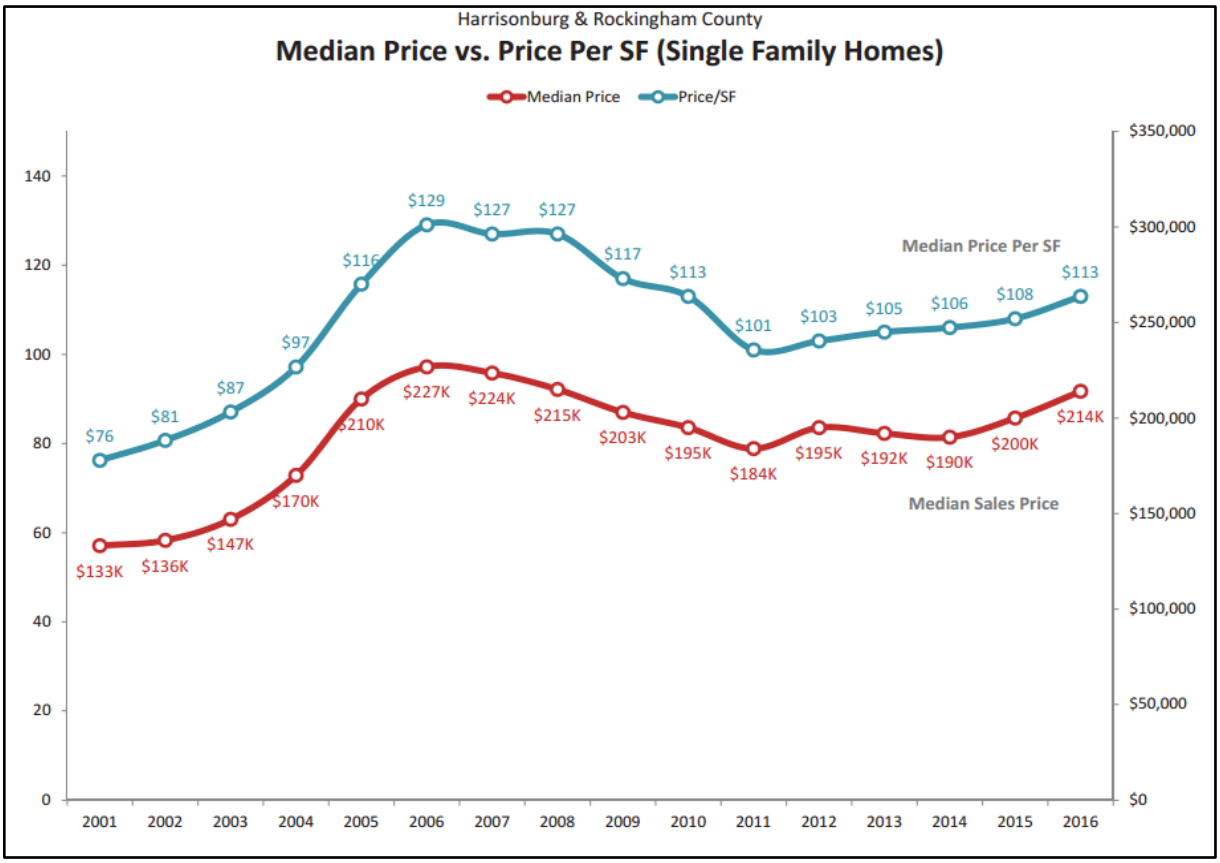


Figure 3.3.1: Graph from the "Harrisonburg & Rockingham county real estate market report" Published by Scott Rogers gives a snapshot the of real estate market through Dec 31, 2016 (Rodgers, 2017).

#### 3.3.2.6 30 Year Cost of Energy

This was calculated using data from the U.S. Energy Information Administration (EIA). During the 2009 Residential Energy Consumption Survey (RECS), data was collected on the average energy expenditures per household as a function of the homes square footage. Total cost of energy per square foot came from the EIA website (RECS Survey, 2009).

$$Total\ lifetime\ energy\ cost = \frac{total\ cost\ of\ energy}{square\ foot} * square\ footage * 30\ years$$

### 3.3.3 Cost of Traditional New Construction

Costs of a traditional home's new construction is broken down in detail in the tables below (National Association of Home Builders, 2017).

Table 3.3.3.1: Single family price and cost breakdowns 2015 national results (NAHB, 2017).

| | | |
|---|---|---|
| | Average Lot Size: | 20,129 |
| | Average Finished Area: | 2,802 |
| **I. Sale Price Breakdown** | **Average** | **Share of Price** |
| A. Finished Lot Cost (including financing cost) | $85,139 | 18.2% |
| B. Total Construction Cost | $289,415 | 61.8% |
| C. Financing Cost | $6,285 | 1.3% |
| D. Overhead and General Expenses | $26,345 | 5.6% |
| E. Marketing Cost | $3,739 | 0.8% |
| F. Sales Commission | $15,104 | 3.2% |
| G. Profit | $42,292 | 9.0% |
| **Total Sales Price** | **$468,318** | **100%** |
| **II. Construction Cost Breakdown** | **Average** | **Share of Construction Cost** |
| **I. Site Work (sum of A to E)** | **$16,092** | **5.6%** |
| A. Building Permit Fees | $3,601 | 1.2% |
| B. Impact Fee | $1,742 | 0.6% |
| C. Water & Sewer Fees Inspections | $4,191 | 1.4% |
| D. Architecture, Engineering | $4,583 | 1.6% |
| E. Other | $1,975 | 0.7% |
| **II. Foundations (sum of F to G)** | **$33,447** | **11.6%** |
| F. Excavation, Foundation, Concrete, Retaining walls, and Backfill | $32,576 | 11.3% |
| G. Other | $871 | 0.3% |
| **III. Framing (sum of H to L)** | **$52,027** | **18.0%** |
| H. Framing (including roof) | $44,640 | 15.4% |
| I. Trusses (if not included above) | $3,884 | 1.3% |
| J. Sheathing (if not included above) | $1,238 | 0.4% |
| K. General Metal, Steel | $1,272 | 0.4% |
| L. Other | $993 | 0.3% |
| **IV. Exterior Finishes (sum of M to P)** | **$43,447** | **15.0%** |
| M. Exterior Wall Finish | $20,717 | 7.2% |
| N. Roofing | $10,069 | 3.5% |
| O. Windows and Doors (including garage door) | $12,127 | 4.2% |
| P. Other | $534 | 0.2% |
| **V. Major Systems Rough-ins (sum of Q to T)** | **$37,843** | **13.1%** |
| Q. Plumbing (except fixtures) | $12,302 | 4.3% |
| R. Electrical (except fixtures) | $12,181 | 4.2% |
| S. HVAC | $12,623 | 4.4% |
| T. Other | $738 | 0.3% |
| **VI. Interior Finishes (sum of U to AE)** | **$85,642** | **29.6%** |
| U. Insulation | $6,467 | 2.2% |
| V. Drywall | $11,744 | 4.1% |
| W. Interior Trims, Doors, and Mirrors | $12,409 | 4.3% |
| X. Painting | $9,002 | 3.1% |
| Y. Lighting | $3,517 | 1.2% |
| Z. Cabinets, Countertops | $16,056 | 5.5% |
| AA. Appliances | $4,463 | 1.5% |
| AB. Flooring | $13,367 | 4.6% |
| AC. Plumbing Fixtures | $4,465 | 1.5% |
| AD. Fireplace | $2,760 | 1.0% |
| AE. Other | $1,393 | 0.5% |
| **VII. Final Steps (sum of AF to AJ)** | **$19,567** | **6.8%** |
| AF. Landscaping | $6,156 | 2.1% |
| AG. Outdoor Structures (deck, patio, porches) | $4,349 | 1.5% |
| AH. Driveway | $6,240 | 2.2% |
| AI. Clean Up | $2,054 | 0.7% |
| AJ. Other | $768 | 0.3% |
| **VIII. Other** | **$1,349** | **0.5%** |
| **Total** | **$289,415** | **100%** |

Table 3.3.3.2 Single family homes sales price breakdown history (NAHB, 2017).

| Sale Price Breakdown | 1998 | 2002 | 2004 | 2007 | 2009 | 2011 | 2013 | 2015 |
|---|---|---|---|---|---|---|---|---|
| 1. Finished Lot Cost | 23.6% | 23.5% | 26.0% | 24.5% | 20.3% | 21.7% | 18.6% | 18.2% |
| 2. Total Construction Cost | 54.8% | 50.8% | 51.7% | 48.1% | 58.9% | 59.3% | 61.7% | 61.8% |
| 3. Financing Cost | 1.9% | 2.1% | 1.8% | 2.4% | 1.7% | 2.1% | 1.4% | 1.3% |
| 4. Overhead and General Expenses | 5.7% | 5.5% | 5.8% | 7.0% | 5.4% | 5.2% | 4.3% | 5.6% |
| 5. Marketing Cost | 1.4% | 2.4% | 1.9% | 2.5% | 1.4% | 1.5% | 1.1% | 0.8% |
| 6. Sales Commission | 3.4% | 3.7% | 3.0% | 4.3% | 3.4% | 3.3% | 3.6% | 3.2% |
| 7. Profit | 9.2% | 12.0% | 9.8% | 11.2% | 8.9% | 6.8% | 9.3% | 9.0% |
| **8. Total Sales Price ($)** | **$226,680** | **$298,412** | **$373,349** | **$454,906** | **$377,624** | **$310,619** | **$399,532** | **$468,318** |

Source: NAHB Construction Cost Surveys, 1998-2013

Average construction is cost is approximately 60% of the average sale price of homes in the U.S. The other 40% of the sale price comes from finished lot costs, financing costs, overhead and general expenses, marketing costs, sales commission, and profits. The 2015 average sale price has practically doubled since 1998 (National Association of Home Builders, 2017).

## 3.3.2 Environmental Impact

The environmental impact of transition to a tiny house is much lower than a traditional home. The sheer volume of materials that are going into the house is much smaller than that of a 2600 square foot home. The Green Buildings Section 3 will go into detail describing the environmental impact of various building techniques, materials, and electrical appliances. The section will also provide a comparison of the various techniques to give the audience an idea of the best choice based on their values and lifestyle (economic, impact, lifetime).

## 3.3.3 Lifestyle

Living tiny does have some drawbacks, as the space is inherently limited there are some concessions that need to be made. The biggest one is the lack of space for ‘stuff’.

We looked at some of the testimonials of those who advocate the lifestyle of decluttering. The Tiny House Conference in Asheville suggested a way to begin the decluttering process; by doing the 200 things challenge. This challenge seeks to rid the home of unnecessary objects by asking yourself: “does it fit in my *life* instead of my house”? If it does not, then it is an object cluttering precious space that a tiny home cannot afford to waste. While for some this can be a hard, if not impossible process, there are testimonials arguing that it has been an incredibly advantageous experience (Tiny House Conference, 2016).

This is more of an anti-consumerist mindset where going against popular belief that we need things. But also transitions into one of the main proponents of tiny living where they have had the most success when starting in communities. Community living gives those who live there a sense of place, shared resources, and individuals to help another as needs arise.

## 3.4 Disadvantages of Living Tiny

### 3.4.1 Legality

Many of the grey areas in making tiny houses legal are zoning laws and meeting building code minimums of the area, while also providing a quality living space. A lot of financial politics are in play in the housing market in localities, where the government controls who lives in what kind of space with high taxes.

This project outlines a way for one to find a lot and build a code complying home as tiny as they desire in the city of Harrisonburg. Later sections will describe the nitty gritty details of the zoning laws and ordinances that will be viable for building a residential home or community, as well as the relative cost of a space. There will also be a section on the building code minimums for a house in compliance with the IBC and VSBC. Building codes are relative to their state, therefore, always follow the stricter code to comply with (Personal Communication with Hendricks, 2017).

### 3.4.2 Lifestyle

Living with less stuff can be a disadvantage of living in a tiny house. Some people believe they need a certain number of objects and space in their home, the philosophy of ‘keeping up with the Jones’’. Additionally, less living space for family and kids, as well as entertaining guests and family (Matthews, 2016). The tiny house lifestyle is likely better suited for millennials, retirees, environmentally conscious people, or low income housing as they typically have fewer needs.

# 4 Green Buildings

There are many definitions of what green building is or does. Definitions range from a building that is “less bad” than the average building in terms of its impact on the environment to a building that is “high performance.” Gaines Group Architect Charles Hendricks’s definition is a home or building that meets the budget, is adaptable, durable, preserves or restores habitat, reduces energy and water use, and provides healthy indoor air quality (Personal Communication, 2017). Hendricks has provided this report with many green techniques to meet these important quality standards.

## 4.1 Shades of Green

There are an infinite number of measures that can be taken to make a home or building eco-friendlier. In this section, many of the national and international energy efficiency standards are explained.

### 4.1.1 Carbon Neutral Building

Carbon neutral means making no net release of carbon dioxide to the atmosphere, or having a net zero carbon footprint. In terms of building, it relates to measuring, reducing and offsetting carbon energy used by building or construction (Department of the Environment and Energy, 2016). This can be calculated by doing a LCA, life cycle analysis, of the embodied energy in the construction and use the building.

### 4.1.2 Net Zero Construction / Energy

Net zero construction is incorporating energy-efficient strategies into the design, construction, and operation of new buildings and undertaking retrofits to improve the efficiency of existing buildings. According to the U.S. DOE net zero energy or zero energy building can be defined as “an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy” (Peterson, 2015).

This concept of establishing a zero energy definition covers zero energy buildings, zero energy campuses, zero energy portfolios, and zero energy communities. All of the developments listed can achieve net zero status, if the total amount of energy generated is less than or equal to the energy consumed within their site boundary. A model of zero energy accounting can be seen in the figure below.

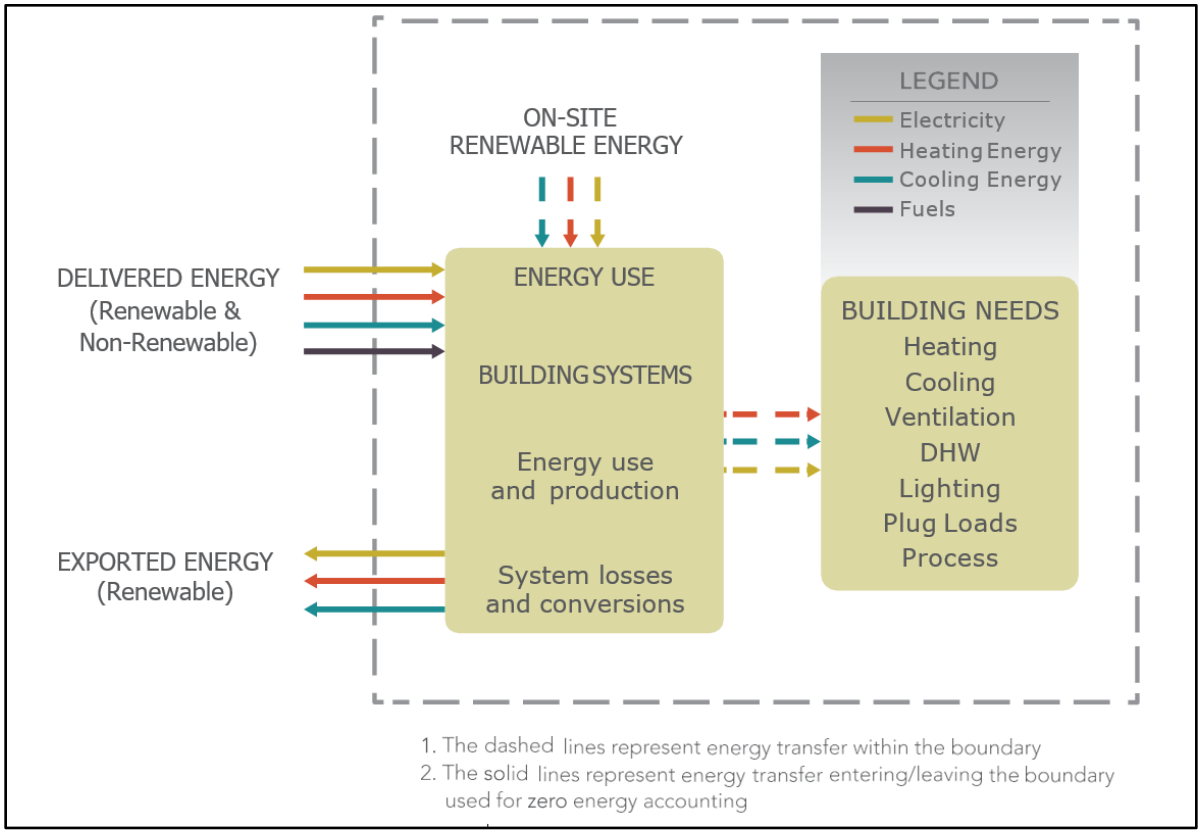

Figure 4.1.2: A Site Boundary of Energy Transfer for Zero Energy Accounting (Peterson, 2015).

## 4.1.3 Green Certifications

There are numerous green building certification standards. Each with their own merit, but for the scope of this project the three most relevant standards selected were LEED, Living Future, and Passive houses.

### 4.1.3.1 LEED

LEED: Leadership in Energy and Environmental Design. This is the premiere certification standard of the U.S.GBC (U.S. Green Building Council).

#### 4.1.3.1.1 LEED v4

Adopted in November 2014, LEED v4 is the latest version that updates some of the standards and increases the overall focus to include more facets of design, education, and retrofitting (USGBC, 2017).

Minimum Standards:

- Must be in a permanent location on existing land
- Defining reasonable LEED project boundaries
    - Identifying all areas of the contiguous land and areas which are altered
    - Existing infrastructure like sewers or power lines
    - Looking at the entire building as a system
    - Ensuring that the existing neighborhood impact is calculated
- Ensuring that it is complying with size requirements

Due to the specific requirements of all buildings, the U.S.GBC has broken their criteria down based on the end use assessment. They compromise:

- Building Design and Construction
- Interior Design and Construction
- Building Operations and Maintenance
- Neighborhood Development
- Homes

Areas of Assessment for LEED Certifications
With all of the major end use assessments, the individual technical requirements cover:

- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Location and transportation

### 4.1.3.2 Living Future

The Living Future institute is an international organization committed to changing the ways humans live on the Earth and interact with the environment. Their basic principles revolve around creating a harmonious relationship between our buildings, communities, social interactions, and the environment. For this section, the focus is on the Living building challenge, one of the most rigorous and energy efficient design standards which encompass the entire life of the structure.

### 4.1.3.2 Living Future Basics

With the Living Building Challenge, you can create buildings that are (Living Building Challenge 3.0, 2014):

- Regenerative spaces that connect occupants to light, air, food, nature, and community.
- Self-sufficient and remain within the resource limits of their site. Living Buildings produce more energy than they use and collect and treat all water on site.
- Create a positive impact on the human and natural systems they interact with.
- Places that last, creating spaces designed to operate for a hundred years.
- Healthy and beautiful, appreciating the aesthetics

'Petals' (dimensions of design) of development:

- Place: restoring a healthy relationship with nature
- Water: creating developments that operate within the water balance of a given place and climate.
- Energy: relying only on current solar or renewable income.
- Health and happiness: creating environments that optimize physical and psychological health and well-being.
- Materials: endorsing products that are safe for all species through time
- Equity: supporting a just and equitable world
- Beauty: celebrating design the uplifts the human spirit

Core Rules adapted from the Living Building Challenge (Living Building Challenge 3.0, 2014):

1. All imperatives assigned to a Typology, or core principles, are mandatory. Some Typologies require fewer than twenty categories as listed below, because the conditions are either not applicable or may compromise other critical needs.
2. Living Building Challenge certification requires actual, rather than modeled or anticipated, performance. Therefore, projects must be operational for at least twelve consecutive months prior to evaluation.

Table 4.1.3.2 below feature a detailed list of all of the petals of development and the typological principles associated with each design facet. This provides a detailed profile of all of the key design features that can be addressed to create a 'living building'. Making a living building will additionally qualify the structure for other sustainable certifications, the most rigorous one being

a Net-Zero building. The important part to note is the expansion of the criteria beyond just the single building. Designers will need to be aware of their equity and social impact, along with being required to include an aesthetic principle.

Table 4.1.3.2: Living Future Design Standard (Living Building Challenge 3.0, 2014).

| | LIVING BUILDING CHALLENGE | | | |
|---|---|---|---|---|
| | BUILDINGS | RENOVATIONS | LANDSCAPE + INFRASTRUCTURE | |
| PLACE | | | | 01. LIMITS TO GROWTH |
| | SCALE JUMPING | | SCALE JUMPING | 02. URBAN AGRICULTURE |
| | | | SCALE JUMPING | 03. HABITAT EXCHANGE |
| | | | | 04. HUMAN-POWERED LIVING |
| WATER | | | SCALE JUMPING | 05. NET POSITIVE WATER |
| ENERGY | | | SCALE JUMPING | 06. NET POSITIVE ENERGY |
| HEALTH & HAPPINESS | | | | 07. CIVILIZED ENVIRONMENT |
| | | | | 08. HEALTHY INTERIOR ENVIRONMENT |
| | | | | 09. BIOPHILIC ENVIRONMENT |
| MATERIALS | | | | 10. RED LIST |
| | | | SCALE JUMPING | 11. EMBODIED CARBON FOOTPRINT |
| | | | | 12. RESPONSIBLE INDUSTRY |
| | | | | 13. LIVING ECONOMY SOURCING |
| | | | | 14. NET POSITIVE WASTE |
| EQUITY | | | | 15. HUMAN SCALE + HUMANE PLACES |
| | | | | 16. UNIVERSAL ACCESS TO NATURE + PLACE |
| | | | SCALE JUMPING | 17. EQUITABLE INVESTMENT |
| | | | | 18. JUST ORGANIZATIONS |
| BEAUTY | | | | 19. BEAUTY + SPIRIT |
| | | | | 20. INSPIRATION + EDUCATION |

### 4.1.3.3 Passive Houses

#### 4.1.3.3.1 The Performance Standard

North American building scientists and builders with funding from the U.S. Department of Energy (DOE) and the Canadian government were the first to pioneer passive building principles in the 1970s. In the late 1980s, the German Passivhaus Institut (PHI) built on that research and those principles and developed a quantifiable performance standard that continues to work well in the Central European and similar climate zones (PHIUS, 2017).

However, in practice, project teams working in North America learned that a single standard for all North American climate zones is unworkable. In some climates, meeting the standard is cost prohibitive, in other milder zones, it is possible to hit the European standard while leaving substantial cost-effective energy savings unrealized (PHIUS, 2017).

In cooperation with the Building Science Corporation under a U.S. DOE Building America Grant, the PHIUS Technical Committee developed passive building standards that account for the broad range of climate conditions, market conditions, and other variables in North American climate zones. The result is the PHIUS+ 2015 Passive Building Standard – North America, which was released in March of 2015. Regardless of the metric, the principles are the same, and the passive building community is working hard to make this approach the mainstream and best practice for building design and construction (PHIUS, 2017).

