August 2023

Off-grid Living for the Normative Society: Shifting Perception and Perspectives by Design

Patsun Lillie
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Off-grid Living for the Normative Society: Shifting Perception and Perspectives by Design

A Thesis Presented

by

Patsun Lillie

Submitted to the Graduate School of the University of Massachusetts Amherst in partial fulfillment of the requirements for the degree of

MASTER OF ARCHITECTURE

May 2023

Department of Architecture
OFF-GRID LIVING FOR THE NORMATIVE SOCIETY: SHIFTING PERCEPTION AND PERSPECTIVES BY DESIGN

A Thesis Presented

by

PATSUN LILLE

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Department of Architecture
DEDICATION

To my husband and to our son, who have unconditionally supported me through my education and are rooting for my success, as well as our joint desire to make a positive difference in this world.
ACKNOWLEDGMENTS

Immeasurable gratitude to all of my professors that have invested time and effort to answer my questions, support, and encourage my learning process during these last four years. To Carl Fiocchi who has been there since the beginning of my graduate journey, for countless inspirational conversations and the openness to always express the mind authentically. To Rob Williams who effortlessly makes constructive criticism a positive and inventive experience to validate and progress design projects forward. To Alex Schreyer and Peggi Clouston who are the nicest as well as some of the most intelligent people that I know. To Ray Mann and Erika Zekos who are always interested to check in with me in passing, as well as to enrich my ideas. To Jordan Kanter and the creative wrestling that happens within group projects, but that produces a quality, finished product. Finally, to Carey Clouse and Caryn Brause, also for their endless encouraging support and who help to point my focus forward toward my future architectural career.
ABSTRACT

OFF-GRID LIVING FOR THE NORMATIVE SOCIETY: SHIFTING PERCEPTION AND PERSPECTIVES BY DESIGN

MAY 2023

PATSUN LILLIE, B.S. UNIVERSITY OF WISCONSIN AT MADISON

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Off-grid houses in the United States are often connoted with mostly non-professional, home-made structures and isolated, hippie living in remote rural areas. These off-grid homeowners may also complete their consumer-independent commitment with a minimal-waste, land-dependent lifestyle that includes methodical harnessing and recycling of resources and materials, raising livestock, and productive gardening on the property. This research paper explores the background, methods and kinds of typical off-grid living structures, their ability to harness natural resources for function and performance, and the ability of its occupants to remain resilient in the face of depleting fuel resources, extreme weather patterns, and rising costs of living.

The goal of this research is to propose modern and resilient off-grid housing design to exist as normalized, micro-communities within typical suburban communities in the United States. The housing prototype, sited in Dudley, Massachusetts, optimizes passive resources for heating and cooling thermal comfort, prefabricated materials for construction, and modern technology for inhabitation. Its hyper-local design incorporates building science that integrates researched techniques and philosophies from current movements of sustainable design in the United States and Canada, such as Passive House, Net Zero, LEED, and the Living Building Challenge.
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CHAPTER 1

INTRODUCTION

When propositioned with the idea of living off-the-grid, one may believe that it requires abandoning the conveniences of modern life, purchasing an isolated piece of land somewhere out in the wilderness, raising chickens, and becoming at one with nature. Images of the stereotypical hippie lifestyle and diet may also come to mind. Books have been written about the off-grid experience and how-to guides that largely support this notion, many of which were born out of distrust with government-regulated systems. Helen and Scott Nearing’s methodical memoir of their transition from living in New York City to the rural mountain farms of Vermont in 1932, during the aftermath of the Great Depression economic crash, “Living the Good Life: How to Live Sanely and Simply in a Troubled World,” was first published in 1954. This would then influence the “Back to the Land Movement” in the late 1970’s, and continue to evolve into current-day homesteading.