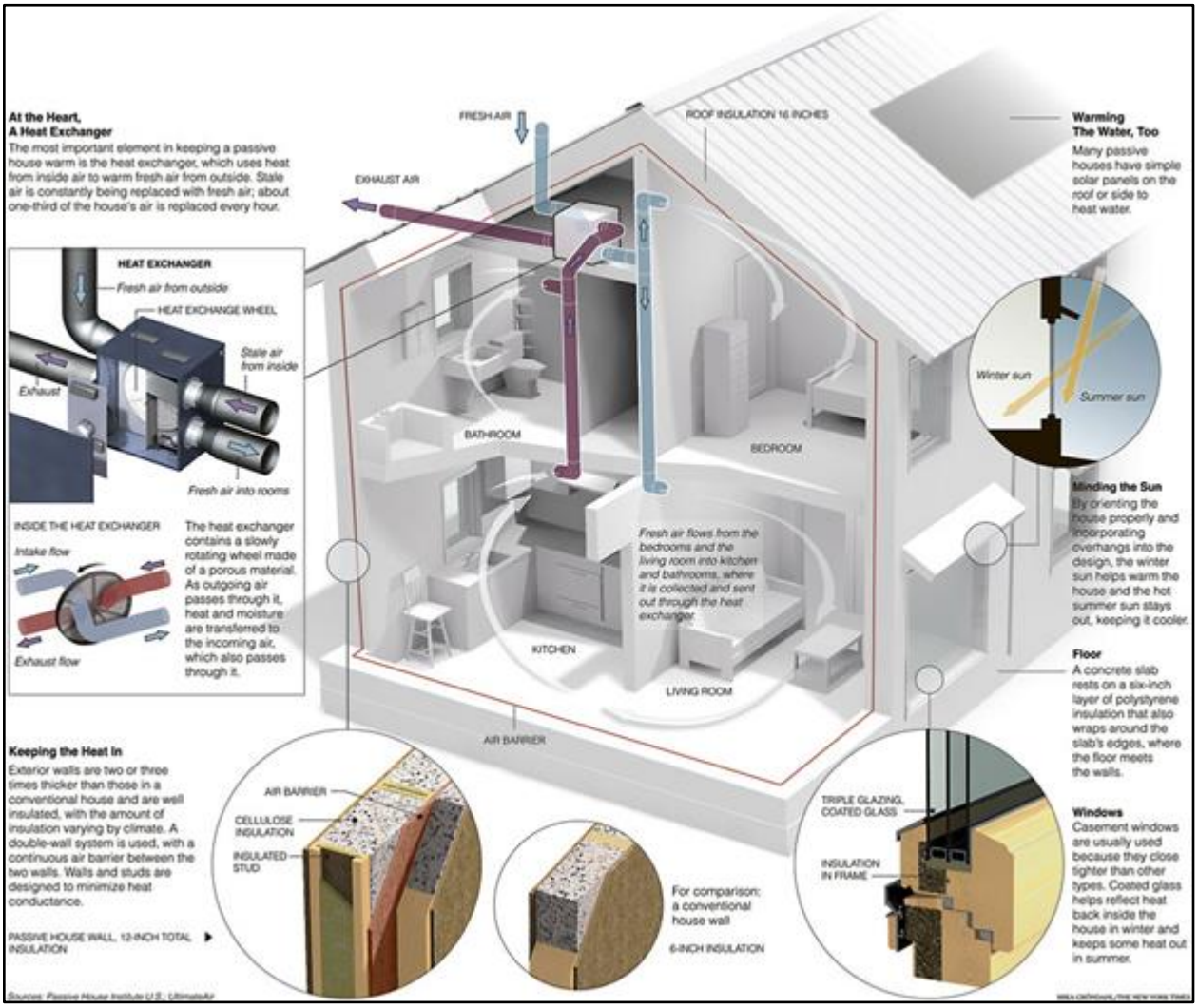

Figure 4.1.3.3: This diagram demonstrates the principle design features of a passive house. Most notably are the passive solar, high R-value insulation, and the heat exchanger to circulate air (Gröndahl, 2009).

#### 4.1.3.3.2 Building Concepts

Passive building comprises a set of design principles used to attain a quantifiable and rigorous level of energy efficiency within a specific quantifiable comfort level. “Maximize your gains,

minimize your losses” summarizes the approach. To that end, a passive building is designed and built in accordance with these five building-science principles (PHIUS, 2017):

1. Employs continuous insulation throughout its entire envelope without any thermal bridging.
2. The building envelope is extremely airtight, preventing infiltration of outside air and loss of conditioned air.
3. Employs high-performance windows (typically triple-paned) and doors.
4. Uses some form of balanced heat- and moisture-recovery ventilation and a minimal space conditioning system.
5. Solar gain is managed to exploit the sun's energy for heating purposes in the heating season and to minimize overheating during the cooling season.

Passive building principles can be applied to all building typologies – from single-family homes to multifamily apartment buildings, offices, and skyscrapers (PHIUS, 2017).

Passive design strategy carefully models and balances a comprehensive set of factors including heat emissions from appliances and occupants to keep the building at comfortable and consistent indoor temperature throughout the heating and cooling seasons. As a result, passive buildings offer tremendous long-term benefits in addition to energy efficiency (PHIUS, 2017):

- High R value insulation and airtight construction provide unmatched comfort even in extreme weather conditions.
- Continuous mechanical ventilation of fresh filtered air provides superb indoor air quality.
- A comprehensive systems approach to modeling, design, and construction produces extremely resilient buildings.
- Passive building principles offer the best path to Net Zero and Net Positive buildings by minimizing the load that renewables are required to provide.

#### 4.1.3.3.3 Performance Criteria

*Thermal insulation*

All opaque building components of the exterior envelope of the house must be very well-insulated. For most cool-temperate climates, this means a heat transfer coefficient (U-value) of 0.15 W/(m²K) at the most, i.e. a maximum of 0.15 watts per degree of temperature difference and per square meter of exterior surface are lost (Passive House requirements).

*Passive House windows*

The window frames must be well insulated and fitted with low-e glazing filled with argon or krypton to prevent heat transfer. For most cool-temperate climates, this means a U-value of 0.80 W/(m²K) or less, with g-values around 50% (g-value= total solar transmittance, proportion of the solar energy available for the room) (Passive House requirements).

*Ventilation heat recovery*

Efficient heat recovery ventilation is the key, allowing for good indoor air quality and energy efficiency. In Passive House, at least 75% of the heat from the exhaust air is transferred to the fresh air again by means of a heat exchanger (Passive House requirements).

*Airtightness of the building*
Uncontrolled leakage through gaps must be smaller than 0.6 of the total house volume per hour during a pressure test at 50 Pascal (both pressurized and depressurized) (Passive House requirements).

*Absence of thermal bridges*
All edges, corners, connections and penetrations must be planned and executed with great care, so that thermal bridges can be avoided. Thermal bridges which cannot be avoided must be minimized as far as possible (Passive House requirements).

### 4.1.4 Off Grid Living

Off grid living is a topic which arises is conversations surrounding tiny houses quite frequently. As part of our proposal we will are recommending individuals stay connected to the grid. The biggest hurdle is that living off grid in the city is illegal. A breakdown of the THOW laws regarding dimensions and 'parking' is discuss in detail in Section 6 (Off Grid World).

But legality aside other challenges include requiring significant technical knowledge, high up front capital investment, and drastically changing one's lifestyle. One of the biggest draws to tiny homes, and THOW in particular is they possess the ability to live off the grid. The technologies to successfully live off grid exist (Off Grid World).

The best option for someone trying to live off grid would be to register their tiny home as an RV, while living in another permanent residence on their property. Their tiny homes can be used for traveling, but it will be subjected to camping and RV laws. The requirements for a home like this would vary depending on the owner's lifestyle. But the biggest questions they will have to answer can be summed up in Table 4.1.4 (Off Grid World).

Table 4.1.4: Challenges with off grid living (Off Grid World).

| Challenge | Potential Solution |
|---|---|
| Energy | Solar PV on the roof and a battery storage system, or having everything run on natural gas/fossil fuels |
| Water | Staying by a site with a source, keeping an appropriately sized water tank in the house |
| Sewer | Composting toilet |
| Food | Either growing own, or if close to development can buy regularly |
| Legality | Questionable at best, highly contingent on locations |
| Accessibility | ● Need to maintain backup of everything<br>● Staying in a place that has internet connectivity or obtain a satellite phone.<br>● live without some modern luxuries |

## 4.2 Residential Buildings

This section is dedicated to understanding what the technical solutions are to develop a sustainable home. Creating a green home starts well before the actual construction begins. First, a profile of where the major energy use with residential housing has to be determined. This is shown in figure 4.2 below. Space heating and cooling account for over 50% of the energy consumed, and this number can be drastically reduced with an energy efficient design that utilizes passive solar. Understanding where and how much energy is being used, solutions can be catered to better meet residential needs.

Having tight and well insulated walls will keep the internal temperature constant, and significantly reduce overall demand. Other measures such as installing solar panels, energy efficient appliances, or LED lighting all will make a difference as well. But above all, these solutions are location specific. To optimize the natural resources of the area factors such as the amount of sunlight, relative humidity, rainfall, temperature, and topography all need to be considered. The following section begins with an overview of Virginia's climate.

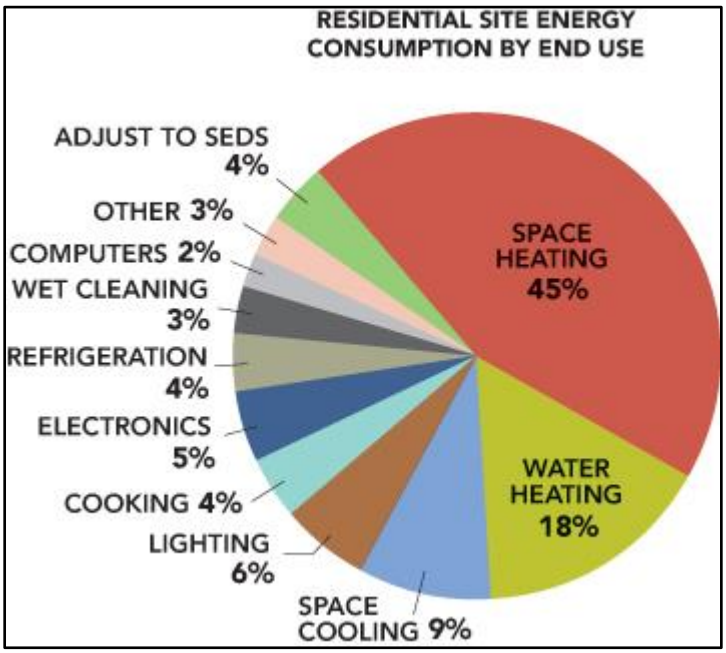


Figure 4.2: Data obtained from the EIA residential energy consumption survey determining the end use of all energy needs in an American home ("Residential End-Use Efficiency", 2017).

## 4.2.1 VA Climate Zones

When designing an ecologically sound building, all of the design measures are relative to the local climate. With the U.S. being highly regionalized, some of the construction planning will need to meet the local demand. The main factors that are included with determining a region's climate include (Climate Zones, 2017):

- Mean temperature (and the variability each season)
    - This is measured in the amount of degree days annually
- Amount of precipitation
- Humidity
- Proximity to coastlines

Virginia Falls under a Mixed-Humid Climate. According to the DOE this is defined as "a region that receives more than 20 in. (50 cm) of annual precipitation, has approximately 5,400 heating degree days (65°F basis) or fewer, and where the average monthly outdoor temperature drops below 45°F (7°C) during the winter months" (Climate Zones, 2017).

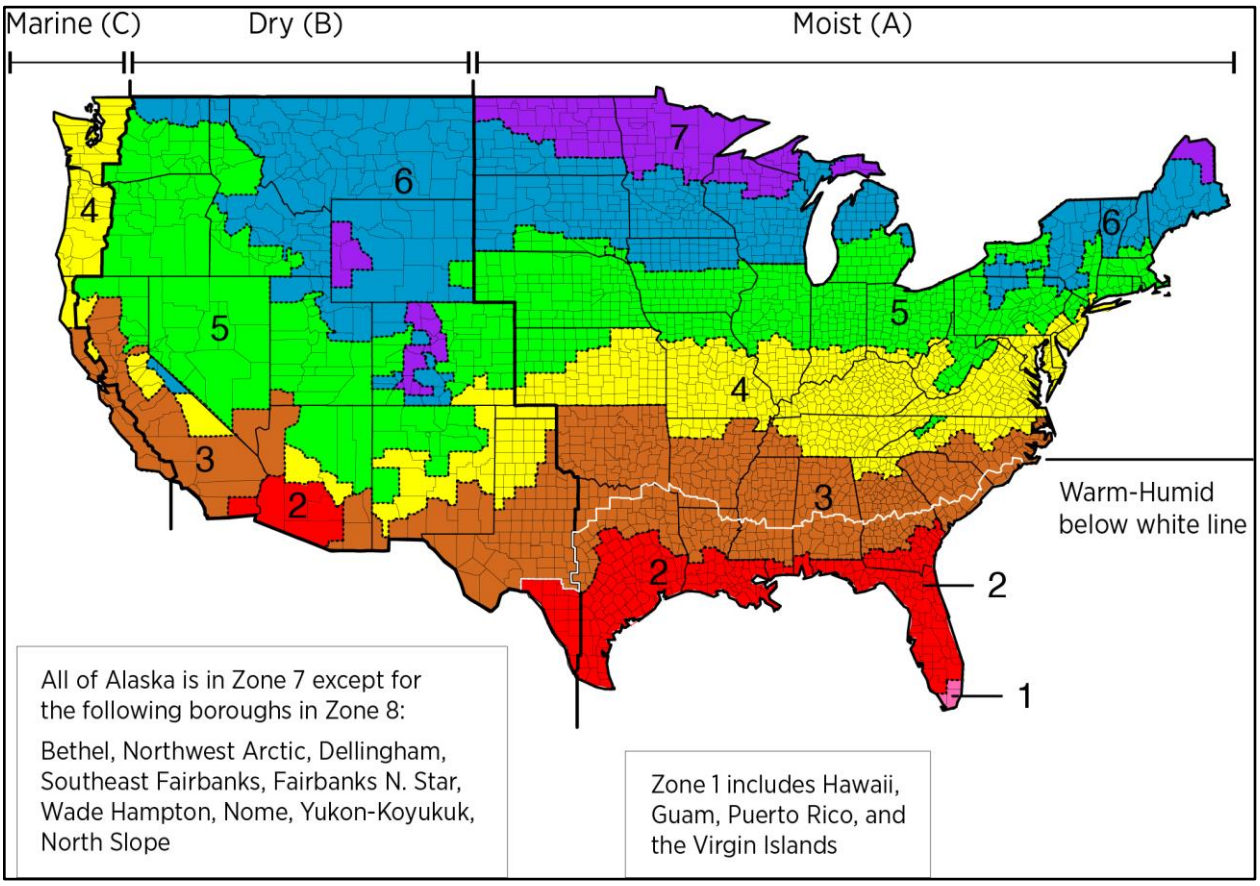


Figure 4.2.1: DOE map showing all of the climate zones within the U.S, each zone has unique climatic features that will require local solutions (IECC, 2012).

## 4.2.2 Energy Efficient Designs

Energy efficiency is the most important part when designing a sustainable home. The first criteria is design. Maximizing the resources that are present on site will reduce loads on the system and will require less input, thus reducing the overall environmental impact.

This section starts with the design, exploring passive solar principles. Then discusses some of the natural ways to retain the solar energy through geothermal and thermal mass. As for the walls, it will matter greatly what they are comprised of considering all materials have different insulating values and embodied energy. The wall's construction can reduce the amount of lumber needed in construction. Efficient energy appliances and generating electricity from renewable sources can cut down or even eliminate monthly utility bills. The last topic explored in depth is maintaining indoor air quality. Building a tight house has the downside of keeping stagnant air inside, and therefore systems need to be implemented to circulate the air and create a healthy internal environment.

### 4.2.1.1 Passive Solar Design

A passive solar home collects heat as the sun shines through south-facing windows and retains that heat within the home's thermal mass (Orientation / South Facing Windows). The solar fraction, or amount of heating load supplemented by passive solar, depends on the area of glazing and the amount of thermal mass. The ideal ratio of thermal mass area to glazing window area varies by climate (6:1 in Virginia's climate) (Thermal Mass). Well-designed homes will provide heating in the winter and cooling in the summer, when combined with other control technologies.

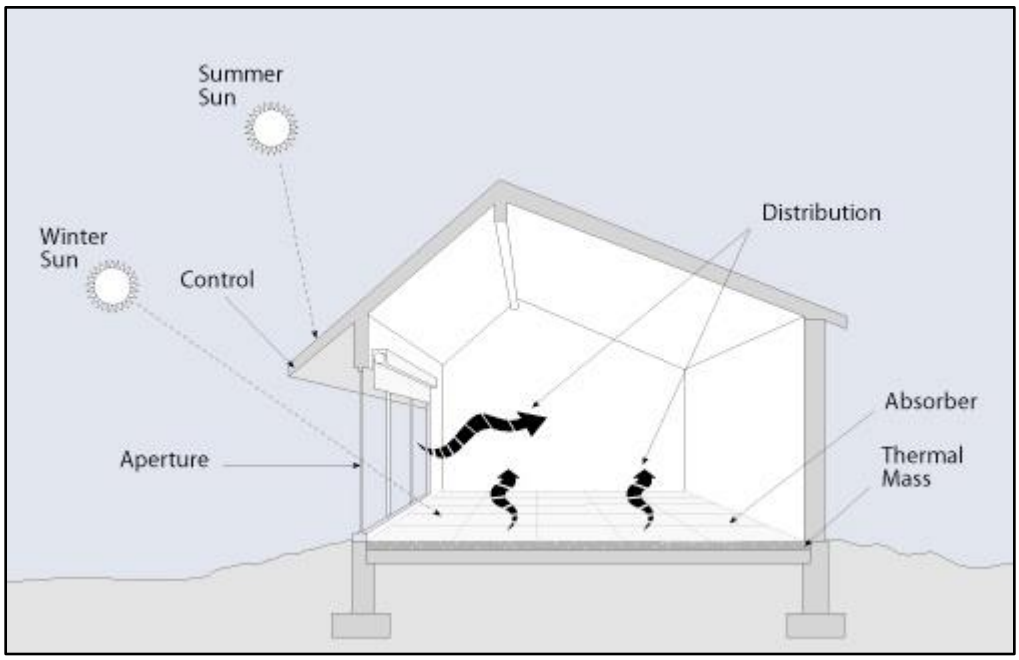


Figure 4.2.1.1 Diagram demonstrating passive the principles of passive solar heating, notably the changing position of the sun, south facing, and thermal mass (Passive Solar Overview).

The following elements below represent the subfeatures of a successful passive solar home (Orientation / South Facing Windows):

- **Properly oriented windows**. Windows should face within 30 degrees of true south. If there are large trees, buildings, or obstructions in the way this will create shading and reduce the effectiveness of the design. Should there be shading, ensure the shadows are not blocking the windows from 9am to 3pm each day. This window of time is the most concentrated amount of direct solar radiation and therefore is critical to effective solar design. During the spring, fall, and cooling season, the windows should be shaded to avoid overheating. The angle of the overhang will be contingent on location, particularly latitude. Some can be electrical and capable of retracting automatically or removed during the winter months (Passive Solar Home Designs).

- **Thermal mass**. Thermal mass, commonly concrete, brick, stone, and tile, absorbs heat from sunlight during the heating season and absorbs heat from warm air in the house during the cooling season. Choosing this material is critical since it will absorb the sun during the day and radiate stored heat to keep the temperature steady at night (Passive Solar Home Designs).

### 4.2.1.2 Geothermal

Called a ground source heat pump, geothermal energy uses the natural properties of the earth as a means of regulating internal air temperature. Depending on latitude, the temperature below ground is constant year round. A geothermal system will use a pump to move air and/or water from the house and bring it to the desired temperature. These systems are highly efficient and reliable, but the downside is they have a long payback period and cannot be retrofitted with existing homes (Geothermal Heat Pumps). The basic principles of this system are explained below in Figure 4.2.1.2.

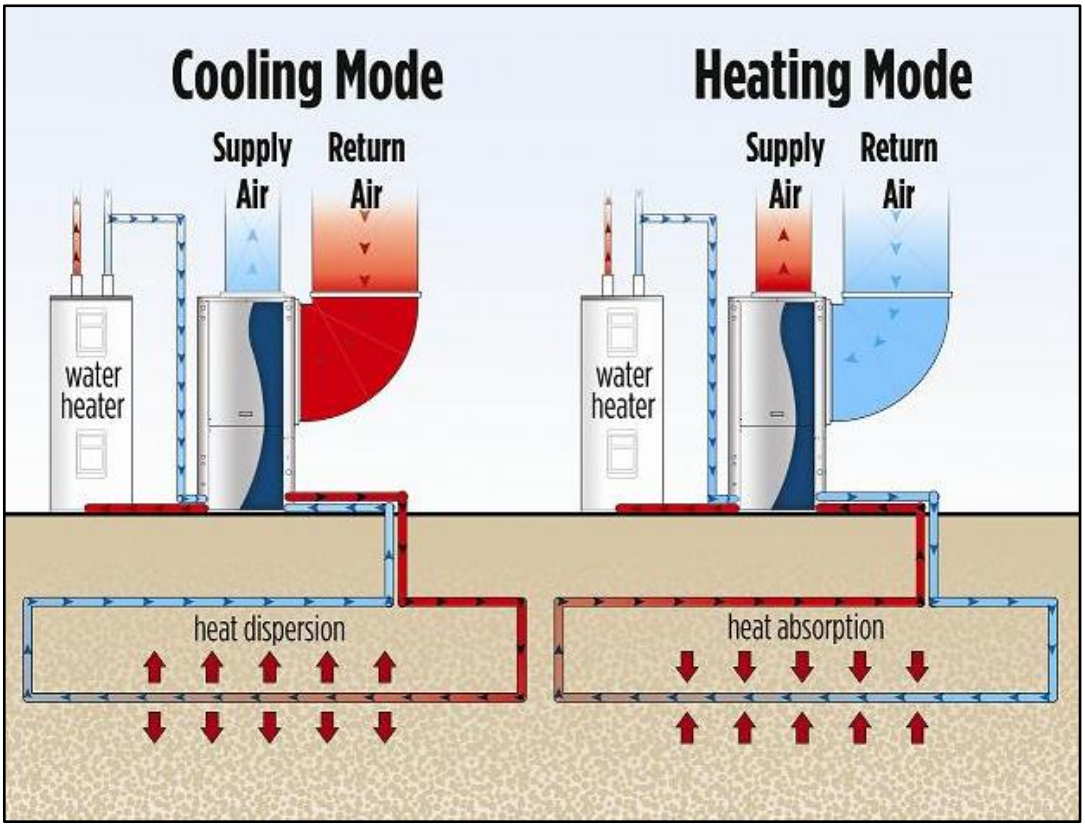


Figure 4.2.1.2: Diagram demonstrates the basic principles of a geothermal heat pump used for hot water heating, this system can also be sued for air circulation (Energy Homes, 2017).

# 4.2.3 Thermal Conservation

### 4.2.3.1 Concrete

For residential buildings, insulated concrete form (ICF) construction can offer operational energy savings of 20% or more compared to code compliant wood-framed buildings in a cold climate. Comparing an ICF that has an insulating value of R-40 or more, to a conventional new code built to ASHRAE 90.2-2007, ICF has been proven to use less energy. For residential buildings, ICF construction can offer operational energy savings of 20% or more compared to code compliant wood-framed buildings (Alter, 2010). However, ICF walls are less cost efficient compared to their premium products, such as structurally insulated panels or any other R-40 wall. In their 2004 study Insulating Concrete Forms Construction Cost Analysis, the Portland Cement Association found that ICF walls cost double what a conventional 2x6 insulated wall cost (Alter, 2010). The table below shows the cost analysis that ICF costs a significant amount more than R-40 walls.

Table 4.2.3 Compares costs of installation ICF wall systems to wood wall systems (Alter, 2010).

| Above Grade Walls | | | | | |
|---|---|---|---|---|---|
| | | 2x4 Wood Wall System[1] | 2x6 Wood Wall System[2] | 4" Flat ICF Wall System[3] | 6" Flat ICF Wall System[4] |
| Labor Hours[5] | (hrs/ft²) | 0.039 | 0.037 | 0.129 | 0.129 |
| Materials | ($/ft²) | 1.28 | 1.59 | 4.11 | 4.56 |
| Installation | ($/ft²) | 1.78 | 1.70 | 1.81 | 1.81 |
| **Total Cost[6]** | ($/ft²) | **3.06** | **3.29** | **5.92** | **6.37** |

While ICF does provide solid insulation, it still has a large environmental drawback in its manufacturing stage. The kilning industry is one of the primary producers of carbon dioxide ($CO_2$), a major greenhouse gas. The manufacturing process of concrete is very $CO_2$ intensive, taking away from some of its environmental stewardship in insulation.

### 4.2.3.2 Spray Foam

With foamed-in-place insulation, it is relatively easy (though not inexpensive) to fill wall and ceiling cavities completely. Closed-cell spray foam provides a higher R-value per inch (6.5) than less expensive insulation types like cellulose and fiberglass (3.5 to 3.7) (Green Building Advisor, 2017). Most spray polyurethane foam is called "two-component" foam. Two ingredients—conventionally called “A” and “B” components—are mixed on site using special equipment mounted in a trailer or truck. Heated hoses convey the components to a mixing gun that sprays the chemicals on the surfaces to be insulated. From there a chemical reaction begins as soon as they’re mixed. The liquid mixture foams, expands, and eventually hardens (Green Building Advisor, 2017).

Spray foam is available in two different types: open-cell spray foam which is usually $0.44 to $0.65 per board foot and closed-cell spray foam which is about $1.00 to $1.50 per board foot. The average cost to have spray foam professionally installed is about $1,905. The average price to cover 200 square feet with a foam insulation kit will run between $300 and $600 (about two to three kits). Inside these kits is something called Icynene, a foam made from two liquids that are heated and pushed through a gun on the can. When Icynene is released, it expands up to 100 times its size as it hits the surface area you are covering. These can contain many gasses, making its installation a dangerous process. Even low-pressure sprayers can be harmful to a homeowners' health (Green Building Advisor, 2017).

#### 4.2.3.2.1 Cellulose

Cellulose Insulation is a low-thermal-conductivity material used to reduce heat loss and gain from a building. It is also a great noise transmission reduction material as it is made of cellular materials (Hendricks, 2017). Additionally, cellulose has a low carbon footprint, with 80% of is being post-consumer recycled newspapers. This will substitute fiberglass insulation which comprises 90% of U.S. homes (Fisette, 2005).

- Dry Cellulose is used in renovation work where you are spraying in material through holes in a wall. This type of insulation will settle over time as gravity pulls it down. To avoid this settling problem, a method called dense-pack is used which requires more than just small holes for installation (Home Advisor, 2017).
- Spray-applied Cellulose is a wet installation that mixes in adhesives during installation. This approach will reduce air movement through the insulation. It forces a drying period for the wall after installation to allow the mixture to dry out. Drywall should not be installed until the material has dried per manufacturer's recommendations (Home Advisor, 2017).
- Stabilized cellulose is often found in flat installations such as attics. It uses water and adhesive in order to reduce settlement and to reduce air movement through the material (Home Advisor, 2017).
- Low-dust Cellulose is the type of insulation used in homes where the occupants may be sensitive to dusts (Home Advisor, 2017).
- Cellulose insulation has a lower thermal performance rating than does spray foams and it is not as airtight. It does provide a higher level of sound insulation than spray foam so it could be used in homes where sound isolation is a priority. Cellulose typically contains between 75-85% recycled paper – often newspaper. It has the lowest embodied energy of any insulation type on the market. The most compelling advantage for this insulation type is that it has thermal storage properties – so it acts similar to a mass wall in storing heat during the day and allowing it out at night (Home Advisor, 2017).

A 19 lb. package of blow-in cellulose, which covers approximately 40 square feet of space at the minimally recommended R-value, is around $28 - $30. So, covering approximately 500 square feet will cost about $375 (Home Advisor, 2017).

#### 4.2.3.2.2 Structural Insulated Panels

Structural Insulated Panels (SIPs), which are pre-cut and set up on site within a couple of days. SIPs reduce thermal transmission by limiting insulation gaps, are straighter and stronger, and have a relatively short payback period of only 2.7 years (Home Advisor, 2017).

### 4.2.3.3 Green Materials and Waste Reduction

#### 4.2.3.3.1 Advanced Framing

This technique helps to minimize weight and materials needed by putting lumber together in very specific ways, making it structurally sound and efficient. Advanced Framing is gaining in popularity but is still a less commonly used method of house framing (Miller, 2015).

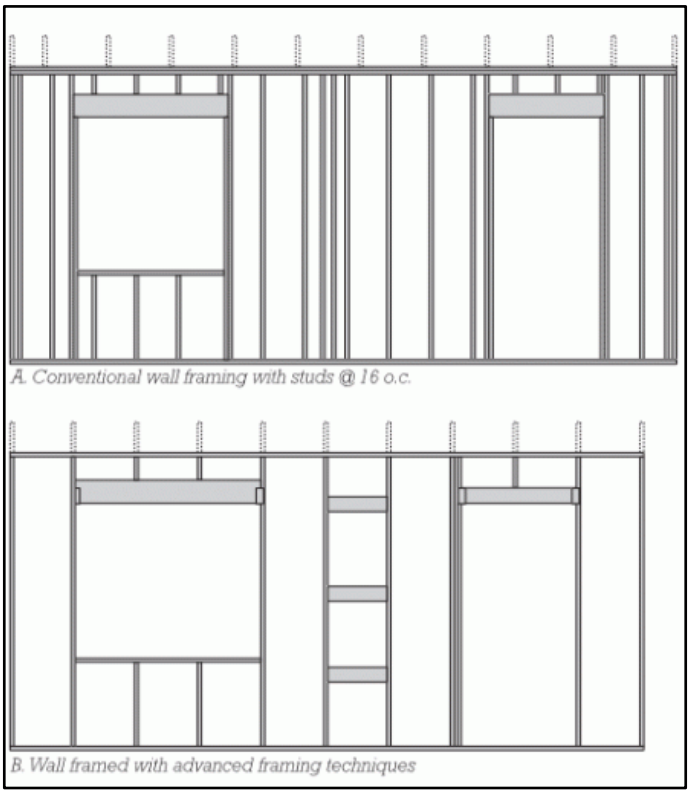


Figure 4.2.3.3.1: Standard framing vs advanced framing (Miller, 2015).

There is noticeably less lumber in advanced framing, reducing the embodied energy. Advanced framing changes how the interior walls are connected to exterior walls. In standard framing you would tie them in with an extra stud so that you get a sturdy connection. However, with advanced framing, you can use ‘ladder framing’ where you can brace with just a few pieces of blocking to attach to. This helps limit thermal bridging in the walls.

#### 4.2.3.3.2 Post and Beam Frame

Similar to post and beam frame, timber frames typically use decorative steel plates to tie members together (Post and Beam, Logangate). A timber framed building uses traditional

joinery, like mortise and tenon, dovetails, and tongue and fork to form the connections. The mortise and tenon joint is used to make the majority of timber framed connections and has been the basis for timber framed projects since the very beginning.

Post and beam construction has a very similar look, especially the joints, but the difference is the connection is made with plates and bolts. Some post and beam projects are done without the plates. For those projects, the connection is made by lag bolting the timber components together (Post and Beam, Logangate).

#### 4.2.3.3.3 Braced Frame

On the other hand, a braced frame uses a centuries old building technique that connects by mortise and tenon joints and secures together with oak pegs. Braced frames are a very common form of construction, being economic to construct and simple to analyze. Economy comes from the inexpensive, nominally pinned connections between beams and columns. Bracing, which provides stability and resists lateral loads, may be from diagonal steel members or, from a concrete 'core' (“Braced Frames”).

### 4.2.3.4 Electricity Use

#### 4.2.3.4.1 Kill Switches

Kill switches stop power from flowing to specific switches, eliminating so-called "phantom loads" and reducing "electrical smog". An entire kill button switch cost anywhere from $7-12 and are easily installed in homes (The Daedalus Project, 2016).

#### 4.2.3.4.2 Solar PV

In the simplest form, solar energy is capturing radiation from the sun and converting this into electricity, demonstrated in Figure 4.2.3.4.2 below. The energy captured is DC, direct current, but to be compatible with many of the appliances of the day it will have to be inverted to AC, alternating current. This energy is used for residential consumption during the day, with all of the excess being sent back to the grid through net metering. Essentially, the grid acts as a battery for the energy and homeowners get energy credits to be used at night or during the winter (Energy Sage, 2017).

As it stands today, the cost of solar is comparable to coal or natural gas and with the cost continuing to plummet, economies of scale will drive costs even lower. Delving into the energy market factors would be outside the scope of this project. But there are other reasons for going solar (Energy Sage, 2017):

- Energy independence
- Fixed rate of electricity
- Lower environmental impact
- Taking advantage of solar tax credits
- Improved health for residents
- Make money over the life of the panel

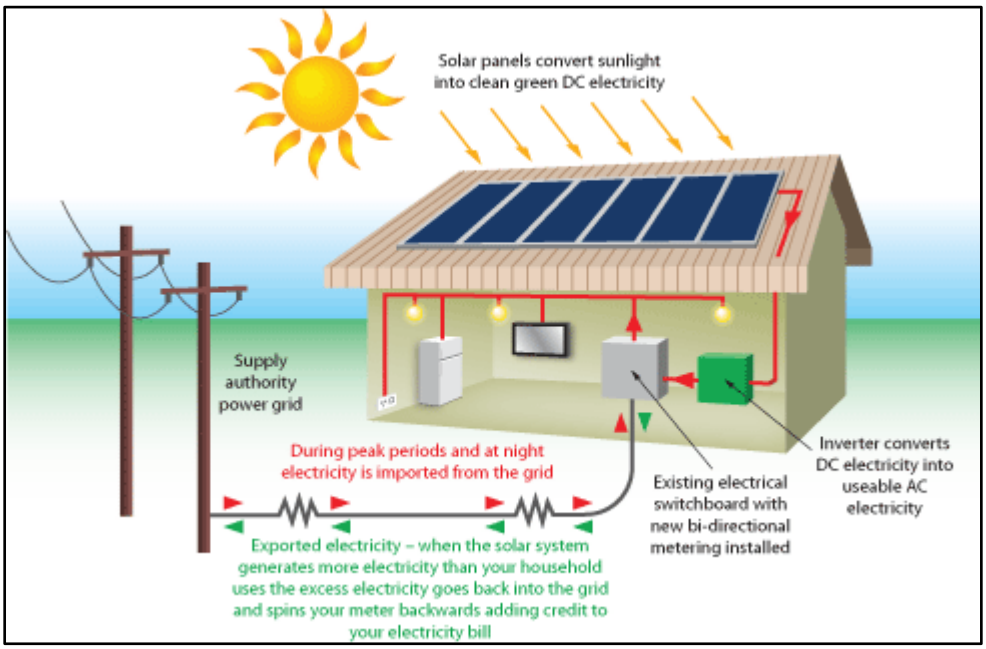


Figure 4.2.3.4.2: Shows how solar panels convert sunlight into electricity (Energy Farm, 2017).

*Net Metering*

Consumers that have solar or wind power on their home or business offset their electricity that they use with the electricity they are producing. If you were to generate more electricity than needed in a billing period then the electric meter turns backwards indicating net excess generation. This is how the electric company tracks your total energy usage. It is also how you take advantage of needed power at night when solar photovoltaic is not producing – you essentially are using the power grid as your battery and paying if you use more than you create (Hendricks, 2017).

### 4.2.3.4.3 Solar Thermal

Solar thermal panels are designed to take advantage of the sun for the purpose of heating hot water. This process is demonstrated in Figure 4.2.3.4.3 below. Water is transmitted through the panels via and pump and stored in a hot water tank until needed. They will adsorb the direct radiation from the sun before being transported back inside and stored in an insulated hot water tank until needed. With 18% of residential energy usage being comprised of hot water heating, utilizing solar thermal technologies can reduce the need by 60%. This will result in significant cost savings and reduce environmental impact (Rexel, 2017).

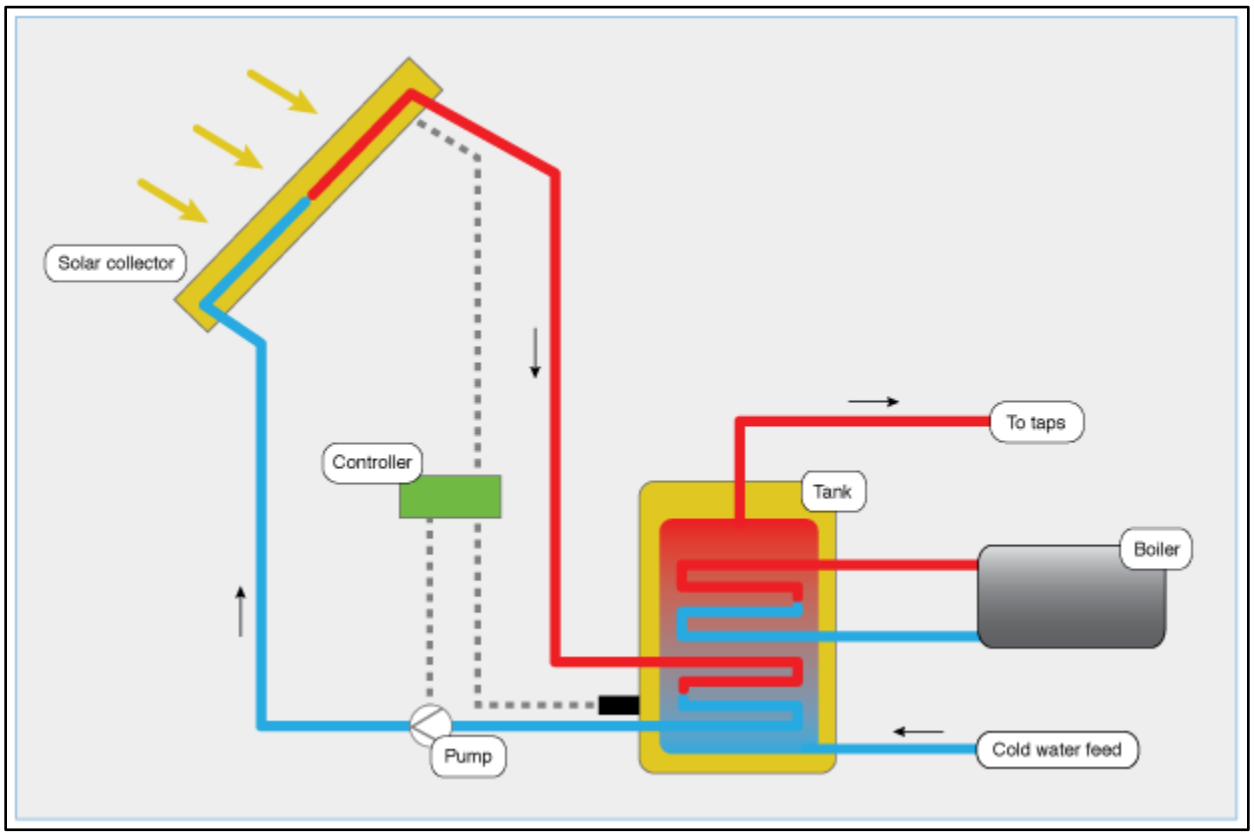


Figure 4.2.3.4.3: This diagram shows the basic principles of a solar thermal hot water heater (Rexel, 2017).

### 4.2.3.5 Air Ventilation

Indoor air quality is especially important in a tiny house because there is less space for air to circulate. Breathing bad air can lead to a number of health conditions such as allergies, respiratory disorders, headaches, sore throat, lethargy and nausea. Preexisting health conditions can worsen the reaction to polluted indoor air. Additionally, long-term exposure can trigger serious health issues including heart disease and certain cancers (“Why Indoor Quality Matters, 2015).

Certain household appliances and furniture are made with toxic glues, Volatile Organic Compounds (VOC) and other toxic materials making people sick over time. VOCs usually are a result from man-made products including fabrics, dyes, plastics, paint, and carpet fibers. Once installed VOC's off gas, which is releasing chemicals from manufacturing to their local environment. This process can take weeks or longer depending on the material and conditions. Some of the gases released can include carcinogens detrimental to human health. (“Why Indoor Quality Matters, 2015).

#### 4.2.3.5.1 Air Source Heat Pump

Installing a heat pump can make a huge difference in your electricity bill by decreasing the cost of heating and cooling of your home. A heat pump will replace both the furnace and air conditioner/central air unit. Since tiny homes are being considered for the project, the cost of the air source heat pump will be much cheaper because a tiny home will require a smaller unit (Tiny House Blog, 2016). The average costs of a smaller unit are approximately $1500 (Homeadvisor, 2017).

#### 4.2.3.5.2 HVAC System (Heating, Ventilation and Air Conditioning)

A heat pump consists of one or more assemblies and utilizes an indoor conditioning coil, compressor, and refrigerant-to-outdoor air heat exchanger to provide air heating. A heat pump may also provide air cooling, dehumidifying, humidifying circulation, and air cleaning (Energy Star, 2017).

Mini splits wall mount HVAC systems are less obtrusive than window units, while being more energy efficient to operate. Since they are ductless, installation is easier and efficiency is increased. Ducting can account for up to 30% energy loss with a central unit. The zone nature of mini splits makes it easy to heat or cool the area of the house being used. The biggest downside of mini splits is a high initial cost and the fact you are supposed to have a certified HVAC technician do the installation. With a mini split system, you are likely to spend at least $600. Window units with heat can be found on sale for less than $200 (Drew, 2017).

#### 4.2.3.5.3 Heat Recovery Ventilation

A Heat Recovery Ventilation (HRV) is a system that uses the heat in stale exhaust air to preheat incoming fresh air. This reduces the energy required to bring outside air up to ambient room temperature. Typical efficiencies range from 55% to 75%, but some extremely efficient models are rated as high as 93% efficiency. At present, these latter units are significantly more expensive and only available from Europe.  However, when you factor the value of energy savings over the unit’s full life cycle, shipping these costly units across the ocean can still make it a financially and ecologically sound investment (Boyer, 2015).

#### 4.2.3.5.4 Energy Recovery Ventilator

An Energy Recovery Ventilator (ERV) is the system used for energy recovery by exchanging the energy contained in air exhausted from the building and using it to treat (pre-conditioned) the incoming outdoor ventilation air in residential and commercial HVAC systems. During the warmer months, the system dehumidifies and pre-cools while humidifying and preheating in the cooler months. However, an ERV is not a dehumidifier. The ERV brings in less humidity than an HRV, but doesn't dehumidify. If you want to ventilate and dehumidify at the same time, you need some type of supplemental dehumidification, such as a ventilating dehumidifier. That's one way to deal with the higher ventilation rates of ASHRAE 62.2-2013 in airtight, low-load homes in humid climates (Bailes, 2014).

The benefits of using energy recovery is the ability to meet the ASHRAE ventilation and energy standards, while improving indoor air quality and reducing total HVAC equipment capacity. It does not make your home more energy-efficient, it is used with a focus on comfort and indoor air-quality. A typical ERV system can cost $800 for an average efficiency system and up to $1100 for a high efficiency system (Hendricks, 2017).

#### 4.2.3.5.5 Manually Operated Windows

Opening a window has zero energy input with no energy required, which is the most energy efficient air ventilation model there is.

# 5 Harrisonburg Zoning

Zoning is one of the most important functions of a local government. This is where all the standards are set to determine the best applications for local land use. Municipalities have the responsibility of establishing areas designed to maintain the essence of a location, while still making it viable for the future. These goals can vary greatly if a county is trying to attract businesses and develop economically, increase tourism, or develop a sense of place for the residents (Kamptner, 2016).

Unfortunately, within the tiny house community, this has been one of the largest hurdles to gaining legal residency. This stems from the ways that the laws are written, in that they are highly inflexible when classifying what constitutes a ‘home’. These classifications are listed below, along with the zones where tiny houses can be applied.

## 5.1 Residential Zoning Classifications

The residential zoning classifications explain the minimum and maximum area and dimensional regulations for single family and duplex residences (Municode, 2014).

Table 5.1.1: Article I. R-1 Residential District under Sec. 10-3-35. - Area and dimensional regulations. (Municode, 2014).

| MINIMUM FEET | | | | | MAXIMUM | | |
|---|---|---|---|---|---|---|---|
| Lot Area Sq. Ft. | Lot Width | Lot Depth | Front Yard | Side Yard | Rear Yard | Stories | Height Feet |
| Single-family: 10,000 | 80 | 100 | 30 | 10 | 25 | 3 | 35 |

Table 5.1.2: Article I. R-2 Residential District under Sec. 10-3-41; area and dimensional regulations (Municode, 2014).

| | MINIMUM FEET | | | | | MAXIMUM | |
|---|---|---|---|---|---|---|---|
| Lot Area Sq. Ft. | Lot Width | Lot Depth | Front Yard | Side Yard | Rear Yard | Stories | Height Feet |
| Single-Family: 7,000 | 60 | 100 | 30 | 10 | 20 | 3 | 35 |
| Duplex: 5,500/Unit | 30/Unit | 100 | 30 | 10 | 25 | 3 | 35 |

Table 5.1.3: ARTICLE K.2. - R-5 HIGH DENSITY RESIDENTIAL DISTRICT. Sec. 10-3-55.5. - Area and dimensional regulations. (Municode, 2014).

| | MINIMUM FEET | | | | | MAXIMUM | |
|---|---|---|---|---|---|---|---|
| Lot Area Sq. Ft. | Lot Width | Lot Depth | Front Yard | Side Yard | Rear Yard | Stories | Height Feet |
| Multifamily: 1,800/unit | 60 | 100 | 10 | 10 | 25 | 4 | 52 |
| Multifamily Quadruplex: 12,000/building, 3,000 sq. ft./unit | 60 ft./4-unit building, 30 ft./individually subdivided lot | 100 | 10 | 10 | 25 | 3 | 40 |
| Townhouse: 2,000/unit | 18 | 112 | 10 | 10 | 25 | 3 | 40 |
| Other uses: 6,000 | 60 | 100 | 10 | 10 | 25 | 3 | 40 |

ARTICLE L.2. - R-7 MEDIUM DENSITY MIXED RESIDENTIAL PLANNED COMMUNITY (Municode, 2014).

- Minimum district size: Two (2) contiguous acres, which may include properties located directly across public or private street or alley rights-of-way from one another.
- Maximum density: Twelve (12) dwelling units per acre.

- Maximum building height: Forty (40) feet (three (3) stories) for all uses except multiple-family dwellings, fifty (50) feet (four (4) stories) for multiple-family dwellings.
- Minimum common open space or park: Fifteen (15) percent of the building.
- Lot area, lot width, lot depth and yards for all uses: requirements as set by the approved master development plan.
- Unless otherwise specified within the master development plan, the provisions of Article T, and the regulations in article CC for wireless telecommunications facilities, shall apply to the R-7 zoning district.
    - Proposed building projects as permitted in this district, which rely on private refuse collection, shall provide a designated point of collection with appropriate facilities. Said facilities shall be screened and shall meet the requirements for accessory buildings per section 10-3-114 (Municode, 2014).

## 5.2 Map of the City Zoning Districts

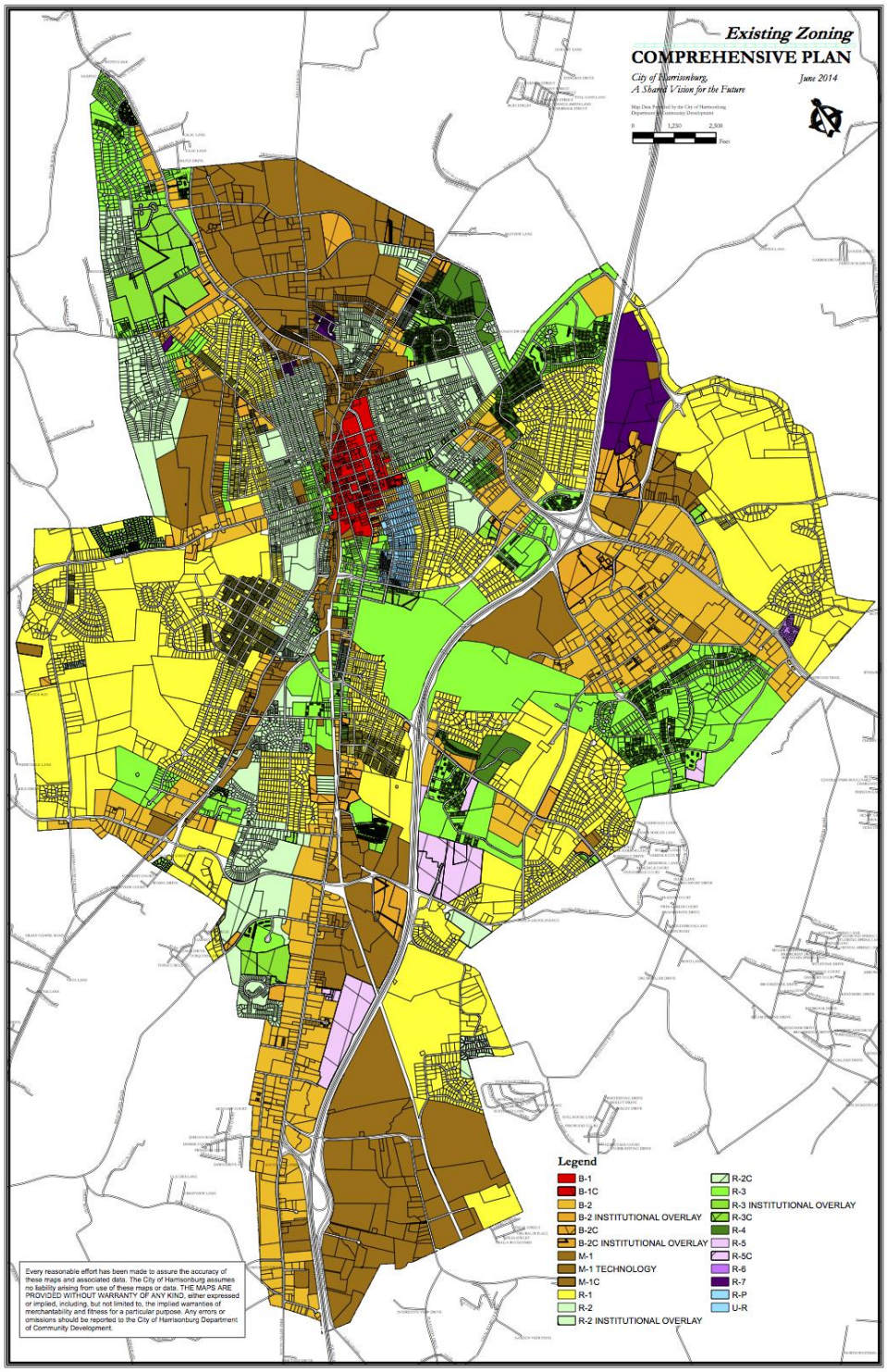


Figure 5.2.1: Map of the existing zoning classifications for the city of Harrisonburg (Lane).