Since then, our nation has restrengthened its economy and maintained its position as a world power, although we are far from being free of labor exploitation or chronic regional financial insecurities. Inflation is continuing to drive up living and fuel costs at a faster rate than minimum wage raises. These costs will become more exacerbated as fossil fuels inevitably become depleted. Moreover, the ongoing global pandemic of COVID and national quarantining shut-downs between 2019-2021 has had an interesting impact on the housing market, where people became more focused on home-

1 Nearing, “Living the Good Life: How to Live Sanely and Simply in a Troubled World”
3 LaPonsie, “Minimum Wage vs. Inflation – Forbes Advisor.”
improvement projects or decided to sell to purchase better homes. Lumber factories could not keep up with the construction demand, as they were dealing with struggling production labor and limited shipping capabilities due to the pandemic. The spike in real-estate demand drove property prices as well as rental rates to all-time highs.  

According to a recent report by Forbes, while housing prices are leveling off due to a cooling market in 2022, they are still higher than the median prices of the previous years. Their economists have mixed predictions that while some regions will experience a slight dip in housing prices, others might still experience a rise due to inventory that is lower than consumer demand.  

As living and housing costs continue to rise, people become more amenable to novel ways to reduce their bills. Perhaps encouraging more homes toward off-the-grid methods will help to secure future financial as well as reduced greenhouse emissions, environmental security, and resiliency. The conventional transport of electricity from utility producers to our homes is currently inefficient, with less than 40% of the produced amount from the factory arriving at our homes. This means that we are burning 2.5 times the amount of non-renewable coal and natural gas than necessary to produce sufficient energy for our homes. If micro off-grid communities could produce their own onsite electricity for onsite use, they could minimize this waste and loss in transport. As our residential areas are becoming increasingly more populated, this will also relieve some of the contractual responsibility and load requirements imposed on utility companies mandating that they provide sufficient and constant electricity.

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4 Siniavskaia, “Single-Family Lot Values Reach Record Highs.”
5 Rothstein and Chris Jennings, “Housing Market Predictions For 2023: Will Home Prices Drop?”
6 EIA, “More than 60% of Energy Used for Electricity Generation Is Lost in Conversion.”
Off-grid housing should not be exclusive to wealthy vacationers or limited to those that wish to escape the commercial life. With more commonplace construction resources and technological knowledge, off-grid housing does not need to be a risky experimental or inexperienced “do-it-yourself” process. This way of living and constructing has been around and repeated long enough that a system of off-grid housing, incorporated with our modern comforts, may become more normal and acceptable. One way that this can be achieved is by considering pre-fabrication methods and their benefits. Owners can place their confidence in intelligently pre-designed, off-grid systems; they should be able to feel as secure with the quality and comfort of an off-grid home as they would with a conventional home.

The prefabrication of building components offers a number of benefits to a project. It speeds up the construction process for contractors and minimizes on-site problems or mistakes. Environmentally, prefabricated production allows for a higher precision of material use that minimizes inefficient waste. This precision can produce a superior quality of high-performing structures to fulfill certification requirements from programs like Passive House or the Living Building Challenge. In their controlled environment of fabrication, the risks involved with on-site weather damage are virtually eliminated. Prefabrication facilities also have the potential ability to access unusual residential building materials, such as hemp wool or steam-pressed straw, at bulk cost for mass production of the same prefabricated units.

Off-grid living is generally legal in the United States, as long as state-adapted International Building Codes and local zoning regulations are being adhered to, along
with proper permitting and licensing of the finished construction project. Cultivating a good working relationship with town or city planners and inspectors helps to resolve potential conflicts of interest or problems that may arise, such as shared use of water and the harvesting of rainwater. Some townships do require in their local regulations that all residential homes are municipally connected. In this case, attempting to live off-the-grid becomes exponentially more challenging. No owner desires to receive fines for unmet regulations, so the importance of knowing the local legislative regulations is of utmost importance.

This paper explores the possibility of developing an off-grid micro-community within a gridded community in the suburban town of Dudley, Massachusetts. How can an off-grid system harmoniously exist within a gridded system? How can communities like this bridge the gap between commercialized living with a more natural way of living? The project examines and draws from a contemporary sustainability movements and standards as well as an array of contemporary North American, off-the-grid community and building case studies: the Three Rivers recreational community in central Oregon; the Dancing Rabbit Ecovillage in Missouri, and The R.W. Kern Center in Massachusetts.