The zoning map below is a rough overlay of where the $700/mo. or less areas where represented on the 2016 AFH estimates, based on Figure 2.1. These are the most important areas to concentrate the affordable housing development efforts. These areas are mainly zoned as residential ordinances.

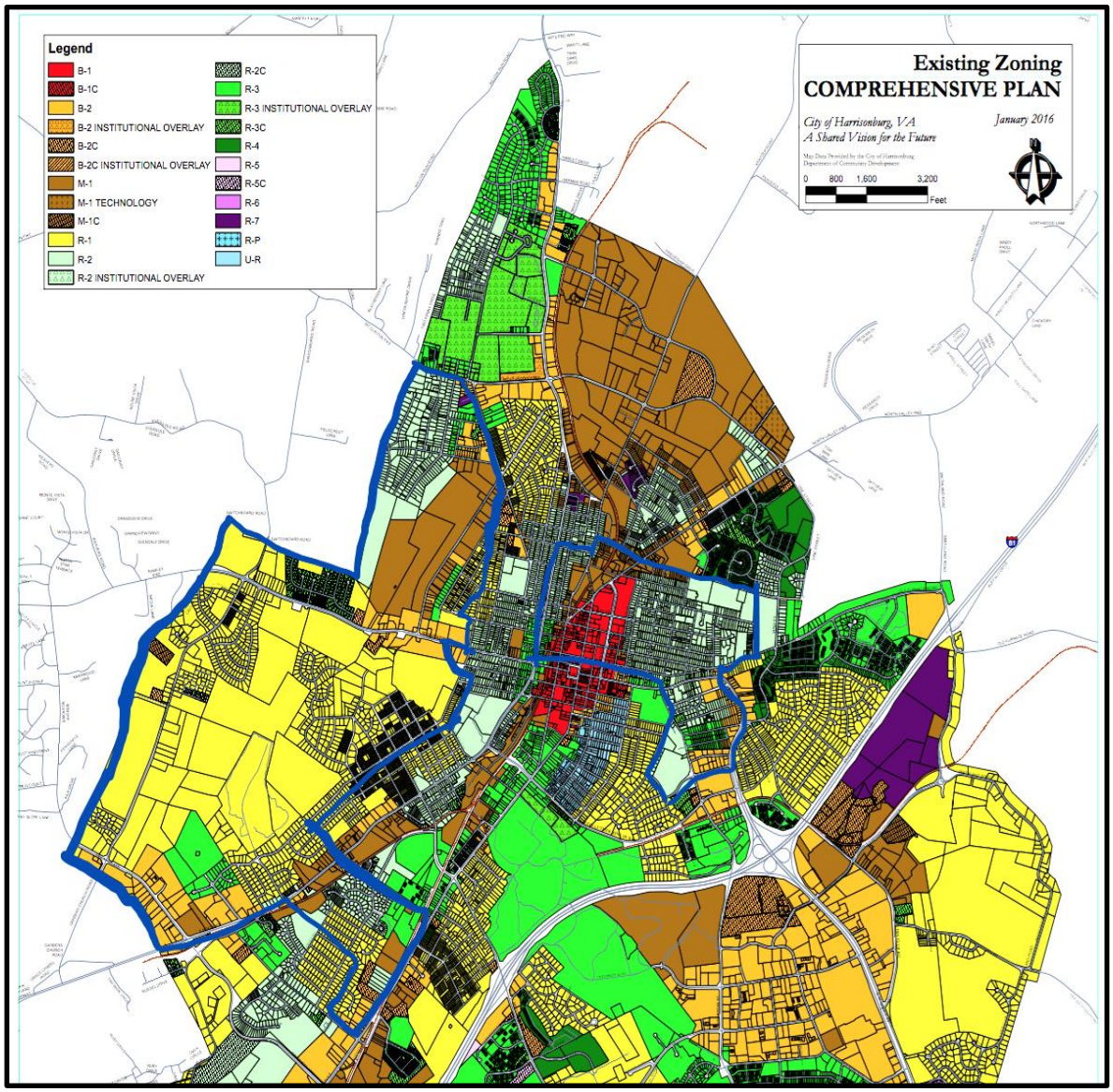


Figure 5.2.2: Harrisonburg zoning map with an overlay of the areas of $700/mo. or less median gross rents from the 2016 AFH estimates.

## 5.3 Zoning Laws in Harrisonburg

Tiny homes on foundations can be built anywhere that is zoned residential for a single-family residence. Within the city of Harrisonburg, there is no minimum size that is required for a residence. All that matter is the house is built up to code, described in section 7, and connected

to the local utilities. This enables great flexibility when looking at prospective sites to build. The biggest challenge will come first from developers who don't typically build tiny homes, their concern is that there is no market for tiny houses. With a major change in demand there will not be a huge change in the overall housing stock.

Tiny homes on wheels (THOW) are far more challenging. Within the city, they are not classified as legal homes, see section 6 for more detail on this, instead they are treated as RVs. This means they are not considered permanent residencies, and cannot be lived in legally full time. If the wheels were removed, the home was built to USBC code, and it was connected to utilities there is a chance for homes on wheels to be accepted in the city (Municode, 2014).

Currently the only places that RVs can legally ‘park’, are within 2 mobile home parks that were grandfathered in. As it stands today, the city will not be issuing any new permits for mobile home parks.

The best option for residents trying to live in THOWs would be to establish an R7 zoning district. These districts are unique in that they do not have any uniform standard to which all the homes need to conform, all the designs are subjected to the master plan. The challenge with getting approval with THOW would require either an overlay or special use permit to allow for these residencies Even then getting the utility hookups may not prove to be cost effective. For these reasons, we do not recommend attempting to live in a THOW within the city.

## 5.4. Applications to Harrisonburg

Harrisonburg is in a unique situation regarding its available affordable housing stock. As of now there is a gap in supply, while demand for affordable housing has increased. The issue has been that many of the affordable housing developments have been in the county, where land is cheaper. Although this does provide housing, the lack of public transportation serves as a barrier for some occupants to maintain stable employment.

Another unique feature is that most of the private investment with the public housing stock has been focused on providing housing options for JMU students as the university expands. Based on the potential market there for student housing, and lack of grants for low income housing tiny houses can fill this gap.

Tiny homes fill a unique need in that they can be built relatively cheaply, and to sizes that will accommodate the need for families to move into affordable housing. The benefit of tiny homes is they are highly scalable. Land can be allocated for a development, and homes can be built as resources are sufficient. Depending on the rental or mortgage structure this can increase homeownership as well. Homeownership will increase the morale of a community, provide accountability to the owners, and all of this while promoting sustainability in home design.

# 6 Tiny Homes on Wheels

## 6.1 Legal Classification

The biggest issue with tiny houses on wheels (THOW) is that they are not considered to be houses. Most tiny house owners today register and classify their homes as recreational vehicles, RVs. This is because they occupy a legal grey area. Due to their size, connectivity, and mobility they do not fit the traditional mold of what constitutes a home.

For policy purposes, the mobility component poses the biggest challenge since an RV cannot be claimed as a permanent residence. Even owning the land cannot prevent this, as an RV is mobile and therefore the homeowner is technically 'camping' on their own property. Typically, there is a 30-day limit on this. Anyone living in one full time can face charges of trespassing, having utilities shut off, or an eviction ("Guidelines", 2017). This makes living full-time in a tiny house on wheels illegal unless the municipality has made several exemptions.

Such exemptions are exemplified in Rockledge, FL where a new zoning classification was created to specifically create a new tiny house community, called a pocket-neighborhood. This is essentially an area in the city that allows for THOW to be legally parked and lived in. Part of the contingency is that they were tied down in the same manner as mobile homes, and that a front and back deck was built around the house. To maintain the permanent nature of the community, only 25% of the developments can be THOW. This was one of the first municipalities to grant legal status to THOW ("Guidelines", 2017).

As it currently stands in Virginia, living full time in an RV is illegal. Currently the definition of a resident in Virginia is "A person who lives in Virginia, or maintains a place of abode here, for more than 183 days during the year, or who is a legal (domiciliary) resident of the Commonwealth is considered a Virginia resident for income tax purposes" (Virginia Tax, 2017). Anyone seeking to live in aTHOW will have to petition the city to change the zoning classifications or create a new development catering to tiny homes, as they have no permanent residency.

## 6.2 Tiny Homes on Wheels Lifestyle Concerns

There is a high degree of variability within the tiny house community when it comes to design and functionality. There are some who choose to construct their homes to go off the electrical grid. In the simplest, form this can be done with well-planned energy efficient construction, solar panels on the roof, having a gas stove/heating element, water tanks with a reliable filling scheme, and a composting or chemical toilet.

However, most homeowners do not go this route, they instead require external hookups. This will mean connecting to the grid for power, and to municipal water and sewer service. These are functionally the same as RVs. Requiring connectivity to operate a tiny house does make it more challenging to find a spot to live that has the necessary accommodations, thus limiting living options (“Guidelines”, 2017).

## 6.3 Tiny House on Wheels Building Codes

The benefit of going through the RV route is that traditional building codes do not apply. If they meet the requirements of the RVIA (Recreational Vehicle Industry Association) they can get the necessary tags to be a legal RV (“Guidelines”, 2017). This is one of the most common reasons that tiny house owners choose to build an RV. Due to the condensed nature of the design most of the spatial dimensions and floor minimums would make the structure too large to meet IRC, international residential code, minimums (“Guidelines”, 2017). Standard building codes for construction are found in the IRC reference guide.

Although there is currently no uniform code exclusively pertaining to tiny homes, most are over engineered to be structurally sound. To drive a house on the highway, everything will need to secure.

## 6.4 Current Legislation with Tiny House Building Codes

On February 6, 2017 Kansas City, MO became the first city in the country to have an official pass a new appendix to the IRC pertaining to tiny houses (“Guidelines”, 2017). This new appendix covers all the definitions, dimensions, and requirements for tiny houses. In addition to this, the International Code Council (ICC) will be adopting the Tiny House appendix to their 2018 IRC (Morrison, 2015).

## 6.5 Trailer Dimensions

According the Virginia DMV, the maximum trailer size is *13.5-feet tall, 8.5-feet wide, and 40-feet long* – 65-feet maximum including the tow vehicle. This dimension is specific for only a truck and trailer combination. Semi-trailers and twin trailers fall under different guidelines (VA DMV Requirements, 2011).

Although the above numbers are maximum dimensions, maxing out is not common in the industry. Since the homes are designed to be moved, a 40ft length is not practical and would exceed the carrying capacity of most trucks. Most tiny homes do not exceed 28 feet in length. There are also some ‘wide load’ exceptions that can be granted for transportation. These would increase the width to 10ft, or even up to 12ft. But anything greater than 11 ft. will require a police escort or someone who has a Virginia Escort Vehicle Certification. Before transportation, the driver will need to complete the Virginia's Escort Vehicle Driver Certification Program. Additionally, they will need to comply with transportation guidelines 24VAC20-81-160 through

24VAC20-81-180 (DMV Hauling Permit, 2011). These cover the times one can transport, precautions the driver must take, and the certification process. Common dimensions are 13.5-feet tall, 8.5-feet wide, and between 16 and 28-feet long (VA DMV Requirements, 2011). This often alleviates the need for transporting wide loads.

In the state of Virginia, the maximum weight of a truck or trailer is determined by the number of axles, the axle rating, and their configuration. For legal purposes, Tiny Houses could weigh 34,000 lbs. with a tandem axle configuration. Since these are designed to be moved coming anywhere close to the 34,000 max would not make for easy transport. This would require massive industrial equipment to move, such as a Road trailer, whereas most Tiny Homes are pulled with a pickup truck (DMV Hauling Permit, 2011). As this is the most common means of transportation, builders will typically construct homes under 10,000lbs. One of the main challenges of this is that most of the tiny homes are built with standard construction materials, thus increasing the weight. This tradeoff is often addressed through material selection and reducing the trailer length.

Figure 6.5.1. Four possible configurations for Tiny House Floor plans that would all still be legal to drive, albeit the one on the far right will require additional permits to move (Tiny House Design, 2016).

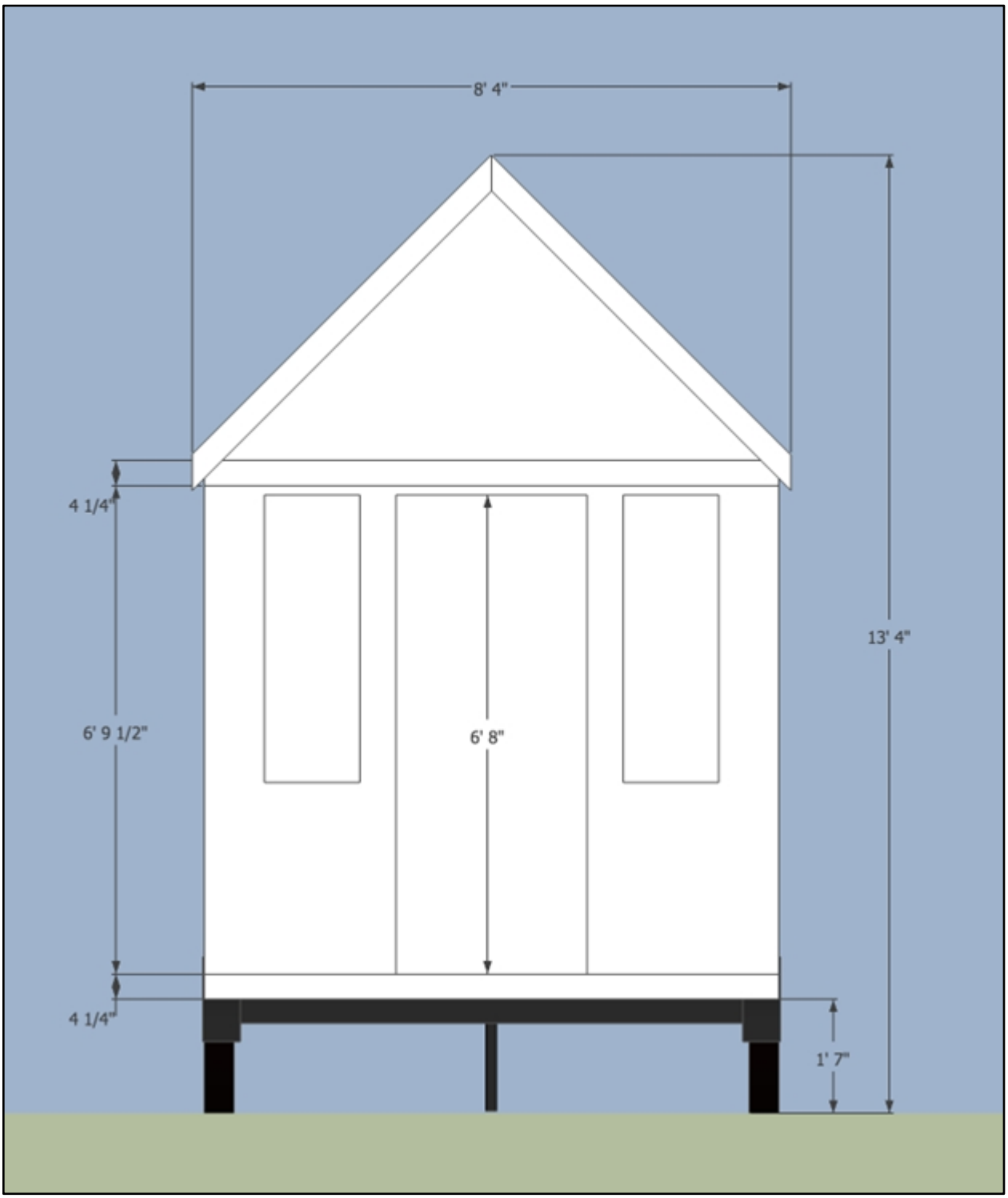


Figure 6.5.2. All dimensions with which one can legally build their home within the 'box' to be compliant with DMV trailer regulations ("Road Limits", 2011).

## 6.6 Where to “Park”

After building a tiny house and getting it properly registered as an RV, the question becomes where can one legally park this? There are a few options, but they vary greatly by local municipality (Nonko, 2016).

### 6.6.1 Accessory Dwelling Units

There are some municipalities that allow for an additional unit on the owner’s property that can be inhabited by another individual. One instance is in Fresno, Ca. They have permitted ADUs for caregivers, or often they can be used for older relatives. After a permanent residence is established on the property, another additional living unit is permitted. This solves the issue of parking, and some homeowners have taken to renting their tiny homes out.

- *See case study for a detailed analysis of Fresno’s ADU law.*

### 6.6.2 RV Parks

These exist in highly localized contexts. For the most part though, they are good options for short terms stays. Often RV parks will have time limits on the duration of stay for the individual. This can range from 30 days to 6 months. In some instances, they may offer full year leases. In Virginia, you cannot camp consecutively for more than 14 days in a 30-day period (Swartz, 2017).

### 6.6.3 Tiny House Communities

Tiny House communities are similar in principle to RV parks, except these places cater exclusively to tiny houses. It’s a community of well-developed tiny homes, having all the necessary communal resources, and at times a larger structure when additional space is needed. These are highly contingent on the local political climate. Several communities currently exist in WA, OR, and CA. Other eco-villages are closer in NC, FL, and TX (Frazier, 2017).

- An eco-village can be defined as a “human-scale, healthy and sustainable development, full-featured settlement, and the harmless integration of human activities into the natural world (Scientific American, 2008)”.

## 6.7 “Don’t Ask, Don’t Tell” Rule

One always has the option to just ignore all the laws on the books. If someone were to acquire a tiny house, designed to be off grid, then they can probably live an uninhibited life. The issue will come when filing for taxes: is a tiny house considered to be ‘property’ or a ‘residence’? If the neighbors don’t file any formal complaints against the tiny house being there, often they will remain undisturbed. However, further legal complications can come up down the road. There

may be issues of insurance; if the house is not legally located and occupied, for instance, will an insurance company cover any losses should they occur?

# 7 Tiny Homes on Foundations

This section will cover all the building codes pertaining to the construction of tiny homes in Virginia. Building codes cover the construction standards builders need to follow to be compliant with local regulations. None of the building codes pertain to zoning regulations. Once land is designated for a specific purpose, these standards determine what can be done with the physical infrastructure.

## 7.1 Current Building Codes in Virginia

As of April 2017, Virginia is operating under the Virginia Uniform State Building Code (USBC). This can also be referred to as the Virginia Construction Code (VCC), a full copy is available for public view through the Virginia Department of Housing and Community Development (DHCD). This is an adoption of the 2012 ICC (international code council) guidelines on all facets of construction. What has been adopted from the 2012 I-codes comprises of (Virginia State Adoptions):

- 2012 International Building Code
- 2012 International Energy Conservation Code
- 2012 International Existing Building Code
- 2012 International Fire Code
- 2012 International Fuel Gas Code
- 2012 International Mechanical Code
- 2012 International Plumbing Code
- 2012 International Property Maintenance Code
- 2012 International Residential Code
- 2012 International Swimming Pool and Space Code

The 2012 USBC was effective statewide on July 14, 2014 (Manner, 2012). Currently, Virginia is expected to update the USBC to reflect the 2015 version of the IBC in March of 2018. However, these code revisions are contingent on the efficiency of Richmond. However, all new construction that is built within a year of the release date can be built under either iteration of the code. In this instance, it will be the adopted version of the 2012 or the 2015 IBC (State Code Status, 2012).

## 7.2 IBC/VCC Building Code Minimum Dimensions

Tiny Homes are the focus of this paper, and the question is to be asked: “what is the smallest possible house that can be built up to code?” The simple answer is 138 square feet under the 2012 IBC or 120 square feet under the VCC (Heben, 2014). This number is strictly in minimum

code compliance with having habitable space, bathroom, kitchen, and bedroom. To theoretically live in this space, some design considerations are to be made.

Under the IBC the bedroom, kitchen, and living space will all be one room. There are setback requirements for the bathroom which set that minimum at 18 square feet. Following the VCC, there are no bathroom requirements meaning all 4 areas can be condensed into a single space. This will require some creative design, but is within one's legal right. Below are the applicable minimum area standards in the 2012 International Residential Code (IRC) for one and two family dwellings (Heben, 2014):

- **R304.1** Every dwelling unit shall have at least one habitable room that shall have not less than 120 square feet of gross floor area*** *(this requirement has been removed in the 2015 IRC- but VA is still under the 2012 version)*
- **R304.2** Other habitable rooms shall have a floor area of not less than 70 square feet (except kitchens)
- **R304.3** Habitable rooms shall not be less than 7 feet in any horizontal dimension (except kitchens)
- **R304.4** Portions of a room with a sloping ceiling measuring less than 5 feet between floor and ceiling shall not be considered as contributing to the minimum required habitable area for that room.
- **R306.1** Requires that every dwelling have a water closet, lavatory, and bathtub or shower (could be as small as 18 sf while still meeting requirements in Section 307)
- **R306.2** Requires that every *dwelling* have a kitchen area with a sink
- There are no requirements stating sleeping area or kitchen must be in separate rooms

This means that the legal limit for a tiny house throughout the U.S. could be as small as 138 square feet (120 sf habitable room at 7' wide + 18 sf bathroom). This does not consider many of the state variations. Even if one maintains the layout of a more traditional house, it could be as small as 260 square feet (bedroom @ 70 sf. + kitchen @ 50 sf + bathroom @ 20 sf + living room @ 120 sf) (Personal Communication with Hendricks, 2017).

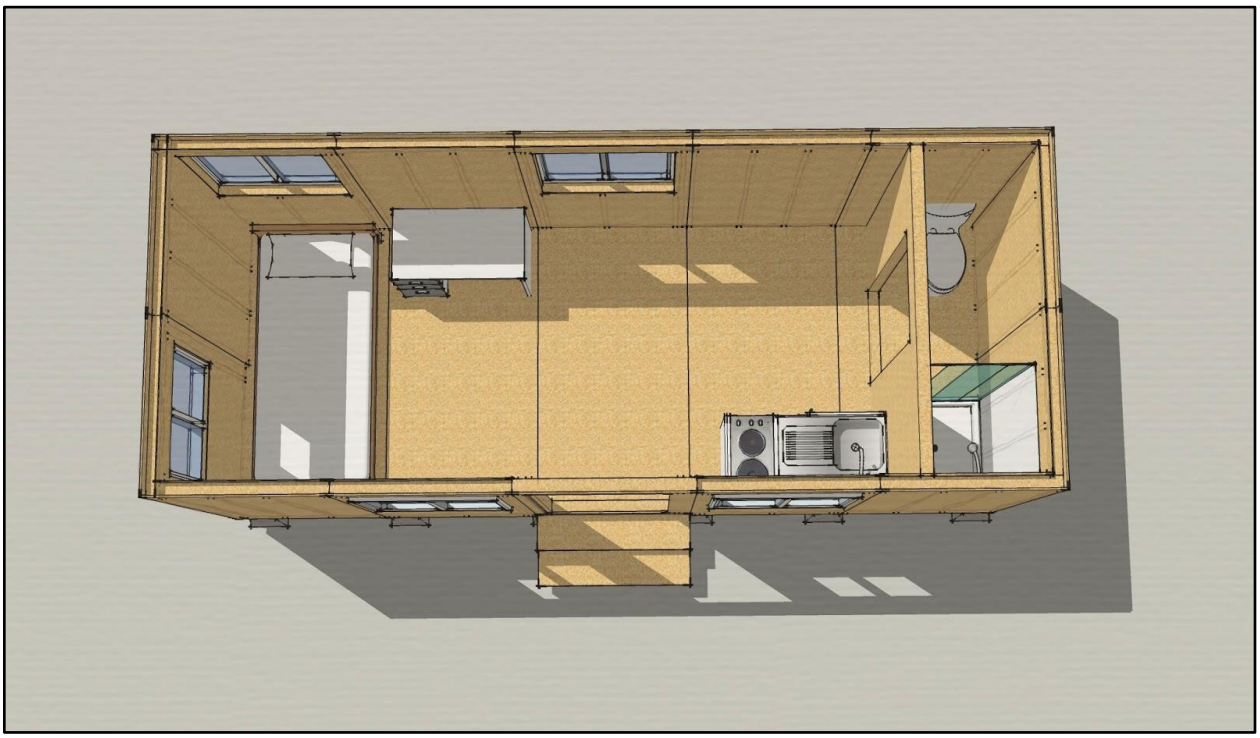

Figure 7.2: This represents an 8’ x 20’ dwelling that would meet the 2012 minimum area requirements for a home that is up to code (Heben, 2014).

## 7.3 Changes to the 2015 IBC

The 120-square foot room requirement has since been eliminated in the 2015 IBC, meaning a dwelling could now be IBC compliant in as small as 88 square feet (70 sf habitable room + 18 sf bathroom). The final documentation surrounding this repeal and the sections eliminated are shown below. Since Virginia has yet to adopt the 2015 version, it is yet to be determined if this amendment will be reflected in the upcoming iteration of the VCC (Meyers, 2015).

**RB106 – 13**
**R304.1, R304.2**

**Proponent:** Thomas Meyers, CBO representing self (Codeconsultant@gmail.com)

**Revise as follows:**

**R304.1 Minimum area.** ~~Every *dwelling* unit shall have at least one habitable room that shall have not less than 120 square feet (11 m2) of gross floor area.~~

**~~R304.2 Other rooms.~~** ~~Other~~ Habitable rooms shall have a floor area of not less than 70 square feet (6.5 m2).

**Exception:** Kitchens.

**Reason:** The code has long provided a minimum room area that was historically accommodated by market expectation. Recently, proponents of minimalist living have advocated living in smaller dwellings to reduce environmental impact and provide for lower living costs through reduced mortgage and maintenance expenses. These dwellings are intended to allow for a minimalist lifestyle that doesn't demand large volumes of living space. Extreme examples of these "minimalist" dwellings may be found by using search engine term "tiny house".

During the past three years, I have attempted to research the basis of the requirement for the minimum room area. There is little, if any, documentation on the life safety benefit of having a certain area provided as a minimum. Logically, there is no real benefit to a minimum area provided that the activities necessary in "dwelling" may be accommodated within the space provided. The code has previously set a minimum of 70sf to perform any "habitable" use. Therefore, that is the value that should be applicable throughout.

Removal of this requirement may provide for a gain in overall life safety. My research indicates that a considerable number of these structures are purposefully built to evade building code oversight. The main reason cited is the minimum area provisions. If the code reduced the minimum area to 70sf, the main objective would be removed.

Consumers make a purposeful and informed decision as to the appropriateness of the housing they choose to live in. It isn't appropriate that the code place arbitrary restrictions that have no demonstrable life-safety benefit.

**Cost Impact:** Proposed change will reduce the cost of construction

Figure 7.3: Copy of the original code changes from the 2012 to 2015 IBC and the reason given for the change in policy (Meyers, 2015).

## 7.4 Energy Efficiency Performance Standards

One segment of the entire ICC code is the IECC, the international energy conservation code. This document outlines all the performance standards necessary for new construction. Although they are used as the guidelines for framing the initial document, the VCBS is the final law of the land. In the case of Virginia, they have changed some of the performance standards in the state and these differences are highlighted in Table 7.4 below (Code, 2009).

Table 7.4.1: Showing minimum energy efficiency performance standards for new construction in Virginia according to the IBC in 2009 (Code, 2009).

| | Windows | | | Insulation | | | | Foundation | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fenestration U-Factor | Skylight U-Factor | Glazed Fenestration SHGC | Ceiling R-Value | Wood Frame Wall R-Value | Mass Wall R-Value | Floor R-Value | Basement Wall R-Value | Slab R-Value and Depth | Crawl Space Wall R-Value |
| Zone 4 | 0.35 | 0.60 | NR | 38 | 13 | 5/10 | 19 | 10/13 | 10, 2 ft | 10/13 |

*NR indicates No Requirement*

Table 7.4.2: Showing the minimum energy efficiency performance standards for new construction in Virginia according to the IBC in 2012 (Code, 2012).

| | Windows | | | Insulation | | | | Foundation | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fenestration U-Factor | Skylight U-Factor | Glazed Fenestration SHGC | Ceiling R-Value | Wood Frame Wall R-Value | Mass Wall R-Value | Floor R-Value | Basement Wall R-Value | Slab R-Value and Depth | Crawl Space Wall R-Value |
| Zone 4 | 0.35 | 0.55 | 0.40 | 49 | 20 or 13 + 5 | 8/13 | 19 | 10/13 | 10, 2 ft | 10/13 |

## Notable VCC and IBC Code Changes

Copying page 102 in the VCC below is the amendment to the energy efficiency section. Here they are outlining some of the roll backs to the efficiency standards in the state. Some of the most notable ones are the minimum level of ceiling insulation and the R- value in the walls. No rationale was given for the change in code, but there is a difference in the overall performance standard between the IBC and VCC.

***Add Section 1301.1.1.1 to the IBC to read:***

**1301.1.1.1 Changes to the IECC.** The following changes shall be made to the IECC:

1. Add Exception 3 to Section C402.4.5.2 to read:

   3. Any grease duct serving a Type I hood installed in accordance with IMC Section 506.3 shall not be required to have a motorized or gravity damper.

2. Change Section C402.4.8 to read:

   **C402.4.8 Recessed lighting.** Recessed luminaires installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. All recessed luminaires shall be IC-rated and labeled as having an air leakage rate or not more 2.0 cfm (0.944 L/s) when tested in accordance with ASTM E 283 at a 1.57 psf (75 Pa) pressure differential. All recessed luminaire lighting, shall comply with Sections C405.6.1 and C405.6.2.

   **Exception:** Where approved because of historical, safety, signage, or emergency considerations.

6. Delete Section R401.3.

7. Change the ceiling *R*-value and wood frame wall *R*-value categories for climate zone "4 except Marine" in Table R402.1.1 to read:

| CEILING *R*-VALUE | WOOD FRAME WALL *R*-VALUE |
|---|---|
| 38 | 15 or 13 + 1[h] |

8. Change the ceiling *U*-factor and frame wall *U*-factor categories for climate zone "4 except Marine" in Table R402.1.3 to read:

| CEILING *U*-FACTOR | FRAME WALL *U*-FACTOR |
|---|---|
| 0.030 | 0.079 |

Figure 7.4.3: Taken from the 2012 VCC under chapter 13 listing the energy efficiency measures. The important note here is the change in R-value in the ceiling and wood frame, along with the U-factor in ceilings and walls (Code, 2012).

## 7.5 Suggested Changes to the USBC

There are a great deal of ways to get around the building codes for tiny house owners. Many of these are highlighted in section 6, but many of them lack permanence. The biggest change has been the addition of the appendix for to the 2018 IBC covering Tiny homes on wheels exclusively. This proposal suggests changes to the existing code, dealing with small homes on foundations.

Section R327, Small Houses (IRC, 2015):

1. Access to the basements, underfloor areas and lofts shall be by means of alternating tread devices, ladders, or any means that complies with Section R311.
2. The minimum floor areas of Section R304 shall not apply.
3. The minimum ceiling height requirements of Section R305 shall not apply.
4. Lofts used as sleeping areas shall not be required to comply with Section R310 provided that the loft opens to a floor containing an emergency escape and rescue opening.
5. Basements and underfloor areas shall not be required to comply with Section R310 provided that the basement or underfloor area does not contain sleeping rooms.
6. The minimum door sizes of Section R311.2 shall not apply.
7. The hallway width requirements of Section R311.6 shall not apply.
8. The guard requirements of Section R312 shall not apply to lofts.
9. The automatic fire sprinkler requirements of Section R313 shall not apply.

# 8 Case Studies

The tiny house movement has garnered a great deal of attention on the national level. Many of the solutions have been creative in how they develop ways to live tiny legally. These range from developing tiny house communities, allowing for tiny houses on individuals' properties, and tiny house hotels to name a few. Below are some of the most prominent case studies where municipalities across the country have addressed tiny homes.

## 8.1 Rockledge, FL

Community development

Rockledge is a small town about an hour north of Orlando, FL. They are currently in the process of developing a tiny house community in the area. They found a plot of land and had that area rezoned as a 'pocket neighborhood'. This gave them special zoning exemptions that permitted the use of tiny homes on wheels as permanent living dwellings.

Within their community, only 25% of the homes can be on wheels, with the majority needing to be built on foundations. Additionally, all houses (wheels too) will need decks on the front and in the back. Below is a more detailed description of what their vision is, some of the city provisions, and their current progress on the development. In the appendix of the document is the text of the ordinance that was passed permitting the development of this tiny house community, under Rockledge, FL (Price, 2015).

Concept

The Rockledge Tiny House Community will be a Pocket Neighborhood. The community will be centered on the idea of sharing resources such as community houses, tools, and a garden among other things. The houses will range from 170 square feet to around 700 square feet and will be arranged around a common green space (Hardee, 2015).

Rent/Own

All properties are for sale. Mortgages, if needed, will be made available through the Rockledge PNC Bank. This is a key provision since most tiny home owners struggle with financing, as banks do not entirely know how to lend out the money for these types of homes.

Foundations/Tiny House on Wheels (THOWs)

The site plan that has been submitted to the City of Rockledge for approval has 12 tiny foundation house lots and 3 THOW lots. Only 25% of the houses can be THOWS per the ordinance.

The 25% THOW provision is to preserve permanence of the community, in the instance all the THOW owners decide to pull up anchor and leave. All houses (including THOWs) are required to have front and back porches. THOW owners would have to build a porch over both the tongue and on the rear of their trailer. The City included this requirement to discourage transient living patterns (Hardee, 2015).

Those things align with our desires of having a sense of permanent living within the community. THOW owners will be required to provide construction documentation, as with standard homes, to the City to ensure the THOW construction meets code.

A mobile home permit from the City is also required, this is needed secure the homes to the ground using tie-downs just like a mobile home.

Homeowners Association (HOA)

The City of Rockledge requires that an HOA be created to maintain the common areas and facilities of interest to the City, such as roads, drainage, access for public safety professionals, and other public services (Hardee, 2015).

## 8.2 Fresno, CA

This is the code from the city website that has permitted tiny houses (on wheels) to be allowed in the city. The provision is that they are specifically treated as “accessory dwelling units” (ADU) (Fresno, 2015). An ADU is traditionally another dwelling such as a backyard cottage. Previous ordinances have been passed allowing for relatives or caretakers to live in homes in the back yard. This one is unique in that it explicitly covers tiny homes on wheels and allows for them to even be used as rental properties.

The major provisions with this ordinance is there must be an existing house on the lot, and the lot needs to be a minimum of 6,000 sq. ft. (5,000 for corner lots) (Fresno, 2015). Other land requirements including setbacks, required amenities, and the standards that the homes need to meet are specified in the Appendix. Building code for trailers specifically are set by the California DMV and follow ANSI 119.2 or 119.5. This legislation came into full effect in Fresno January 3, 2016.

*A full text of the city ordinance can be found in the Appendix under Fresno, CA.*

## 8.3 Spur, TX

Below is the text from the city of Spur, TX and the provisions they enacted to become the first “Tiny House Friendly City in the country”.

“Any tiny house that features wood or metal framing, flush toilets connected to city utilities, and electrical work properly done, is welcome in Spur. All new houses must be set on a foundation that is re-enforced with some rebar and goes at least six inches below ground, (The Texas frostline) (Herrera, 2014).

If you already own a tiny house on wheels that fits the above description and are looking for a permanent home, they are completely legal if the axles are removed and the house is set on a foundation.

A simple permitting process will establish that your house design meets structural safety requirements.

In July of 2014, Spur announced that it was Tiny House friendly. Explicitly this means two things:

1. If you have or want a THOW, you can order it, build it, and park it in Spur, with access to utilities. If pursuing this route, we do require a THOW to be secured to a foundation while in city limits. This is a safety concern as there are occasionally high winds which could otherwise knock your house over, or worse, into someone else’s home and property. If you buy land just outside of city limits, you’re welcome to do as you please.

2. If you've always wanted to build your own custom home – of any size – you are welcome to do it here." (Herrera, 2014).

## 8.4 Walsenburg, CO

In 2014 the city of Walsenburg, CO amended its zoning regulations to allow for houses less than 600 square feet. This change was the result of 3 years of work from a developer looking to build a community in the town to address the need for affordable housing (O'Neil, 2015). The result of this was a city ordinance pertaining strictly to tiny houses. The major provisions included (Eccher, 2016):

- Defining 'tiny houses'; which are between 100 and 500 sq. feet.
- Built on a foundation and connected to local utilities
- follows the 2015 IBC, with several sections waived or modified

# 9 Concluding Proposal

## 9.1 List of Assumptions

This proposal provides a potential building plan for a tiny house in Harrisonburg City. The building will need to be connected to sewage, water, and electric. We propose a 720-square foot home, because of the value per square foot will be affordable, comfortable, and easy to make energy efficient. The home will be large enough to support a single family, with two bedrooms.

This project presents readers with a solution to 'sustainable affordable housing', balancing dimensions of cost, comfort, and sustainability. Using the knowledge of green technologies, building codes, and case studies, we outlined a plan to build a tiny house in Harrisonburg. We are going to make recommendations based on our findings presented in earlier sections of the report to design the most comfortable, affordable, and sustainable tiny home.

## 9.2 House Specifications

- Assuming designing a single-family home (2 bedrooms. Parents + 1 to 2 kids)
- $150 as a cost estimate per square foot. As this home will be built above code, the cost per square foot will above standard construction of a single-family home.
    - In construction as the size of the house decreases, the cost/ sq. foot increases. The reason being kitchen and bath are the most expensive areas and these cannot be excluded. Larger homes drop this cost with larger living space. A room that only has drywall and flooring, at ~$50/sq. ft., will be significantly cheaper than a kitchen loaded with appliances, wiring, and countertops costing upwards of $150/ square foot ("Let's Discuss", 2017).

- Build to code under the 2012 USBC

## 9.3 Proposed Floor Plan

The figure below is a proposed floor plan for our recommended tiny house design. The overall structure will be approximately 720 square feet. This design is optimal with meeting the needs of a single family. This design features a solid north wall that will optimize the passive solar design. Technologies chosen were designed to meet residential energy demands. According to the EIA space heating, water heating, and space cooling comprise two/thirds of residential energy demand.

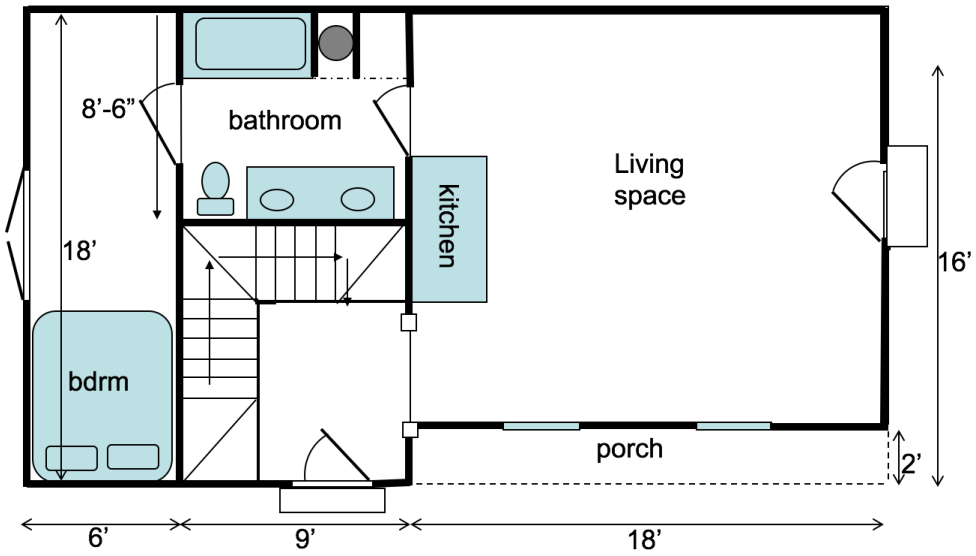


Figure 9.3.1: Bottom floor of proposed floor plan for our approximately 720 sq. ft. house design.

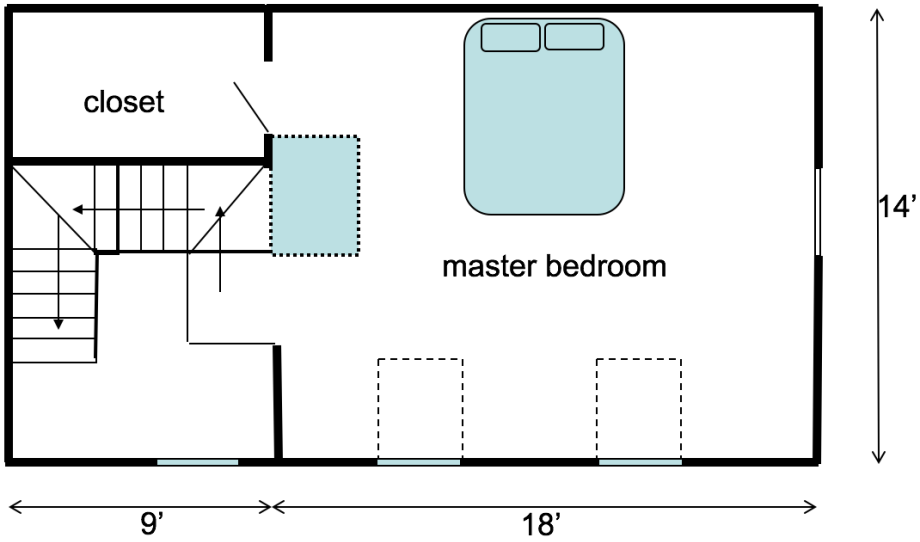


Figure 9.3.2: Top floor of proposed floor plan for our approximately 720 sq. ft. house design.

## 9.4 Roof Materials

For the roof selection, we recommend using a simple asphalt shingle roof design. When comparing the installation and maintenance costs, this was the most economical option. Having PV panels on the top were an influencing factor since the individual will need to get on top of the roof for things such as snow removal. Not all types are appropriate for the Virginia climate. The more expensive options cannot be justified when the end use of these homes is to increase affordable housing stock. All the design criteria are explained in Table 9.

To compliment this, under the roof will be sealed with R-38 spray foam insulation. Even though spray foam is a petroleum based product, this was chosen over cellulose since cellulose will lose its performance value if it gets wet. The choice of roof insulation is often determined by quality of the roof, where spray foam is often used for varying qualities.

Table 9.4: A Comparison of Various Roof Materials Commonly used in construction (Home Style Choices).

| **Material** | **Cost** | **Availability** | **Ease of Installation** | **Durability** | **LCA** | **Comments** |
|---|---|---|---|---|---|---|
| Asphalt shingles | Low | Most common type of roof | Easy to work with, can be done without contractors | Degrade over time due to Sun, more prone to be damaged | Can be recycled | |
| Wood shingle | High | Available, but large variety in terms of the wood | Best to hire contractor | High maintenance cost, weathers easily and prone to fungi/other small insects | Sustainable material; biodegradable after use | Very visually appealing.<br><br>Will be cooler than other materials |
| Metal roofing | Med. | Common and in a wide variety of materials | Requires more specialized installation and sizing | Long lasting, unless in coastal areas | Can be recycled. Some of the best cooling properties | Great for shedding snow and ice |
| Clay tiles | High | Common in the SW, as they best | Need professionals, high | Durable and maintenance free | | great as a reflective surface, air |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | match the climate there | weight and brittleness should be done with care | | | gap can insulate; not compatible with solar panels |
| Slate | Very high | Not too common, mostly used for aesthetic values | Need contractors, not common | Can last indefinitely | Can be reused | Heavier weight, may need reinforcement |

## 9.5 Insulation and Framing

For insulation, we recommend stick frame over post and beam. Using basic 2x4s with cellulose insulation and 2 inches of polyisocyanurate rigid foam on the outside will be most cost efficient while using most efficient materials the rigid spray foam discussed in Section 3 is like some solid spray foam in that it is a petroleum based product, but with a solid R-value (R-13). Combined with the cellulose will provide a higher than needed R-value for the wall insulation (R-22), well over the VA minimum insulation requirement (R-13) (Personal Communication with Hendricks, 2017).

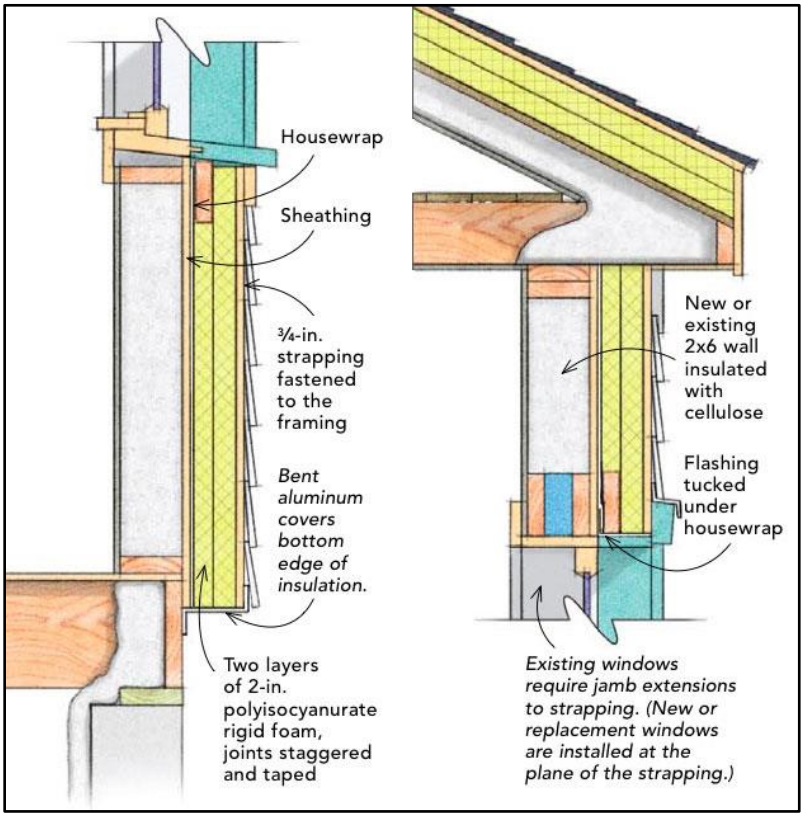

Figure 9.5. This figure demonstrates our proposed wall insulation with cellulose, house wrap, and a 2-inch rigid foam sheathing (Gibson, 2011).

We do not recommend the ICF walls discussed in Section 3 for this proposed structure. ICF walls are beneficial in that they are the Lego like structures, with all the blocks fitting together, with the highest R-value (R-50). A large disadvantage to ICF in tiny houses is that the walls are typically 11in thick, which is taking up significant space in a small home. Another major downside is they are filled with concrete, which has a high embodied energy, also discussed in Section 3.

Post and beam is also not recommended for this proposal. Post and beam is advantageous in reducing wood waste, and limiting the amount of thermal bridging (poorly insulating material allowing an easy pathway for heat flow across a thermal barrier). However, stick frame provides more shear resistance, which is the tendency for a house to move side to side with high wind (Personal Communication with Hendricks, 2017). Some shear resistance is provided by the siding on the house, however stick framing provides much of the shear resistance.

## 9.6 Windows

Windows are one the most important areas of concern with a house when considering energy efficiency measures. Windows are one of the mains sources of heat loss and thermal bridging. Thermal bridging is a gap in insulating material that allows an easy pathway for heat flow across a thermal barrier. To minimize this effect, home builders would not recommend that more than 10% of the overall walls be windows. The difference in R-value of windows versus walls is substantial, and reducing the overall area of the insulating material lowers the energy efficiency of the house. Therefore, selecting the right windows, and installing them properly with surrounding insulation and caulking, is vital to minimizing the movement of heat through the windows (Fibertec).