7 “Off Grid Living Legal States 2023.”
2.1 Preamble

In the earliest form of North American democracy, the Six Nations (or the Haudenosaunee) of indigenous tribes came together to write The Great Law of the Iroquois Confederacy, also known as The Great Law of Peace. This important document would then influence the writing of the United States Constitution. Law 28 in The Great Law of the Iroquois Confederacy evokes the future seven-generational philosophy of thinking for its nation leaders:

“The thickness of your skin shall be seven spans. . . In all of your deliberations in the Confederate Council, in your efforts at law making, in all your official acts, self-interest shall be cast into oblivion. . . Look and listen for the welfare of the whole people and have always in view not only the present but also the coming generations, even those whose faces are yet beneath the surface of the ground – the unborn of the future Nation.”

The hope is that many can resonate with this message in belief of intention and responsibility for the next generations, for considerate environmental practices and for securing financial stability. Despite varying views about climate change or global warming, all current and collective facts support that non-renewable resources are finite and will someday become exploited to depletion. As consumer demand eventually surpasses supply, prices will skyrocket faster than inflation, and more consumers will financially struggle to maintain daily lives. With that in mind, forward preparation matters: homeowners should consider contemporary, off-the grid housing as a more

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efficient way of living, as well as an investment toward the future resiliency for themselves, the environment, and for future generations.

The challenge in this concept will be to bring two lifestyles together into a cohesive one: the original way of land reliance that also gives back to the land, and the newer way that disconnects from the land by its reliance on third-party energy sources and technologies to provide for a mono-climate, or “mono-culture”\(^\text{10}\) of modern comforts and conveniences. How can these two find a common ground in residential housing? How can a self-sufficient, micro off-grid community coexist within a larger and existing gridded community, with minimal disruption to modern lifestyles and neighborhood dynamics? Even more radically, how can communities such as this go even further to benefit the larger community as a whole? This paper will look to historical events, philosophies, and sustainability movements to move forward toward transformative residential, off-grid solutions.

### 2.2 Crescendo to Our Current Environmental and Economic Dilemma

Within less than a century of colonization and the steady influx of immigration to North America, the continent’s landscape and its use had dramatically transformed from the one that the Native Americans knew to rely on. Soon after the Declaration of Independence in the United States, the Embargo Act of 1807 by Thomas Jefferson, and the War of 1812 with the British sparked the need for North American industrialization during the latter half of the 1800’s into the 1900’s.\(^\text{11}\) This movement rapidly produced

\(^{10}\) Michler, “Hyperlocalization of Architecture.” p. 13
densely populated cities that centralized around mills, factories, and machine mass-production. By 1900, the United States impressively had “half of the world’s manufacturing capacity.” The invention of electricity and then the development of the telephone radically changed the way that people interacted and shared ideas to advance other technologies like the automobile and computers.

In the discipline of architecture, the introduction of The Crystal Palace in 1850 at Hyde Park in London by Henry Cole and Joseph Paxton for the Great Exhibition of 1851 at the world’s first international trade fair was a significant turning point in building technology during the European and the North American industrial revolution. The Crystal Palace, although it still utilized vertical timber members in its structural bays, showed the world how the primary use of iron, steel, concrete, and glass was possible at an impressively larger scale. This building technology quickly caught on in the United States and was championed by architect Louis Sullivan of Chicago with his first skyscrapers in the late 1880’s, alongside the development of operable and safe elevators. Since then, high-rise buildings and skyscrapers have transformed American cityscapes, factories, and suburban municipal buildings.

Within three generations of the Industrial Revolution, strikingly tall buildings and rapid advancements in modern-life comforts and conveniences had been established. Most Americans are now connected by an infrastructure grid of steady energy supply, indoor plumbing, controlled sewage and sanitation, the internet/cable, and wireless gadgets. Today, most people cannot imagine ordinary life without these common-place

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14 Ibid
amenities. Buildings and their interior environments are now increasingly dependent on temperature-controlled technology. In Andrew Michler’s book, “Hyperlocalization of Architecture,” co-writer Lloyd Alter refers to this phenomenon as mono-temperature cultures that rely on programable, smart technology where people go from their home to their car to their building destination – all that are all cooled or heated to a similar temperature range and humidity level. According to Alter, buildings have essentially become “human refrigerators.”