### 9.6.1 Orientation/Placement

Window orientation is vital to energy efficiency. Using passive solar principles, windows will be placed to allow for the maximum amount of light during the year, minimizing loss proper planning and installation can reduce heating and cooling cost by over 50% (Passive Solar Home Design).

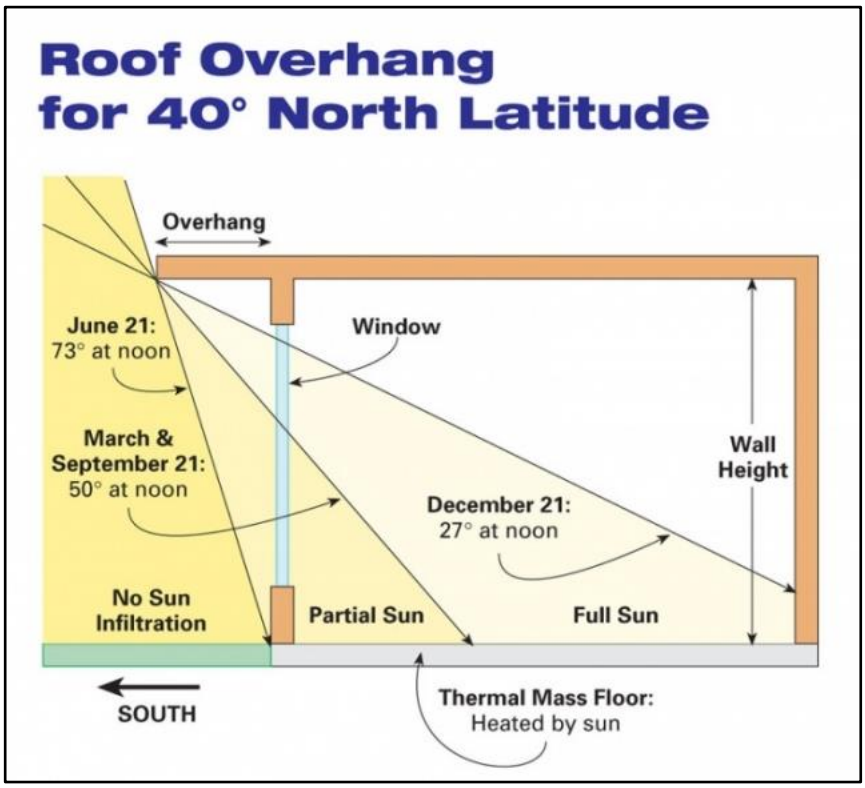


Figure 9.6.1: This is a cross section of a house designed using passive solar design principles. This model was done with 40 North Latitude, in Harrisonburg we are located 38.4 N (Home Power Magazine).

The North side of the house will feature no windows, as there is no potential for solar heating energy at this point. On the East and West side of the house there will be some windows, but this is site contingent. Some of the concerns will be related to the overall layout of the site, such as the best views facing east, and minimal shading from tree cover. Most of the windows will be facing South, this will optimize passive solar heating, and allow for the most amount of natural light to enter the living space. Outside of this space there will be an overhang, this cools the space in the summer and allows light in the winter as the sun is lower in the sky, as seen in the figure above.

## 9.6.2 Recommendation

For our proposal, we would recommend installing a double pane window with argon gas inside. When comparing this option to single and triple pane regarding efficiency, durability, and cost, it was a clear choice. With all the windows, they should be low have a low emissivity. This is a coating on the windows that reflects heat during the summer, and absorbs heat in the winter. It works by distinguishing between the short-wave radiation in the winter, and reflects the long wave infrared in the summer (Extreme Temperatures).

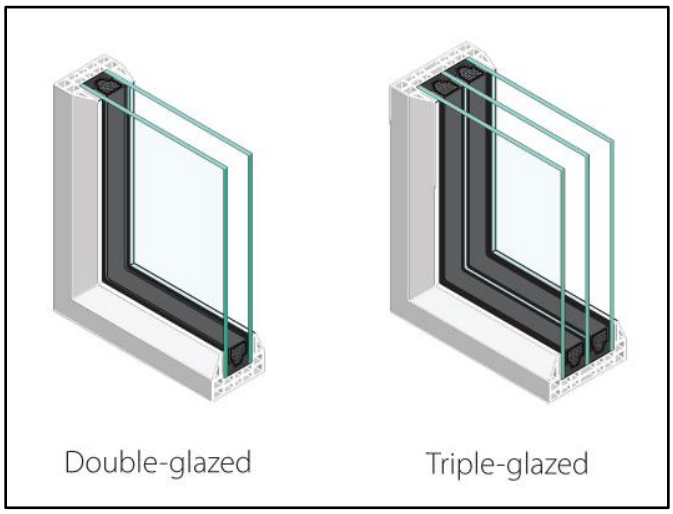


Figure 9.6.2: Showing a cross sections of double and triple pane windows. The difference is in performance with the additional layer of glazing and argon or krypton gas inside (Extreme Temperatures).

Single pane can be eliminated during initial planning since this only has a single layer of glass. This provides very little insulation, and allows for a great deal of heat flow through the year. In climates where there is a steady year-round mild temperature this can be justified since the cost is low. However, in VA this is not a practical solution as the R-value of single pane windows is 1.

Double Pane, as seen in figure 9.6.2, has a second layer of glass along with argon or another gas (such as krypton) trapped inside. This gas or air gap provides some insulating properties in addition to the gas and raises the R-value from 1 to 3 (Extreme Temperatures).

Triple pane windows are the newest addition to the market. They are essentially the same in construction as double pane windows only with an additional layer of glass, and air/gas layer in between. This will raise the R-value to 5, but with a significant rise in cost. The cost increase is not offset by the savings from the heat retained with the better insulation, most notably with the house being powered through solar. Triple pane windows are also heavier and the weight will be considered when designing the walls (Extreme Temperatures).

In some of the northern latitudes, New England and above, this will be more applicable with some of the colder climates. The embodied energy with a triple pane window is higher as well. When considering a window, the location of the manufacturer matters. There is a local supplier in Salem who builds double pane windows. They are also the biggest supplier for triple pane windows to Canada. The transportation cost must be factored in, and makes up a part of the overall life cycle cost when comparing options (Extreme Temperatures). For triple pane windows, consistent construction and ease of installation are critical, but performance is better overall.

For homeowners concerned about the loss in performance, thermal curtains can be installed over a double pane window. Depending on the curtains this will make up for and potentially exceed the performance delta for a fraction of the cost, along with providing the aesthetic of curtains (Acme).

## 9.7 Floor and Crawl Space

Based on the topography of Harrisonburg, the land cover is mainly hillslopes and developed. Most buildings in the area will likely be constructed on a greater than 5% slope. Therefore, most residential buildings will have a sort of basement or crawl space. The depth and the land itself is variable in the area and will dictate if it's viable to have a basement/crawl space.

We recommend an encapsulated crawl space underneath the building. The insulation technique of the floor will consist of a slab, covered with a plastic lining (vapor barrier), and closed cell spray foam insulation (R-10). Ideally, two 3 foot "lowboy" electric water heaters will fit in the crawl space and minimize space used in the home. One hot water heater will provide enough water for kitchen use and the other will be proficient for the bathroom and shower (Personal Communication with Hendricks, 2017).

## 9.8 Hot Water Storage

We are recommending in installing two 40 gallons 'low boy' hot water heaters. The solar panels installed on the roof, and the low cost of electricity make this the most viable option. This will reduce the environmental impact since natural gas, or other fossil fuels, are not needed to heat water for residential use.

Using 2 smaller units instead of a single larger one is due to space and usage. In tiny homes every square foot matters, and therefore fitting a full scale residential hot water storage tank would prove challenging. This could be changed based on the land, but our proposal is to place these in the crawl space or in the basement. Additionally having 2 sources to pull from will have 2 hot water inputs and faster heating time during peak demand (Personal Communication with Hendricks, 2017).

## 9.9 Greywater

Greywater consists of untreated water from bathtubs, showers, bathroom wash basins, washing machines and laundry tubs. Greywater does not include wastewater generated from toilets, kitchen sinks, dishwashers, and laundry water from soiled diapers; this is considered blackwater.
Due to the high variability in black water content, it is hard to determine safe use standards. Under the right circumstances this can be used for irrigation, but it is not regulated.

Grey water can be reused to irrigate and fertilize gardens and provide water for toilet flushing. Utilizing greywater is recycling the water internally from the house and putting it toward other uses. This offers additional protection on the landscape from potential drought, and eases some of the burden or operational expense on local treatment facilities. Overall, reusing greywater can reduce residential water use by 30%, leading to a lower water bill and ecological impact.

### 9.9.1 Laws Governing Greywater Use

Use of rainwater and reuse of greywater (Title 32.1. Health).
A. The Department shall develop by January 1, 1999, guidelines regarding the use of greywater and rainwater. The guidelines shall describe the conditions under which greywater and rainwater may appropriately be used and for what purposes. The guidelines shall include categories of used water, such as types of used household water and used water from businesses, which are appropriate for reuse. The guidelines shall include a definition of gray water that does not include used toilet water.

B. The Department, in conjunction with the Department of Environmental Quality, shall promote the use of rainwater and reuse of greywater as means to reduce freshwater consumption, ease demands on public treatment works and water supply systems, and promote conservation. 1998, c. 155 (Legislative Information System).

## 9.10 Solar System Specification

For our proposed home one of the biggest moves toward sustainability will be the installation of solar panels on the roof, this system as estimated to cover the electrical need of a single-family home using a PV system. Below are all the calculations used to determine the estimated capacity needed, system specifications, and determining a payback period for the panels.

### 9.10.1 Cost of Electricity

The data was published in 2013, and may not be reflective of the cost of energy today. But the number of customers, monthly consumption, and cost of electricity on the state level are calculated. Data for the 2017 RECS has not been published.

Table 9.10.1. This is based on the EIA Residential energy consumption survey (EIA, 2016).

| 2015 Average Monthly Bill - Residential | | | | |
|---|---|---|---|---|
| (Data from forms EIA-861- schedules 4A-D, EIA-861S and EIA-861U) | | | | |
| **State/Region** | **Number of Customers** | **Average Monthly Consumption (kWh)** | **Average Price (cents/kWh)** | **Average Monthly Bill (Dollar and cents)** |
| New England | 6,322,833 | 626 | 19.43 | 121.60 |
| Middle Atlantic | 15,872,487 | 707 | 15.97 | 112.81 |
| East North Central | 19,800,512 | 771 | 12.96 | 99.87 |
| West North Central | 9,283,472 | 912 | 11.47 | 104.61 |
| South Atlantic | 26,787,726 | 1,118 | 11.74 | 131.20 |
| **Virginia** | **3,332,083** | **1,149** | **11.37** | **130.58** |
| East South Central | 8,183,139 | 1,205 | 10.82 | 130.31 |
| West South Central | 15,442,362 | 1,177 | 10.95 | 128.81 |
| Mountain | 9,395,149 | 844 | 11.83 | 99.91 |
| Pacific Contiguous | 18,013,417 | 656 | 14.28 | 93.61 |
| Pacific Noncontiguous | 710,621 | 549 | 25.34 | 139.22 |
| U.S. Total | 129,811,718 | 901 | 12.65 | 114.03 |

## 9.10.2 Energy Calculations

Assumptions

- In Virginia, the average house is consuming 1149 kwh/mo. (EIA RECS, 2009)
- The average size of a home in the south is 2,393 sq. ft. (U.S Census Bureau, 2010)

- Constant cost of electricity at 11.37¢/ kwh over the life of the system (EIA RECS, 2009)
- Calculation based on the sustainable tiny home we are proposing
- Assuming using standard 250W solar panels
- Being connected to the grid, and using net metering

$$\frac{1149\ kwh}{month} \div \frac{2393\ sq\ ft}{home} = \$0.48 kwh/\text{sq ft}$$

$$\frac{\$0.48/kwh}{sq\ ft} * \frac{\$.1137}{kwh} * 800\ sq\ ft = \$43.67$$ (average monthly utility bill)

$$\frac{\$0.48/kwh}{sq\ ft} * 800\ sq\ ft = 384\ kwh/month$$ (capacity to meet monthly energy demands)

Since each solar panel is 250W we recommend installing a 3.75KW system. Since our house design is built above the minimum construction code, the 384 kwh/ month is an overestimate for what is needed. By utilizing technologies such as passive solar heating, high R value insulation, and energy efficient appliances this number can be significantly lowered.

## 9.10.3 Solar Return on Investment

### 9.10.3.1 Installation Cost

Assumptions with installation cost (Fu, 2016)

- Including the 30% federal tax credit
    - 30% of installation costs on residential solar through 2019, 26% in 2020, 22% in 2021, 10% in 2022 (EnergySage,2017)
- Fixed plate collector
- Number based on NREL estimates from Q1 of 2016 (Fu, 2016).

$$3750W * \frac{\$2.93}{Watt} = \$10{,}987.50$$

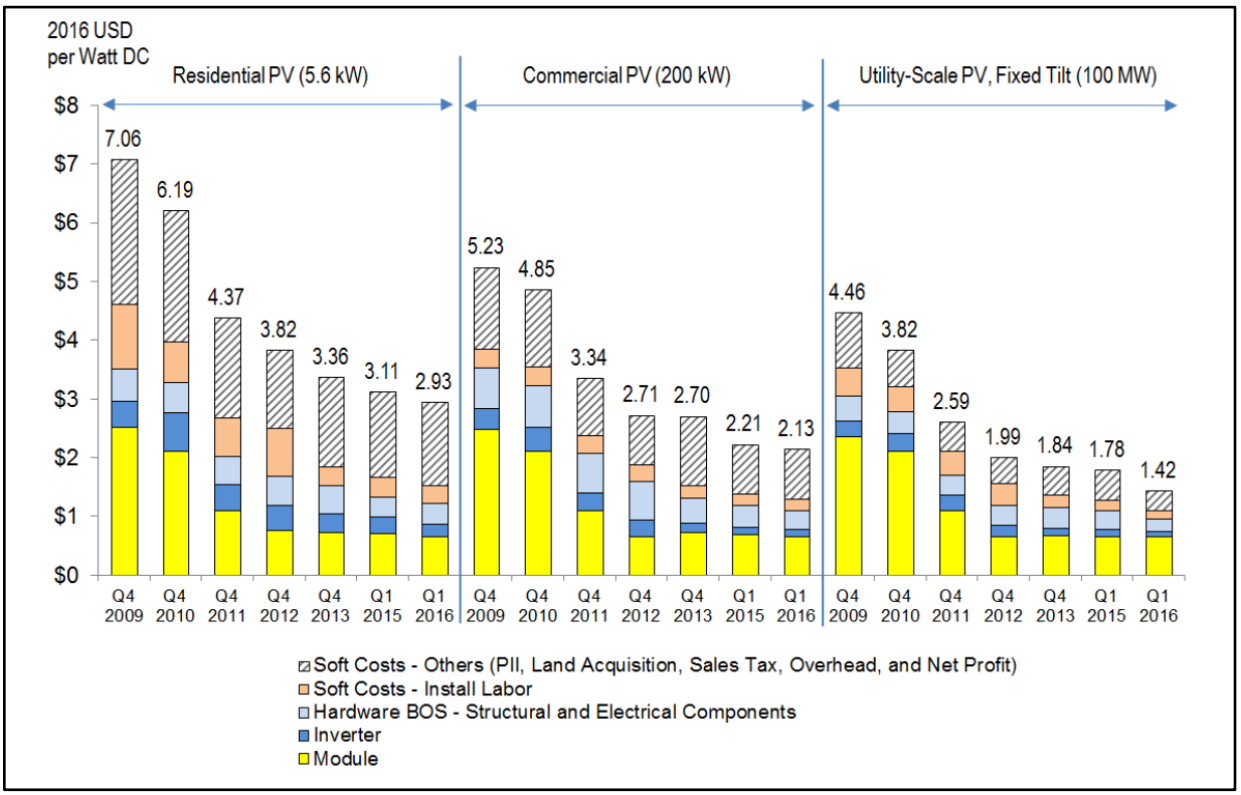


Figure 9.10.3.1: NREL PV system cost benchmark summary (Fu, 2016).

### 9.10.3.2 Simple Payback Period

Calculations for simple payback period were calculated as follows,

$$\$10,987.5\ installation\ cost\ \div\ \$43.67\ monthly\ utility\ bill\ saved\ =\ 261.6\ months$$

$$261.6\ months * \frac{1\ year}{12\ months} = 20.97\ or\ 21\ years$$

After 21 years, all the energy produced by the panel will be solely net profit for the homeowner. The 21 years is based on market rates today, if the trend continues and solar prices keep falling then the payback period will decrease.

### 9.10.3.3 Future Energy Considerations

All the estimates are based on data accrued today (Fu, 2016). Delving into the solar market in depth is beyond the scope of this project, but the trend nationally as seen in Figure 9.10.3.1 is that the prices will continue to drop. These are primarily due to market forces with manufacturers increasing production, international policies promoting renewable energy, and the principles of economies of scale.

The solar price today for a residential system is hovering around $3/watt. In the next 3 to 5 years that number could drop below $2 by some estimates (Four Peaks, 2015), and without government subsidies.

Additionally, the added benefit of installing solar is that the homeowner has a fixed rate of electricity. In Virginia today, homeowners will be paying approximately 8¢/ kwh if they choose to install solar. This is cheaper than the 11.37¢/kwh which is the current market rate. As solar prices continue to drop, this number could go down to 6¢/kwh (Fu, 2016). Fossil fuel based utilities are commodities and their prices are completely subjected to market forces. Installing solar will enable energy independence and enable a constant supply at a known rate.

## 9.11 HVAC

The tiny house proposal needs to meet minimum HUD and Virginia Code requirements. Below is a table showing the minimums for HUD and VA Code.

Table 9.11. Minimums for HUD and VA Code.

| Minimum VA Standards | Minimum HUD Standards |
|---|---|
| 18 SEER (cooling) | 13 SEER |
| 8.6 HSPF (heating) | 8.0 HSPF |

We recommend installing a heat pump, ERV and dehumidifier. This combination is most cost efficient and space efficient for a tiny home. As stated in Section 3, the ERV brings in less humidity than an HRV, but does not dehumidify (Bailes, 2014). A dehumidifier will be necessary to deal with the higher ventilation rates of ASHRAE 62.2-2013 in airtight, low-load homes in humid climates. Therefore, it will be the best option for the combination of HVAC systems.

| Equipment Type | Size Category | Heating Section Type | Minimum Energy Efficiency Criteria |
|---|---|---|---|
| Air-Source Heat Pump | ≥65,000 Btu/h – <135,000 Btu/h | Electric Resistance (or None) | 11.8 EER; 14.1 IEER; 3.4 COP* |
| | | All other | 11.6 EER; 13.9 IEER; 3.4 COP* |
| Air-Source Heat Pump | ≥135,000 Btu/h – <240,000 Btu/h | Electric Resistance (or None) | 10.9 EER; 13.5 IEER; 3.3 COP* |
| | | All other | 10.7 EER; 13.3 IEER; 3.3 COP* |

Table 9.11: Energy Star Ratings comparing the minimum requirements of an air source heat pump as a function of capacity (Bailes, 2014).

We did not recommend mini wall splits, which are most efficient with slab foundation, because the cost is too high. The future is bright for the mini wall splits, and as they become more popular in smaller homes for their high efficiency and taking up less space, they will become a more affordable option (Personal Communication, 2017).

## 9.12 Concluding Remarks

Cities benefit from tiny house ordinances. With significant need for affordable housing, cities are under pressure to find solutions that quickly expand their low-income housing stock without burdening an already burdened system. Tiny houses enable more people to become homeowners and contribute to their communities, while higher rates of homeownership improve neighborhoods and community morale. Tiny houses are a practical and effective solution for many homebuyers because of reduced costs, reduced environmental impact, and the simplified lifestyle.

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# Appendix

**Harrisonburg Legal Definitions Pertinent to Residential Living**

**Accessory structure**. A subordinate structure incidental to and located upon the same lot occupied by the primary structure or use. This includes prefabricated buildings, whether located on permanent foundations or not.

**Dwelling*:*** A building or portion thereof which is designed or used exclusively for residential purposes.

**Dwelling, accessory**. A complete, detached dwelling unit located on the same parcel as a primary single family detached dwelling. Dwelling, accessory apartment. A complete dwelling unit that is accessory to a commercial or office use.

**Dwelling, duplex**. Two (2) dwelling units constructed as side-by-side units or upper and lower units. Each dwelling unit shall be occupied by one (1) family.
Dwelling, farm-worker. A dwelling unit designed for and occupied exclusively by a person and/or his family solely or mainly working for the farming operation, which may include a farm worker who has retired from the farm on which the farmworker dwelling is located, the widow or widower of such a person, and any resident dependents. This dwelling may include a manufactured home.

**Dwelling, in-house security service**. A dwelling unit on the site of an industrial use used solely for housing an individual (and family) who provides twenty-four (24)-hour on-site security. The dwelling may be located within an industrial structure or it may be a stand-alone dwelling.

**Dwelling, manufactured home**. A structure subject to the U.S. Department of Housing and Urban Development (HUD) regulation, which is transportable in one (1) or more sections; is eight (8) body feet or more in width, and forty (40) body feet or more in length in the traveling mode, or is three hundred twenty (320) or more square feet when erected on site, is built on a permanent chassis; is designed to be used as a single-family dwelling, with or without a permanent foundation, when connected to the required utilities; and includes the plumbing, heating, air-conditioning, and electrical systems contained in the structure. This definition shall exclude on-frame modular dwellings, industrialized buildings, mobile units, mobile offices, mobile classrooms, recreational vehicles, and camping trailers.
**Dwelling, rowhouse**. A dwelling unit for a single family, on its own lot, separated from adjoining units by a vertical wall with no openings; and having separate, direct access to the outside. Also known as townhouse.

**Dwelling, single-family detached**. A dwelling unit designed for and occupied exclusively by one (1) family, including a modular dwelling on a permanent foundation, but not including a manufactured home. Permanent foundation is defined herein.

**Dwelling unit**. A unit providing complete, independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation

**Family**. A single housekeeping unit comprised of one of the following: (i) one (1) person living alone; (ii) two (2) or more persons related by blood, marriage, or adoption; (iii) as many as five (5) unrelated individuals; or (iv) as defined by the Code of Virginia §15.2-2291, eight (8) or fewer individuals residing together as a family unit in a residential facility, as defined below, with a resident counselor or other staff persons.

**Family, immediate.** For the purpose of this chapter, an immediate family member shall be any person who is a natural or legally defined offspring, stepchild, spouse, parent, grandparent, child, grandchild, or sibling.

**Group home.** More than eight (8) individuals residing together as a family unit in a residential facility, as defined herein, with one or more resident counselors or other staff persons.

**Mixed-use structure**. A structure that includes residential, business, and mercantile uses, or any combination thereof.

**Nonconforming structure, valid**. A structure that complied with all regulations at the time of construction but, as a result of the subsequent amendments to this chapter, does not conform to the requirements of this chapter by reason of height or condition, or by reason of its impingement upon required yard area. Chapter 17. Zoning. Rockingham County, VA 23
**Nonconforming use, valid**. A use that complied with all regulations at the time of establishment but, as a result of the subsequent amendments to this chapter, does not conform to the requirements of this chapter.

**Overlay zoning district**. A district where certain additional requirements are superimposed upon the underlying base zoning district and where the requirements of the underlying base zoning district may or may not be altered.

**Recreational vehicle.** A vehicle which is built on a single chassis, is four hundred (400) square feet or less when measured at the largest horizontal projection, is designed to be self-propelled or permanently towable by a light-duty vehicle, and which is designed not for use as a primary dwelling but as temporary living quarters for recreational camping, travel, or seasonal use.

**Vehicle, inoperable**. Any motor vehicle, trailer or semitrailer, as those vehicles are defined in Virginia Code § 46.2-100, which has one or more of the following characteristics: (i) it is not in operating condition; (ii) it does not display valid license plates if the vehicle is required by State

law to display valid license plates; (iii) it does not display an inspection decal if the vehicle is required by State law to display a valid inspection decal; or (iv) it displays an inspection decal that has been expired for more than sixty (60) days.

**Zero-lot line**. A common lot line on which a wall or a structure may be constructed.

**Zone**. (for the Airport Overlay District) All areas provided for this chapter, generally described in three dimensions by reference to ground elevation, vertical distances from the ground elevation, horizontal distances from the runway centerline and the primary and horizontal surfaces, with the zone floor set at specific vertical limits by the surfaces found in this chapter.