These economic and lifestyle advancements, their ongoing maintenance, and their adoption by booming populations, have caused an enormous increase in the demand and consumption of natural resources. Michler asserts that “it appeared that for every new technology created, a new condition of [air and water] pollution and its effects arose.”

To illustrate this statement, Michler references rainwater runoff in cities that end up polluting nearby water sources. Heat islands in cities increase energy consumption for cooling that adds to air-pollution levels. More than half of the United States energy production is extracted from non-renewable coal, natural gas, and petroleum oil. The mining and use of coal produces mountains of toxic slag that must be safely contained to be disposed of. The drilling for and transport of natural gas and oil is destructive, polluting, and disruptive to ecological systems. Ultimately, the combustion and use of all these resources release prehistoric stores of greenhouse gases that trap solar heat in our atmosphere.

To make matters worse, “Energy that is purchased from the electric grid typically has a site-to-source ratio of around 2.8 in the United States, meaning that it requires 2.8

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units of energy consumed in the generation and delivery process to deliver one unit of energy to the site,”

according to a 2021 report by Archtoolbox. This means that consumers are paying for almost three times the amount of energy that they require in their homes; utility companies are combusting 2.8 times more coal, oil, or natural gas than the actual demand to fulfill the demand. We are consuming our natural resources and releasing excessively more CO₂ emissions into our atmosphere than we need to.

The world experienced a global pandemic in 2020 that put many communities into lockdown. According to the IEA key findings in their Global Energy Review 2021 publication, energy demand declined during this pandemic, but was still higher than pre-Industrial Revolution levels, and is now back on the rise. The IEA quotes: “Despite the decline in 2020, global energy related CO₂ emissions remained at 31.5 Gt, which contributed to CO₂ reaching its highest ever average annual concentration in the atmosphere of 412.5 parts per million in 2020 – around 50% higher than when the industrial revolution began.”

Increased levels of greenhouse gases in the atmosphere that cause rising ocean temperatures have created compounding problems of melting polar ice caps, rising sea levels, harmful algae blooms, and more extreme weather occurrences due to increased humidity and changing global wind patterns. These dramatic environmental changes have catastrophic effects on the survival of plants, wildlife, and eventually for humans as well.

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18 Skwiot, “Site vs Source Energy - Archtoolbox.”
2.3 Back to the Land Movement, Earthship Homes, and Homesteading

For a decade after 1929, the United States experienced a severe economic depression, the Great Depression, that shook America’s confidence in its financial institutions and businesses. Between this, the anti-war movement in the 1960s, and then the energy crisis in 1973, a growing movement of people decided to leave cities and move into rural areas to reframe their lifestyles around communal self-sufficiency by returning “back to the land” and to “make do with less.” This group of people, often motivated by Helen and Scott Nearing’s 1954 publication of “Living the Good Life: How to Live Sanely and Simply in a Troubled World,” were frustrated with mindless consumption and waste; they began to have a heightened consciousness toward conservation and the use of renewable resources such as wood. According to Jeffrey C. Jacob in “The North American Back-to-the-Land Movement,” a survey found that 58% of the people associated with this movement were young adults, with either undergraduate or at graduate level education.

In their book, Helen and Scott Nearing define their three main goals for leaving their materialistic, New York City life for a more natural one in Vermont and then later on in Maine: economic independence, hygienic health, and social/ethical liberation. They detail their journey toward becoming completely self-reliant with their financial economy and provisions, as well as the importance of community with what few neighbors they had, particularly for the mutual practice of trading resource and skills.

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20 History.com, “Great Depression.”
24 Nearing, Helen and Scott. “Living the Good Life,” p. xvii
They intentionally moved away from capitalism and commercial exploitation, a culture of working with the primary focus to collect money for material purchases, to reframe their lifestyle culture to cultivation and enjoyment of natural resources and life. Careful and thoughtful land purchases were made based on their usefulness and near zero waste of resources. They learned to grow wholesome vegetables, built their hardy masonry home from stones collected from their land, and harvested wood off their land to provide for their winter warmth. While they never decided to raise livestock, they assert that their vegetarian diet was more flavorful and nutritious than any processed grocery food that they had ever consumed in the city, and that their labor benefited them with improved physical health, significantly better than when in their previous daily city jobs. They never felt lacking in clothing, food or shelter in their lifestyle; a lifestyle which allowed them to live free from superficial social expectations.

As the movement spread into the Southwest, Michael Reynolds completed his thesis on Earthship home construction in 1971 in Taos, New Mexico, that was published in Architectural Record.25 His concept of Earthship homes began with his patented idea of reusing empty soda steel cans that he configured to be bound and formed into stackable brick sized units, and then encased in a rammed-earth mixture to finish. This technique evolved into rammed-earth recycled tires that were stacked to form walls capable of bearing loads that did not require a foundation. These rammed-earth tire walls were installed against excavated earth as a back wall that becomes a thermal mass for the building, while the front of the building utilized large areas of glazing for passive solar collection. The roofs of his Earthship homes contain operable flaps or windows to allow

for natural ventilation. These homes are completely self-sufficient for heating and cooling needs. Many of them still exist or are being constructed today, primarily in the Southwest region of the United States.

To the Northeast, architect Malcolm Wells advocated for “Earth Sheltered homes” that are constructed deeper into the earth than the typical Earthship home. He published his book, titled “Gentle Architecture,” in the 1980s. His philosophy is to design homes that are the least destructive, or rather more restorative, to its natural landscape. By constructing these homes into the earth, they are benefiting from the temperature stability of the earth that reduces energy consumption during the wintertime (complimented with natural solar heating) as well as maintaining coolness in the summertime. Included in architectural planning that is gentle to the land is gentle hardscaping, or minimized asphalt pavement, for minimized rainwater run-off. His argument for architecture that encourages the health of the landscape is also rooted in belief that nature is more capable of cleaning up our polluted air and water than we are, and that our primary job is to conserve our resource consumption as well as to minimize and manage our waste production.\textsuperscript{26} Malcolm Wells did build to reside in an earth-sheltered home and office at Cape Cod in Massachusetts in 1979.\textsuperscript{27}

Following the Energy Crisis of 1973, a number of additional mainstream movements have continued to advocate for increased energy efficiency and resource sensitive building practices. Particularly during the last decade, growing global environmental concerns have motivated designers and architects to pay more intention to

\textsuperscript{26} Wells, “Gentle Architecture,” p. 56-57
\textsuperscript{27} Yale, “Architect Malcolm Wells’ Underground Cape Cod Home Hits The Market.”
local environments, regard for regional cultures, and consideration for human wellness and health.

2.4 Mainstream Sustainability Movements of Today

2.4.1 Passive House

According to Environmental and Energy Study Institute’s (EESI) “History of Passive House,” a passive solar design movement originated in the United States and Canada by a group of engineers and architects from the University of Illinois Small Homes Council shortly after the 1973 energy crisis. This group designed the Lo-Cal house in 1976 that used only 40% of the energy of the most efficient buildings at that time.\(^{28}\) The EESI describes that achievement of this house led to the design of Canada’s Saskatchewan Energy Conservation House the following year, which used even less energy and reduced peak loads. This movement was praised for its passive building science systems in 1982 in the book “The Saunders-Shrewsbury House,” by William Shurcliff, a renowned Massachusetts Physicist.

However, as the cost of fuel leveled back down and the urgency to conserve passed during the 1980’s, people returned to old, comfortable habits in the United States and the Passive Solar movement diminished as quickly as it had arisen on the continent. Fortunately, its philosophy reinterpreted and revived overseas by Wolfgang Feist, a physicist in Germany, who founded the Passivhaus Institute (PHI) and pushed forward the implementation of building science principles into mainstream architectural practices. The Passivhaus Institute established a rigorous standard for energy efficiency that

limited annual heating demand to a maximum of “15 kilowatt-hours per square meter of living space” (or 4.75 Btu/sf). Interest in the Passive House movement grew in the United States in the early 2000’s, driven largely by Katrin Klingenberg, who became the co-founder of the Passive House Institute US (PHIUS). The PHIUS then created the PHIUS+ performance standard to include climate-specific criteria that accounts for North America’s weather extremes as well as cost-effective consideration criteria.