## Rockledge, FL City Ordinance

Below is the text for the city ordinance that permitted the development of the Rockledge Tiny House community in the City. All the provisions and building requirements are explained below:

Tiny house Pocket neighborhood requirements Rockledge, FL.
Ordinance NO. 1680-2015

An ordinance of the city of Rockledge, Brevard County, Florida, amending chapter 7 of the Rockledge Land development regulations to add a section 70.90 providing for tiny houses in pocket neighborhoods as a use within the redevelopment mixed use (RMU) and planned unit development (PUD) districts; declaring that invalidity of any portion hereof shall not affect the remaining portions of this ordinance; providing for the effective date hereof and for other purposes.'

A. A tiny home shall be defined as a principal residential dwelling that has a square footage of between 170 and 1,100.. Tiny Homes are only permitted within the redevelopment mixed use district (RMU) or a planned unit development (PUD) in a Pocket neighborhood setting.
    1. Each dwelling unit shall have a minimum gross floor area of not less than 170 square feet for the first occupant and not less than 100 square feet for each additional occupant.
    2. Required space in sleeping rooms. In every dwelling unit of two or more rooms, every room occupied for sleeping purposes by one occupant shall contain at least 70 square feet of floor space, and every room occupied for sleeping purposes by more than one occupant shall contain at least 50 square feet of floor space for each occupant thereof.
    3. Minimum ceiling height. Every habitable room, foyer, bathroom, hall or corridor shall have a ceiling height of at least seven feet. If any room has a sloping ceiling, the prescribed ceiling height for the room is required in only one-half the

area thereof, but the floor area of that part of any room where the total floor area of the room for the purpose of determining the maximum permissible occupancy thereof.

4. Structure width. The minimum width of a tiny home must be at least 8.5 feet, with a maximum of 20 feet.

B. A tiny house on wheels (THOW), *for the purposes of these Guidelines*, is a structure which is intended as a full time residence or year-round rental property and meets these five conditions:

1. Built on a trailer that is registered with the builder's local DMV.
2. Towable by a bumper hitch, frame-towing hitch, or fifth-wheel connection, cannot move (and was not designed to be moved) under its own power.
3. Is no larger than allowed by applicable state law. (The typical THOW is no more than 8'6" wide, 30' long, and 13'6" high. Larger tiny houses may require a special commercial driver's license and/or special permits when being towed.)
   a. Verify with the DMV that the THOW is with limits of the law.
   b. Roof height is from bottom of tires to the top of the highest exterior point on the house, including any protrusions. The roof height may be taller when stationary, as long as it is collapsible for towing of the THOW. Chimney piping may need to be removed for travel and then reinstalled to meet clearance requirements for use.
   c. Built to the standards of a Florida ASCE structural engineer's approved plans

4. has at least 170 square feet of first floor interior living space.

5. includes <u>basic functional areas</u> that support normal daily routines (such as cooking, sleeping, and toiletry).

6. The following documentation will be required to be submitted for building permit for a THOW in a pocket neighborhood:

   a. Detailed structural plans illustrating the location of studs, joists, rafters, and engineered connectors (hurricane clips, tension ties, etc.). Plans should clearly address how the structure is secured to the trailer, and how the floors, walls, and roof are framed and sheathed. Plans should also include an illustration of a floor, wall and roof section, showing the building members, insulation, vapor barrier, moisture barrier, sheathing, siding and roofing.
   b. Detailed diagram of the electrical plan.
   c. Photographs of the framing, roof, insulation, rough plumbing, and rough electrical.
   d. A statement describing your construction methods along with the names and addresses of any subcontractors you may have hired.

C. A tiny home will be permitted within a planned pocket neighborhood. A pocket neighborhood is defined as meeting the following requirements:

1. A minimum of 4 tiny homes and maximum of 12 tiny homes per pocket neighborhood. Twenty-five percent of these home sites may be for THOW's.

2. Centralized common area. The common open space area shall include usable public spaces such as lawn, gardens, patios, plazas or scenic viewing area. Common tables, chairs and benches are encouraged, with all homes having access to it
    a. Four hundred square feet of common open space is required per unit.
    b. Fifty percent of units must have their main entry on the common open space.
    c. All units must be within five feet of each common open space(s). Setbacks cannot be counted towards the common open space calculation.
    d. The principal common open space must be located centrally to the project. Additional common open space can only account for twenty-five percent of the total requirement with trails and pathways connecting the total development. Passive trails are allowed and may count towards the common open space requirement.
    e. Community buildings or clubhouses can be counted towards the common open space calculation.
    f. Tiny Houses must surround the common open space on a minimum of two sides of the green.
    g. Common open space shall be located outside of stormwater/detention ponds, wetlands, streams, lakes, and critical area buffers, and cannot be located on slopes greater than ten percent.

3. All homes must have both front and rear porches.
    a. Porches shall be oriented towards common open space or street and designed to provide a sense of privacy between units. Porch shall be a minimum of (80) eighty square feet and a minimum of (8') eight feet deep on the common open space side of the building. The square footage of the porch may be reduced to (60) sixty square feet (six by ten feet deep) on units less than six hundred total gross square feet.
    b. Secondary entrances facing the parking and sidewalk are required to have a minimum five-by-five-foot porch.

4. Pocket neighborhood communities must be part of a condo or homeowners association to maintain the common areas

5. Lot Requirements.
    a. Area. The minimum lot area per dwelling unit shall be of (1,200) Twelve Hundred square feet. Maximum lot area per dwelling unit shall be (3,000) Three thousand square feet. Maximum lot coverage 40% for structure, porches and drives 30%
    b. Width. Minimum width per lot shall be 18 feet. Maximum width per lot 30 feet.
    c. Depth. Minimum length per lot 50 feet. Maximum length per lot 100 feet

6. Setbacks.
    a. Front setback: shall be twenty feet to be used for front porch and parking.

b. Rear or next to common area the setback shall be five feet for the construction of a rear porch.
c. Side Setbacks: The sum of side setbacks shall be not less than ten feet. If the side setback adjoins public open space, these setback requirements may be reduced by an amount equal to the distance from the property line to the centerline of the open space.
d. A modified setback shall be endorsed upon the approved site plan. No portion of a building or appurtenance shall be constructed as to project into any commonly owned open space. No structure or portion thereof shall be closer than five feet to any structure on an adjacent lot.

7. Maintenance of open space and utilities. Before approval is granted, the applicant shall submit covenants, deeds and homeowners' association bylaws and other documents guaranteeing maintenance and common fee ownership of public open space, community facilities, private roads and drives, and all other commonly owned and operated property. These documents shall be reviewed and accompanied by a certificate from an attorney that they comply with the requirements of this chapter prior to approval. Such documents and conveyances shall be accomplished and be recorded, as applicable, with the county auditor as a condition precedent to the filing of any final plat of the property or division thereof, except that the conveyance of land to a homeowners' association may be recorded simultaneously with the filing of the final plat.
8. Tiny houses on wheels (THOW) in pocket neighborhoods must comply with the following:
a. THOWs must be placed in a designated area in the approved site plan of the pocket neighborhood.
b. All THOWs must be placed adjacent to common open space area.
c. Must meet the tie down and skirting requirements of the Mobile Home requirements of the Land Development Regulations. The Building Official may require additional standards to ensure the porches hide any hitches.

**Fresno, CA ADU Ordinance:**

**SEC. 15-2754. - SECOND DWELLING UNITS, BACKYARD COTTAGES, AND ACCESSORY LIVING QUARTERS.**

A. **Purpose.** The purpose of this section is to:
1. Maintain the character of single-family neighborhoods;
2. Ensure that new units are in harmony with developed neighborhoods; and
3. Allow Second Dwelling Units as an accessory use to Single-Unit Dwellings, consistent with the Government Code (Section 65852.2).

B. **Architectural Compatibility.** If visible from a public street or park, the architectural design, roofing material, exterior materials and colors, roof pitch and style, type of windows, and trim

details of the Second Dwelling Unit, Backyard Cottage, or Accessory Living Quarters shall be substantially the same as and visually compatible with the primary dwelling.

C. **District Standards.** Second Dwelling Units, Backyard Cottages and Accessory Living Quarters may be established on any lot in any residential district where single-unit dwellings are permitted or existing. Only one Second Unit, Backyard Cottage or Accessory Living Quarters may be permitted on any one lot. Minor Deviations and/or Variances to meet the minimum lot sizes are not permitted.

D. **Minimum Lot Sizes.**

1. **Second Dwelling Unit.** 6,200 square feet.
2. **Backyard Cottage.**
    a. Interior Lot Size: 6,000 square feet.
    b. Corner Lot Size: 5,000 square feet.
3. **Accessory Living Quarters.** 5,000 square feet.

E. **Type of Unit.**

1. **Second Dwelling Unit.** May provide separate, independent living quarters for one household. Units may be attached, detached, or located within the living areas of the primary dwelling unit on the lot, subject to the standards of this subsection. Kitchens, including cooking devices are permitted.
2. **Backyard Cottage.** May provide separate, independent living quarters for one household. Units may be attached, detached, or located within the living areas of the primary dwelling unit on the lot, subject to the standards of this subsection. Kitchens, including cooking devices are permitted. Backyard Cottages shall be located behind the primary dwelling unit, unless attached and integral to the primary dwelling unit.
    a. A Tiny House may be considered a Backyard Cottage if it meets all the requirements of this section.
    b. The Director shall review the design of the Tiny House to insure that the structure is compatible with the main home and the neighborhood.
3. **Accessory Living Quarters.** Accessory Living Quarters provide dependent living quarters. They may be attached, detached, or located within the living areas of the primary dwelling unit on the lot, subject to the standards of this subsection. Accessory Living Quarters may not provide kitchen facilities, however a bar sink and an under-counter refrigerator are allowed, but no cooking devices or other food storage facilities are permitted. Accessory Living Quarters shall not be located in front of the primary single-family dwelling.

F. **Maximum Floor Area.** The following are the maximum square footages of habitable area. The following calculations only include habitable floor space. Minor Deviations and/or Variances are not permitted to increase the maximum floor areas.

1. **Second Dwelling Units.** 1,250 square feet.
2. **Backyard Cottages.** 440 square feet.
3. **Accessory Living Quarters.** 500 square feet or 30 percent of the primary single-family dwelling, whichever is less.

G. **Development Standards.** Units shall conform to the height, setbacks, lot coverage and other zoning requirements of the zoning district in which the site is located, the development standards as may be modified per this subsection, other requirements of the zoning ordinance, and other applicable City codes.

H. **Lot Coverage.** Per the underlying zone district.

I. **Setbacks.** Per the underlying zone district.

J. **Building Entrances.** Entrances from an Accessory Living Quarters or a Backyard Cottage shall not be visible from the street, unless the parcel is a corner parcel and the entrance is oriented to the opposite street as the primary residence.

K. **Space Between Buildings.** If detached, there shall be a minimum of six feet from the primary residence, or 10 feet if there is an entry from either one of the units into the space between.

L. **Maximum Building Height.** Thirty feet.

M. **Openings.**

1. For two story buildings, there shall be no openings, such as windows and doors, within 10 feet from an interior side or a common rear property line with another single-family home.
    a. Clerestory windows, six feet from the floor of the interior of the unit, are excepted.

2. The Director may grant a waiver, for detached units that are located 10 feet or less from a side or rear property line on walls facing said property lines if he/she finds that there are no substantial privacy, noise, health, safety, or visual impacts to neighbors associated with the location and siting of the detached unit.

N. **Parking.** Parking shall comply with the following:

**1. General Parking Conditions.**

A. The parking outlined below shall be provided in addition to the required parking for the primary dwelling.

B. Parking for the primary unit shall comply with all development standards of the district. If the primary single-unit dwelling was constructed prior to covered parking requirements, a covered space shall not be required of the existing unit.

C. Required parking for the primary single-family dwelling may not be removed for the creation of any of the three types (e.g., garage conversions), or allocated to meet the parking requirement for the Second Dwelling Unit, unless replacement parking is provided in accordance with this Code.

D. Any rooms having the potential of being a bedroom and meeting the standards of the California Building Code as a sleeping room shall be counted as a bedroom. Offices or other rooms that have the ability of being converted into bedrooms shall also be considered bedrooms for parking purposes.

2. **Second Dwelling Units.**

A. One covered parking space shall be provided for a Second Dwelling Unit with one bedroom.

B. One additional, covered or uncovered, parking space for two or more bedrooms in the second dwelling unit.

C. A tandem parking space may also be used to meet the parking requirement for the Second Dwelling Unit, providing such space will not encumber access to a required parking space for the primary single-unit dwelling.

D. An existing two vehicle garage and/or carport may not be provided in-lieu of these parking requirements unless the parking spaces are accessed from different garage doors.

3. **Backyard Cottage.** No additional parking required.

4. **Accessory Living Quarters.** No additional parking required.

O. **Access.** Vehicular access shall be provided in the following manner:

1.**Driveways.** Shall be provided per the underlying district.

2. **Pedestrian Access.** An all-weather surface path to the Second Dwelling Unit, Backyard Cottage, or Accessory Living Quarters shall be provided from the street frontage.

P. **Mechanical Equipment.** Mechanical equipment shall be located on the ground or, in the case of a tiny house on wheels, incorporated into the structure, but shall in no case be located on the roof.

Q. **Utility Meters/Addresses.**

1. **Second Dwelling Units.** Separate gas and electric meters may be permitted if approved by the Building Official and Pacific Gas & Electric.

2. **Backyard Cottage and Accessory Living Quarters.** Separate utility meters and/or addresses are not permitted.

R. **Home Occupations.** Home occupations are permitted pursuant to Section 15-2735, Home Occupations.

S. **Airports.** All applications shall comply with operative airports plans.

T. **Owner Occupancy Requirements.** The following shall apply prior to the issuance of a building permit.

1. **Second Dwelling Unit and Backyard Cottage.**

A. Either the primary dwelling unit, the Second Dwelling Unit, or the Backyard Cottage shall be owner-occupied.

B. The property owner shall enter into a restrictive covenant with the City, which shall be recorded against the property.

C. The covenant shall confirm that either the primary dwelling unit, the Second Dwelling Unit, or the Backyard Cottage shall be owner-occupied and prohibit rental of both units at the same time.

D. It shall further provide that the Second Dwelling Unit or Backyard Cottage shall not be sold, or title thereto transferred separate and apart from the rest of the property.

2. **Accessory Living Quarters.**

A. The property owner shall enter into a restrictive covenant with the City, which shall be recorded against the property.

B. The restrictive covenant shall prohibit rental of both units at the same time.

C. It shall further provide that the Accessory Living Quarter shall not be sold, or title thereto transferred separate and apart from the rest of the property. The covenant shall be recorded prior to the issuance of a building permit.

(Added Ord. 2015-39, § 1, eff. 1-9-16; Am. Ord. 2016-32, § 32, eff. 10-21-16).

**IBC Appendix for the legal Definitions of Tiny Homes**

Public Comment RB168-16 MORRISON 1 :

**Proponent : Andrew Morrison, representing Tiny House Enterprises, LLC (Andrew@TinyHouseBuild.com); Martin Hammer, representing Martin Hammer, architect (mfhammer@pacbell.net); Chris Keefe, representing OrganicForms Design (chris@organicformsdesign.com); Brandon Marshall, representing FOG Studio (brandon@fogprojects.com); Gabriella Morrison, representing Tiny House Enterprises, LLC (Gabriella@TinyHouseBuild.com); James Herndon, representing self (jamesmherndon@gmail.com); Tiffany Redding, representing FOG Studio (tiffany@fogprojects.com); Nabil Taha, representing Precision Structural Engineering, Inc. (bill@structure1.com) requests Approve as Modified by this Public Comment.**

**Replace Proposal as Follows:**

**2015 International Residential Code**

APPENDIX V TINY HOUSES CHAPTER PART AV101— GENERAL

**AV101.1 Scope.** This appendix shall be applicable to tiny houses used as single dwelling units. Tiny houses shall comply with this code except as otherwise stated in this appendix.

**CHAPTER PART AV102— DEFINITIONS**

**AV102.1 General.** The following words and terms shall, for the purposes of this appendix, have the meanings shown herein. Refer to Chapter 2 of this code for general definitions.

**EGRESS ROOF ACCESS WINDOW.** A skylight or roof window designed and installed to satisfy the emergency escape and rescue opening requirements in Section R310.2.

**LANDING PLATFORM.** A landing provided as the top step of a stairway accessing a loft.

**LOFT.** A floor level located more than 30 inches (762 mm) above the main floor and open to it on at least one side with a ceiling height of less than 6 feet 8 inches (2032 mm), used as a living or sleeping space.

**TINY HOUSE.** A dwelling that is 400 square feet (37 m2) or less in floor area excluding lofts.

**CHAPTER PART AV103— CEILING HEIGHT**

**AV103.1 Minimum ceiling height.** Habitable space and hallways in tiny houses shall have a ceiling height of not less than 6 feet 8 inches (2032 mm). Bathrooms, toilet rooms, and kitchens shall have a ceiling height of not less than 6 feet 4 inches (1930 mm). Obstructions shall not extend below these minimum ceiling heights including beams, girders, ducts, lighting and other obstructions.

**Exception:** Ceiling heights in lofts are permitted to be less than 6 feet 8 inches (2032 mm).

**CHAPTER PART AV104— LOFTS**

**AV104.1 Minimum loft area and dimensions.** Lofts used as a sleeping or living space shall meet the minimum area and dimension requirements of Sections AV104.1.1 through AV104.1.3.

**AV104.1.1 Minimum area**. Lofts shall have a floor area of not less than 35 square feet (3.25 m2).

**AV104.1.2 Minimum dimensions.** Lofts shall be not less than 5 feet (1524 mm) in any horizontal dimension.

**AV104.1.3 Height effect on loft area.** Portions of a loft with a sloping ceiling measuring less than 3 feet (914 mm) from the finished floor to the finished ceiling shall not be considered as contributing to the minimum required area for the loft.

**Exception**: Under gable roofs with a minimum slope of 6:12, portions of a loft with a sloping ceiling measuring less than 16 inches (406 mm) from the finished floor to the finished ceiling shall not be considered as contributing to the minimum required area for the loft.

**AV104.2 Loft access.** The access to and primary egress from lofts shall be any type described in Sections AV104.2.1 through AV104.2.4.

**AV104.2.1 Stairways.** Stairways accessing lofts shall comply with this code or with Sections AV104.2.1.1 through AV104.2.1.5.

**AV104.2.1.1 Width.** Stairways accessing a loft shall not be less than 17 inches (432 mm) in clear width at or above the handrail. The minimum width below the handrail shall be not less than 20 inches (508 mm).

**AV104.2.1.2 Headroom.** The headroom in stairways accessing a loft shall be not less than 6 feet 2 inches (1880 mm), as measured vertically, from a sloped line connecting the tread or landing platform nosings in the middle of their width.

**AV104.2.1.3 Treads and risers.** Risers for stairs accessing a loft shall be not less than 7 inches (178 mm) and not more than 12 inches (305 mm) in height. Tread depth and riser height shall be calculated in accordance with one of the following formulas:

1. The tread depth shall be 20 inches (508 mm) minus 4/3 of the riser height, or

2. The riser height shall be 15 inches (381 mm) minus 3/4 of the tread depth.

**AV104.2.1.4 Landing platforms.** The top tread and riser of stairways accessing lofts shall be constructed as a landing platform where the loft ceiling height is less than 6 feet 2 inches (1880 mm) where the stairway meets the loft. The landing platform shall be 18 inches to 22 inches (457 to 559 mm) in depth measured from the nosing of the landing platform to the edge of the loft, and 16 to 18 inches (406 to 457 mm) in height measured from the landing platform to the loft floor.

**AV104.2.1.5 Handrails.** Handrails shall comply with Section R311.7.8.

**AV104.2.1.6 Stairway guards.** Guards at open sides of stairways shall comply with Section R312.1.

**AV104.2.2 Ladders.** Ladders accessing lofts shall comply with Sections AV104.2.1 and AV104.2.2.

**AV104.2.2.1 Size and capacity.** Ladders accessing lofts shall have a rung width of not less than 12 inches (305 mm) and 10 inches (254 mm) to 14 inches (356 mm) spacing between rungs. Ladders shall be capable of supporting a 200 pound (75 kg) load on any rung. Rung spacing shall be uniform within 3/8-inch (9.5 mm).

**AV104.2.2.2 Incline.** Ladders shall be installed at 70 to 80 degrees from horizontal.

**AV104.2.3 Alternating tread devices.** Alternating tread devices accessing lofts shall comply with Sections R311.7.11.1 and R311.7.11.2. The clear width at and below the handrails shall be not less than 20 inches (508 mm).

**AV104.2.4 Ships ladders.** Ships ladders accessing lofts shall comply with Sections R311.7.12.1 and R311.7.12.2. The clear width at and below handrails shall be not less than 20 inches (508 mm).

**AV104.2.5 Loft Guards.** Loft guards shall be located along the open side of lofts. Loft guards shall not be less than 36 inches (914 mm) in height or one-half of the clear height to the ceiling, whichever is less.

**CHAPTER PART AV105— EMERGENCY ESCAPE AND RESCUE OPENINGS**

**AV105.1 General.** Tiny houses shall meet the requirements of Section R310 for emergency escape and rescue openings.

> **Exception:** Egress roof access windows in lofts used as sleeping rooms shall be deemed to meet the requirements of Section R310 where installed such that the bottom of the opening is not more than 44 inches (1118 mm) above the loft floor, provided the egress roof access window complies with the minimum opening area requirements of Section R310.2.1.

**Commenter's Reason:** During the Committee Action Hearings in Kentucky, IRC Committee members explained their disapproval of RB168-16, but also their support for addressing the issue of small houses. In the published reasons the Committee stated "The issue of small houses and apartments is important," and that "The IRC needs to address them in some fashion." They encouraged further development of the proposal, stating "There needs to be a more comprehensive approach", and that "The concept of smaller houses may be more suited for an appendix."

This Public Comment follows the Committee's advice by replacing the original piecemeal proposal with a proposed appendix that takes a "more comprehensive approach". It also reduces the 500 square foot threshold for "small houses" in the original proposal to the widely accepted threshold of 400 square feet for "tiny houses". At that smaller size there is increased difficulty in meeting certain dimensional requirements of the IRC; however, through years of practice by tiny house advocates and years of extensive use of comparably sized "recreational park vehicles" governed by ANSI A119.5, safe alternative dimensions and other requirements have been established that are included in the proposed appendix.

In the published reasons the Committee finally noted that "Small houses are a growing concern, [and] the demand for them is increasing." The reasons for that growing demand are both environmental and financial in nature. Below are statistics illustrating problematic housing trends, the environmental impacts of construction, the cost of home ownership, and how tiny houses can be a part of the solution. That is followed by specific reasons for the code language in the proposed appendix.

The average home size in the U.S. increased 61% since 1973 to over 2600 square feet. In that time period the average household size decreased, leading to a 91% increase in home square footage per inhabitant (1000 SF per person) (source: US Census Bureau).
The average house in the U.S. uses approximately 17,300 board feet of lumber and 16,000 square feet of other wood products. A 200 square foot tiny house uses only 1,400 board feet of lumber and 1,275 square feet of additional wood products. The lifetime conditioning costs can be as low as 7% of a conventionally sized home.
United States Green Building Council (USGBC), the California Energy Commission (CEC), and other entities are working hard to increase energy efficiency in the construction industry. This is a great start, however a reduction in home size is the easiest way to lower energy consumption.
National homeownership fell to 63.7% in 2015, the lowest level in two decades. Increased housing cost is cited as the main reason for low ownership rate. (source: Joint Center for Housing Studies (JCHS) at Harvard University)
The average home in the United States costs approximately $358,000 to build, an increase of roughly $200,000 since 1998, whereas the average annual income in the United States has remained unchanged for the last several years, lingering near $52,000. (source: US Census Bureau)
The average American spends roughly 27% of their annual income on housing (nearly 11 hours of every 40-hour work week). 48% of households making less than $30,000 annually pay more than half of their income on housing, leaving these households less than $15,000 a year to purchase food, healthcare, education, clothing, and anything else. (source: JCHS)
The cost of new construction for a 200 square foot tiny house can be as low as $35,000. A typical down payment on an average-sized house is $72,000, more than twice the full cost of a tiny house.
Cities benefit from tiny house ordinances. With significant need for affordable housing, cities are hard-pressed to find solutions that quickly expand their low -income housing stock without burdening an already burdened system. Tiny houses can be quickly installed in municipalities and set up at little or no cost to the cities.
Although not addressed in the proposed code language of this public comment, it is important to recognize the need for codes pertaining specifically to movable tiny houses. For some people, homeownership is heavily impacted by the cost of land and even the construction of a fixed tiny house becomes unattainable. For those individuals, the presence of movable tiny houses in the building code may create their only path to homeownership. The flexibility of a movable tiny house allow s individuals to locate their homes in areas of community living or on ancillary home sites, without the burdensome cost of a single-family lot. It also allows them to take their home with them should they need to relocate, thus eliminating many typical costs of moving.