The North American Passive House similarly strives to perform “up to 85 percent less energy for heating and cooling than the average home,” which more than compensates for costing “3-5% more than conventional building methods.” Passive House achieves this by utilizing airtight envelope design, high-performance windows that also take their orientation into design consideration, extra insulation, the elimination of thermal bridges, and high efficiency heat and moisture recovery ventilation systems.

2.4.2 Net Zero

While Passive House standards focus on a reductive design that minimizes its energy consumption and cost footprint, Net Zero building standards are more focused on net cumulative CO₂ equivalency levels in the atmosphere. According to netzeroclimate.org, “Net zero refers to a state in which the greenhouse gases going into the atmosphere are balanced by removal out of the atmosphere,” which essentially results in a canceled net effect on the climate system. The Net Zero philosophy of practice may be broken up into more specifically descriptive categories such as Climate

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30 Ibid
31 Phius, “Phius Passive Building Principles.”
32 Ibid
Neutral, Climate Positive/Net Negative, Carbon Neutral, Carbon Negative, Green House Gases Neutral, Absolute Zero/Zero Emissions, Green House Gas Removals, or 1.5°C Aligned (in correlation to the goals of the Paris Agreement).

The Net Zero’s commitment standards were developed by the University of Oxford, based on fifteen years of interdisciplinary research on climate neutrality. Its research fellows are more politically involved than Passive House participants in setting forth legislative standards by “tracking and informing climate science, law, policies, economics, clean energy, transportation, land and food systems and greenhouse gas removal and storage.” To date, twenty-three states have set Net Zero emissions goals, including Massachusetts, where Governor Baker and Lieutenant Governor Karyn Polito signed the 2008 Global Warming Solutions Act that committed Massachusetts to be Net Zero (85% reduction) by 2050: 10-25% reduction by 2020, 50% reduction by 2030, and 75% reduction by 2040. Massachusetts’s plan to achieve this goal is outlined in the “Administration’s 2050 Decarbonization Roadmap and Clean Energy and Climate Plan.”

2.4.3 LEED

The principal philosophies of LEED (Leadership in Energy and Environmental Design) and the resulting formation of the USGBC (The US Green Building Council) were introduced in 1993 by Rick Fedrizzi, David Gottfried, and Mike Italiano, in

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36 Clean Energy States Alliance, “Table of 100% Clean Energy States.”
37 “Baker-Polito Administration Releases Roadmap to Achieve Net Zero Emissions by 2050”
partnership with the AIA, along with representatives from sixty firms and nonprofits. The LEED performance rating attempts to holistically evaluate environmental impact. It seeks to “reduce contribution to global climate change, enhance individual human health, protect and restore water resources [as well as] biodiversity and ecosystem services, promote sustainable and regenerative material cycles, [and] enhance community quality of life.” LEED is a point-based, prerequisite and accreditation system that addresses:

“carbon, energy, water, waste, transportation, materials, health and indoor environmental quality. Projects go through a verification and review process by GBCI and are awarded points that correspond to a level of LEED certification: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points).”

This methodical system is often the most practical and efficient business philosophy for architecture firms to align with, as well as the most easily recognized type of certification at the global level.

2.4.4 The Living Building Challenge

The Living Building Challenge (LBC) was developed by the International Living Future Institute (ILFI) that is headquartered in Seattle, Washington. This movement adopts the philosophy to design buildings that are regenerative and make health-improving contributions to the local environment. Their mission is summarized in one question: “What if every single act of design and construction made the world a better place?” The LBC uses the clean and efficient design and function of a flower to serve

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38 LEED, “USGBC | U.S. Green Building Council | About/mission-vision”
39 Ibid
40 Ibid
41 International Living Future Institute, “What Is The Living Building Challenge?”
as a metaphor for their seven “Petals” of building performance requirements that include: place (restorative), water, energy (solar), health and happiness (physical and psychological), materials (healthy and safe), equity, and beauty (positive aesthetic). Each building project scope is defined under four typologies: new building, existing building, interior, or landscape or infrastructure. Under each typology, the seven petals are further defined by twenty imperative requirements, with temporary exceptions that may be modified or removed according to material resource limitations.\textsuperscript{42} The LBC Petal Handbook includes a “Red List” of materials that have been deemed to be unhealthy or have an irreversibly negative impact on the environment.