Tiny houses can play an important role in minimizing the environmental impacts of housing while providing safe and healthy homes at affordable prices. Pride of ownership improves neighborhoods and community morale. Tiny houses enable more people to become homeowners and contribute to their communities.

**REASONS FOR DEFINITIONS:**

**EGRESS ROOF ACCESS WINDOW**. Most manufacturers use this term for their skylights and roof windows that are designed to satisfy the dimensional requirements of emergency escape and rescue openings in U.S. building codes.

**LANDING PLATFORM:** Landing platforms have been demonstrated in practice to allow for the safe transition between stairways and lofts. (See photos)

**LOFT**. This definition is a modified version of the definition of loft area in Section 1-3 of ANSI A119.5 Recreational Park Trailer Standard.

**TINY HOUSE.** This definition is based on the widely accepted maximum square footage for tiny houses in the construction industry.

REASONS PER SECTION:

**AV103. CEILING HEIGHT**: The minimum ceiling height for non-loft habitable spaces in this proposed appendix is 6 feet 8 inches. Though lower than the 7 foot minimum for habitable spaces in the IRC, it is higher than the minimum of 6 feet 6 inches in Section 5-3.5.4 of ANSI A119.5 Recreational Park Trailer Standard, that has proven to provide safe and adequate headroom during the extended occupancy of recreational park trailers.

**AV104 LOFT:** Tiny houses have considerably smaller footprints and building height than conventional houses. As such, lofts are essential to maximize the use of space in tiny houses and make them viable shelter for many individuals and families.

It is common knowledge to many building inspectors that spaces labeled "non-habitable storage" in dwellings of all sizes are sometimes used for sleeping or other habitable purposes once the final inspection is complete. Rather than being unable to enforce a falsely stated use, building departments could regulate the health and safety of those spaces for their intended use w ith the proposed appendix, ensuring health and safety with minimum loft dimensions, requirements for access and egress, and proper emergency escape and rescue openings.

**MINIMUM AREA** and **MINIMUM DIMENSIONS**: Lofts in tiny houses are small by necessity; however, minimum dimensions are required for lofts used as a living or sleeping space, so as to not impose a risk to occupant health and safety.

**HEIGHT EFFECT ON LOFT AREA**: For most roof designs in tiny houses, a minimum ceiling height of 3 feet has proven adequate in sleeping lofts for consideration of their required floor area. For gable roofs with moderate to high slopes, the slope has an aggressive impact on the loss of ceiling height but makes up for it with higher areas under the ridge. Thus lofts under gable roofs with a minimum 6:12 slope have a lesser minimum ceiling height when calculating their required floor area.

**STAIRWAY WIDTH:** These dimensional requirements are identical to those in Section 5-10.4.1.1 of ASNI A119.5. This provision is considered and proven safe for extended occupancy of recreational park trailers.

**STAIRWAY HEADROOM**: Because tiny houses are limited in square footage and height, IRC compliant head heights for stairs serving lofts are often not achievable. Therefore the stair headroom requirement has been reasonably reduced to 6 feet 2 inches.

**STAIRWAY TREAD/RISER**: This is identical to the requirements for treads/risers in Section 5-10.4.1.1 of ANSI A119.5. This provision is considered and proven safe for extended occupancy of recreational park trailers.

**LANDING PLATFORMS:** Landing platforms have been demonstrated in practice to allow for the safe transition between stairways and lofts. The required range of dimensions allow for a simple transition between standing and kneeling when entering or exiting the loft. (See photos)

**LADDERS**: This is identical to the requirements for ladders in Section 5-10.5 of ANSI A119.5. This provision is considered and proven safe for extended occupancy of recreational park trailers.

**ALTERNATING TREAD DEVICES**: Alternating tread devices as described in the IRC, are allowed to provide access to and egress from lofts.

**SHIPS LADDERS**: Ships ladders as described in the IRC, are allowed to provide access to and egress from lofts.

**LOFT GUARDS:** The height requirement for loft guards is identical to that for guardrails in Section 5-10.7 of ANSI A119.5.

**AV105 EMERGENCY ESCAPE AND RESCUE:** Due to the considerably smaller footprints of tiny houses, ceiling heights in sleeping lofts therein are often necessarily lower than minimum ceiling heights required by the IRC for sleeping rooms in larger houses. Egress roof access windows (which are specifically designed to meet the dimensional requirements of emergency escape and rescue openings) can be installed with their openings within 44 inches of the loft floor, thus meeting the requirements of Section R310 w hen w all mounted w indow s meeting these requirements are not possible.

**Bibliography:** ANSI A119.5 Recreational Park Trailer Standard 2009 Edition

## Physical Standards for HUD Housing

Last updated in 1996, the standards below cover all of physical visual inspections for the establishment of the Federal Section 8 housing. Full text can be found in the Code of Federal Register under section 24.

**24 CFR 5.703 - Physical condition standards for HUD housing that is decent, safe, sanitary and in good repair (DSS/GR).**

**§ 5.703 Physical condition standards for HUD housing that is decent, safe, sanitary and in good repair (DSS/GR).**

HUD housing must be decent, safe, sanitary and in good repair.Owners of housing described in § 5.701(a), mortgagors of housing described in § 5.701(b), and PHAs and other entities approved by HUD owning housing described in § 5.701(c), must maintain such housing in a manner that meets the physical condition standards set forth in this section in order to be considered decent, safe, sanitary and in good repair. These standards address the major areas of the HUD housing: the site; the building exterior; the building systems; the dwelling units; the common areas; and health and safety considerations.

**(a)*Site.*** The site components, such as fencing and retaining walls, grounds, lighting, mailboxes/project signs, parking lots/driveways, play areas and equipment, refuse disposal, roads, storm drainage and walkways must be free of health and safety hazards and be in good repair. The site must not be subject to material adverse conditions, such as abandoned vehicles, dangerous walks or steps, poor drainage, septic tank back-ups, sewer hazards, excess accumulations of trash, vermin or rodent infestation or fire hazards.

**(b)*Building exterior.*** Each building on the site must be structurally sound, secure, habitable, and in good repair. Each building's doors, fire escapes, foundations, lighting, roofs, walls, and windows, where applicable, must be free of health and safety hazards, operable, and in good repair.

**(c)*Building systems.*** Each building's domestic water, electrical system, elevators, emergency power, fire protection, HVAC, and sanitary system must be free of health and safety hazards, functionally adequate, operable, and in good repair.

**(d)*Dwelling units.***

**(1)** Each dwelling unit within a building must be structurally sound, habitable, and in good repair. All areas and aspects of the dwelling unit (for example, the unit's bathroom, call-for-aid (if applicable), ceiling, doors, electrical systems, floors, hot water heater, HVAC (where individual units are provided), kitchen, lighting, outlets/switches, patio/porch/balcony, smoke detectors, stairs, walls, and windows) must be free of health and safety hazards, functionally adequate, operable, and in good repair.

**(2)** Where applicable, the dwelling unit must have hot and cold running water, including an adequate source of potable water (note for example that single room occupancy units need not contain water facilities).

**(3)** If the dwelling unit includes its own sanitary facility, it must be in proper operating condition, usable in privacy, and adequate for personal hygiene and the disposal of human waste.

**(4)** The dwelling unit must include at least one battery-operated or hard-wired smoke detector, in proper working condition, on each level of the unit.

**(e)*Common areas.*** The common areas must be structurally sound, secure, and functionally adequate for the purposes intended. The basement/garage/carport, restrooms, closets, utility, mechanical, community rooms, day care, halls/corridors, stairs, kitchens, laundry rooms, office, porch, patio, balcony, and trash collection areas, if applicable, must be free of health and safety hazards, operable, and in good repair. All common area ceilings, doors, floors, HVAC, lighting, outlets/switches, smoke detectors, stairs, walls, and windows, to the extent applicable, must be free of health and safety hazards, operable, and in good repair. These standards for common areas apply, to a varying extent, to all HUD housing, but will be particularly relevant to congregate housing, independent group homes/residences, and single room occupancy units, in which the individual dwelling units (sleeping areas) do not contain kitchen and/or bathroom facilities.

**(f)*Health and safety concerns.*** All areas and components of the housing must be free of health and safety hazards. These areas include, but are not limited to, air quality, electrical hazards, elevators, emergency/fire exits, flammable materials, garbage and debris, handrail hazards, infestation, and lead-based paint. For example, the buildings must have fire exits that are not blocked and have hand rails that are undamaged and have no other observable deficiencies. The housing must have no evidence of infestation by rats, mice, or other vermin, or of garbage and debris. The housing must have no evidence of electrical hazards, natural hazards, or fire hazards. The dwelling units and common areas must have proper ventilation and be free of mold, odor (e.g., propane, natural gas, methane gas), or other observable deficiencies. The housing must comply with all requirements related to the evaluation and reduction of lead-based paint hazards and have available proper certifications of such (see 24 CFR part 35).

**(g)*Compliance with State and local codes.*** The physical condition standards in this section do not supersede or preempt State and local codes for building and maintenance with which HUD housing must comply. HUD housing must continue to adhere to these codes.

## Virginia Housing Development Authority: 2016 Minimum Design and Construction Requirements

### Requirements for All Developments

The following requirements were created to address issues related to the design, construction, maintenance, marketing, life cycle costs and aesthetic concerns for developments utilizing low income housing tax credits (LIHTC), and/or developments financed by the Virginia Housing Development Authority (VHDA). Submittal requirements for VHDA loan applications are listed on the Architectural & Engineering Review sheet which can be found at the conclusion of the Minimum Design and Construction Requirements. Submittal requirements for the LIHTC program are contained in the tax credit application.

Drawings, specifications and scope of work are to comply with the latest applicable issue of the *Virginia Uniform Statewide Building Code (USBC)2, International Building Code (IBC)3,* other applicable Virginia and national codes, requirements of localities, prevailing design and construction practices and the Minimum Design and Construction Requirements of VHDA. Installation of materials, equipment, products, and building systems are to be per the manufacturer's' requirements, specifications, and recommendations. All developments are to comply with accessibility requirements of *USBC*.

### Requirements for New Construction

SITE WORK

1. Finished floor elevations of buildings are to be a minimum of 8 inches higher than the adjoining finished grade. When achieving an 8 inch height separation is not feasible, due to accessibility requirements or other conditions, provide an alternate solution acceptable to VHDA.

2. Areas around buildings are to be graded to have a minimum 5% slope away from foundation walls for a minimum distance of 10 feet, per *IBC*. Install yard drains, storm inlets, or drainage pipes under concrete walks to drain properly if the space between foundation walls and concrete walks is less than 10 feet. Drainage systems are to be designed to avoid water drainage over sidewalks. Provide an alternate drainage solution acceptable to VHDA:
    a. when buildings are closer than 10 feet to concrete walks
    b. when a minimum 5% slope is not feasible
    c. to avoid water draining over sidewalks
    d. at accessible entrances, when applicable

3. Install seamless gutters and downspouts for all buildings. When discharging on grades steeper than 20%, or less than 1%, water from gutters and downspouts is to be piped underground to a storm sewer system, or to daylight at grades that will avoid soil erosion.

1 The 2016 VHDA Minimum Design and Construction Requirements apply only to VHDA loans received in the 2016 calendar year as well as developments receiving Federal Low-Income Housing Tax Credit allocations for year 2016. 2 (USBC 2012) *Uniform Statewide Building Code* (Latest applicable edition as referenced by the *USBC*)
3 (IBC 2012) *International Building Code* (Latest applicable edition as referenced by the *IBC*)

4. Paving designs are to be based upon the soil report, California Bearing Ratio (CBR) of the soil, traffic count, and loading. Drive lanes of parking lots are to be designed for dumpster trucks. Parking bays may have lighter paving than the drive lanes of parking lots.

5. Extend concrete dumpster pads at least 12 feet into the asphalt so that the load bearing wheels of trucks rest on concrete while emptying the dumpsters. Thickness of concrete is to be a minimum of 6 inches with reinforcement. Dumpsters and/or compactors are to meet accessibility requirements. Install a privacy screen on at least three sides of all dumpster and/or compactor pads.

6. Minimum width of sidewalks is to be 3 feet. Sidewalks that are located perpendicular to parking spaces are to be a minimum of 5 feet wide or 3 feet wide with 2 feet of space between the sidewalks and curbs. Provide gravel and sand base under walks when required by the soil report. Provide control and expansion joints.

7. Pole lights are to be located so that site lighting is not blocked by trees.

8. Finish grade, seed, and landscape all barren and disturbed areas. Grade to avoid standing water. Provide a smoothly graded transition from disturbed to undisturbed areas. Provide ground cover materials or sod for slopes steeper than 20%. Provide foundation plantings in the front of all buildings. Clean site and dispose of all construction debris.

ARCHITECTURAL

1. ROOFING

a. Roof sheathing thickness is to be a minimum of 15/32 inch thick plywood or 15/32 inch OSB. Install sheathing with clips. ZIP System roof sheathing or similar products are not accepted.

b. Install drip edge on all sides of the roof.

c. Install ice barrier extending from eave's edge to a point 24 inches inside the exterior wall of buildings.

d. Roof shingles are to be a minimum 25-year, anti-fungal product, and are to be nailed (not stapled).

e. Flat roofs to have a minimum 20-year manufacturer's warranty.

2. Provide roofs/overhangs over the front entrance doors to all units that are accessed directly from the exterior. Provide a minimum overhang of 30 inches along the front and 12 inches along each side of the door; or the door may be setback a minimum of 24 inches from the face of the exterior wall.

3. Stairs to apartment units where stair halls are not enclosed are to be protected against rain and snow by design features, such as, setting back stairs a minimum 5 feet from the exterior wall and/or installing a roof overhang at the second floor level, projecting a minimum of 5 feet beyond the first riser.

4. Install waterproofing on exterior walls up to finished grade where finished floor elevations of apartment units or public spaces are below adjoining finished grades. Provide a 10-year material/manufacturer's warranty.

5. Install weep holes in brick veneer at foundation walls, over lintels, and relief angles.

a. Weep holes at foundation walls are to be a minimum 6 inches above finished grade.

b. Provide mortar mesh to prevent blockage of weep holes.

c. Provide continuous flashing at all weep holes and end dams at flashing terminations.

6. At brick window sills, and caps for brick veneer walls that do not terminate directly under roofs, provide a positive slope resulting in a minimum 3/4 inch differential over the length of the brick.

7. All sill plates in contact with concrete or masonry are to be of treated wood. Provide sill sealer for sill plates at all exterior walls.

8. All brick veneer or sidings, such as vinyl, aluminum, wood and HardiePlank™, are to have a solid backing of plywood, OSB, gypsum, structural insulated sheathing, or similar material. Siding and brick are to be installed over an appropriate drainage plane,

such as Tyvek® or equal. Install pre-manufactured mounting blocks for all penetrations in siding such as electrical, plumbing, HVAC, etc.

EXCEPTION: ZIP System wall type sheathing or similar materials may be used, provided the following conditions are met:

1) Store products to meet manufacturer's requirements.
2) Installation

a) Architect to provide approved flashing details prior to installation of windows and doors.
b) Tape all joints with manufacturer approved products so that all joints are watertight. Install tape using ZIP System tape gun or roller.
c) All penetrations, including fasteners, which break the surface of the integral drainage plane, must be sealed with a manufacturer's approved product
d) When weather conditions warrant, follow manufacturer's requirements for inclement weather installation and storage.
e) Manufacturer's representative to review and approve the final installation to confirm all manufacturers' requirements are met prior to the installation of the exterior cladding. Documented acceptance of ZIP System installation is required.

9.The bottom of all siding is to be a minimum height of 6 inches above the finished grade or mulch beds.

10. All exhaust ducts are to discharge to the exterior of the building. Exterior wall caps for bath and kitchen exhaust ducts are to be of a quality that will minimize repair and replacement.

11. Exterior wood, such as trim, fascia, rake boards, and columns, is to be clad with vinyl, vinyl coated aluminum, or similar materials. Use materials designed for cladding with a minimum thickness of 0.019 inch or thicker and provide a stiffening crimp when trim and fascia boards are more than 8 inches wide. VHDA recommends the use of low maintenance composite/manufactured materials instead of wood for exterior use.

12. Use vinyl, aluminum, or steel for railings, handrails, guard rails, posts and pickets instead of wood. Provide a minimum 10-year warranty for paint/finishes on steel products. Steel is to be primed and painted prior to placement in concrete.

13. Windows and sliding glass doors are to have a minimum ½ inch insulated glass. Provide a minimum 10- year material warranty for windows and sliding glass doors. Insulating glass is to have a minimum 10-year warranty for breakage of seal. Provide thermal break for aluminum frames. Install and flash per manufacturer's specifications. Provide sample installation.

14. All apartment exterior doors, except sliding glass doors, are to be of insulated fiberglass or insulated metal. Solid core wood doors may be used where entrances are

through interior conditioned corridors. Use fiberglass or metal doors for outside storage or mechanical closets.

15. Install hard surface flooring at the interior of all entrance doors, except for doors entered through carpeted interior hallways. Hard surface area is to be approximately 3 foot by 4 foot using flooring materials such as VCT, sheet vinyl, hardwood, or tile.

16. Flooring such as sheet vinyl, VCT or ceramic is to be installed over minimum ¼ inch underlayment grade plywood, cementitious board, or similar underlayment materials. Flooring may be installed over concrete, provided concrete is finished smooth and uniform. When installed over Gypcrete, or a similar material, apply manufacturer approved sealer.

17. Carpets are to have a minimum number of seams. Seams are not to be located in heavily trafficked areas. T-seams are not acceptable except in closets.

18. All interior doors are to be side hinged. Bifold, pocket, or sliding doors are not acceptable. Install or undercut doors a minimum of ¾ inch clear to prevent dragging and to provide ventilation. Paint bottom top and all other sides of doors.

19. All base and base moldings in a unit are to be wood and are to match in design and finish.

20. All windows are to have blinds, shutters, or other similar products, and sliding glass doors are to have vertical blinds.

21. Provide a minimum of 1 ½ bathrooms (one full bathroom and one half bathroom) in all two bedroom units and a minimum of 2 full bathrooms in all three or more bedroom units.

22. Concealed blocking is to be provided for all items such as handrails, grab bars, and wall mounted bathroom accessories.

23. Tub and shower surrounds built of ceramic tile, marble, or similar materials are to be installed over minimum ½ inch cementitious board.

24. Provide a pass-through opening with counter space when kitchen and dining/living areas are separated by a wall.

25. Kitchen cabinets and bathroom vanities are to comply with *Virginia Housing Development Authority's Minimum Cabinet Requirements*:

a. All cabinets are to be factory/manufacturer assembled.

b. Kitchen cabinets and bathroom vanities are to abut the side walls or provide a minimum spacing of 12 inches between wall and cabinets. Wall cabinets are to abut the ceiling/soffits or provide minimum of 12 inches between cabinet and ceiling/soffits.

c. Kitchen wall cabinets are to be screwed to studs or blocking with a minimum of four screws; two in each upper and lower nailing strip for each wall cabinet.
d. Plastic laminate countertops are to be post formed or have back splashes that are factory attached to the counter top and sealed.

e. A side splash is to be installed when the kitchen base cabinets or bathroom vanities are located in a corner.
f. Holes in cabinet backs for plumbing are to be drilled, sealed, and completely covered by escutcheon plates.

26. Install a cleanable surface, such as plastic laminate, metal, or ceramic tile on the sidewall next to the cooking range when it is located directly adjacent to a wall. Materials such as plastic laminate or metal are to be installed with adhesive.

27. APPLIANCES

a. Provide 30 inch wide range in all units except studio/efficiency and one bedroom elderly apartments, which may have a minimum 20 inch wide range. Provide maximum 24 inch wide range hood for all 20 inch wide ranges.
b. Provide a range hood or combination range hood-microwave over all cooking ranges.
c. Provide a 24 inch wide dishwasher in all units, except for studio/efficiency apartments, which may have 18 inch wide dishwashers.
d. All refrigerators are to be frost free. The refrigerators are to have separate doors for freezer and refrigerator compartments. Minimum sizes of refrigerators are to be 12 cubic feet for studio/efficiency apartments, 14 cubic feet for 1 and 2 bedroom apartments, and 16 cubic feet for 3 and 4 bedroom apartments.
e. Provide clothes washing machines and dryers or hookups for full-size side-by-side or full-size stack type washers and dryers in all units. Laundry equipment shall be installed in a closet with doors in a location other than a living room or bedroom. Otherwise, provide onsite laundry facilities. (See “Plumbing” section for washing machine pan requirements.)
f. All kitchen appliances in an apartment unit are to match in color.

MECHANICAL

1. Provide Heating, Ventilation, and Air Conditioning (HVAC) equipment with R-410A refrigerant in all dwelling units. All apartments are to have ducted HVAC systems with the exception as noted in #3 below. Size of HVAC equipment, ducts and diffusers are to be designed per heat gain/loss calculations.

2. For all ducted HVAC systems including ducted mini-splits and self-contained packaged systems (similar to Magic-Pak or First Co):

a. Air supply diffusers are to be located near windows in living rooms, dens and bedrooms. Exception:
The mechanical engineer may locate diffusers at alternate locations with VHDA's prior approval based on supporting calculations.

b. Provide HVAC diffusers for kitchens and all full baths.

c. Provide standard size air filters.

d. Seal air duct penetrations in unheated spaces.

e. Refrigerant and condensate lines are to be concealed within walls.

3. Ductless Heat Pumps (mini-splits) may be used in housing for the elderly and apartments with less than 600 net square feet.

a. All mini-splits are to discharge condensate to grade through a pipe concealed within the exterior wall system.

b. Provide separate mini-split wall mounted unit for each bedroom, den or living room.

c. Provide separate wired wall mounted thermostat for each mini-split wall mounted unit.

d. Provide a heater with a thermostat or timer controlled heat lamp for all full baths.

4. Install walk pads that provide access to all roof condenser units. Provide interior roof access from a common area.

5. Do not install condenser units in front of windows.

6. Electric baseboard heating and electric forced air heating shall not be used as the primary heating method.

PLUMBING

1. Clothes washing machines or hook-ups for clothes washing machines are to have a pan, with a drain, connected to the sewer system per applicable plumbing code.

2. The bottoms of bathtubs are to have slip resistant/textured finish.

3. All tubs/showers and shower diverters are to have internal shut-off-valves or external shut-off-valves with access panels.

4. Bathrooms which include a roll-in shower shall have <u>either</u>:

a. a minimum of 3'-0" of the bathroom floor outside of the shower opening slope back towards the shower drain at approximately 2%, and a zero height transition between the bathroom floor and the shower floor, or
b. a secondary floor drain located outside of the shower. The bathroom floor shall slope towards the secondary floor drain.

5. When installing wall-hung sinks, provide concealed arm type carriers.

6. Use of PVC foam core pipe is not accepted.

7. All floor drains and indirect waste receptors to receive trap primer or code approved drain trap seal device.

ELECTRICAL

1. Provide fluorescent light fixtures or LED light fixtures in all public common areas such as offices, multipurpose rooms, laundry rooms, hallways, and stairs.

2. Kitchens are to have a minimum of one light fixture 4 feet long with two 32 watt fluorescent bulbs, or lighting fixture(s) that provide a minimum illumination of 30 foot candles distributed across all countertops.

3. Pre-wire cable TV and internet outlets for all bedrooms, living rooms, family rooms, and dens. Provide a minimum of one telephone outlet in either the kitchen or living area, and one telephone outlet in the master bedroom. All wiring for the interior and exterior of the building is to be concealed within the walls.

4. Exterior fixtures are to be LED, fluorescent, metal halide, high or low pressure sodium, or mercury vapor. Tenant controlled exterior lighting is exempt. Provide exterior lighting to illuminate all parking areas, dumpster pads, building entrances and mailboxes with a minimum of one foot candle of illumination. Provide illumination so that building numbers and apartment numbers are legible at night.