Under the LBC system of requirements and evaluation, buildings may submit their design and construction documentation, show performance documentation for a 12-month period of occupancy, and undergo a third-party evaluation audit to be awarded Petal Certification for: LBC 2.1, 3.0, 3.1, or 4.0 (highest rating), Core Green Building Certification, Zero Energy Certification, or Zero Carbon Certification.\textsuperscript{43}

\textbf{2.5 Hyperlocalization of Architecture, Cradle to Cradle}

In the book “Hyperlocalization of Architecture,” Andrew Michler uses precedent studies of homes around the world to expand a philosophy of building that is “the product of its climate and environment, [as well as] its history, culture, [and] a reflection of the personalities of the people who built it and surrounded it. . . it is based on the history of how people have built in the past, the understanding of how to adapt to climate. Michler argues that designers can learn lessons from the past and use them as template for the

\textsuperscript{42} International Living Future Institute, “What Is The Living Building Challenge?”
\textsuperscript{43} Ibid.
While Michler’s design roots are in the Passive House philosophy, he also draws upon William McDonough’s Cradle-to-Cradle concept of using materials sustainably, where: “A good design creates habitat and abundance, is part of a circular economy, and improves connections, both human and natural. A 'less bad' design reduces the use of raw materials, it requires less pollution to operate, it creates less harm to inhabitants.”

A quintessential example of hyperlocalized construction with the ultimate cradle-to-cradle design can be found in the living-root bridges and ladders of the Khasi Tribe in Northern India. By training the roots of existing, opposing Rubber Fig trees to join across rivers or ravines that run between villages, intertwined to grow through and encase hollowed Betal Nut trunks and thoughtfully selected flat stones, these lasting bridges are self-strengthening as the roots grow more thickly intertwined. They are strong enough to withstand the region’s powerful monsoon rains and floods. This construction technique works with nature without a carbon footprint, and the trees return to the earth to support the growth of new trees at the end of their natural life cycle. Culturally, the Rubber Tree is sacred to the Khasi people and is symbolic of their spirituality and mortality, while the betel nut tree is cornerstone to their betel nut economy.

Michler sets out the challenge to re-localized design that marries site-specific design to carbon negative architectural aspirations of resiliency, sustainability, and regeneration. Using his philosophy, Michler combines the practice of Passive House and Cradle-to-Cradle, to use “healthy, non-toxic materials with low embodied energy [to
build[ the first off-grid and foam-free Passive House in the United States”47 for himself. His MARTaK house was completed in 2016. It has an annual energy use of only 10% of the heating consumption for other similar homes built under current codes.48 The MARTaK house easily generates its own energy supply and has no need to be on the energy grid. Chapter 3.3 in this paper details this home in further detail as a case study.

2.6 Off the Grid or Close To

Each one of these sustainability movements have the common motivation and sense of urgency to reduce net negative effects of buildings to the environment by minimizing energy consumption, using passive strategies, producing energy, encouraging local sourcing of materials, and/or adding benefit to the surrounding environment and inhabitants. All these examples offer potentially positive effects on a global scale that, in turn, naturally enhances human health. The ideal hyperlocalized building that is off-grid composed of cradle-to-cradle materials for today would be one that is composed of healthy, sustainable local resources, uses passive strategies to minimize energy consumption, and produces its own energy supply reliably.

This thesis design project explores designing hyper-localized, off-grid homes in the New England region of the United States, by employing the technologies and philosophies of the movements discussed above.

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47 Michler, Lloyd Alter from “Hyperlocalization of Architecture.” p. 13
CHAPTER 3
OFF-GRID HOUSING

3.1 The Modern Movement

According to architect Lori Ryker, “Off the grid” is a term “that simply refers to systems that work independently from the larger municipal systems [and that] incorporate cleaner energy supplies into our lives. . . . [with] options to ensure that the removal of waste from the home contributes as little as possible to the pollution in our water, air, and ground.”

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The off-grid living system is homeowner monitored, and “draws from ancient concepts of living, simple energy concepts, and advanced technological interpretations of these concepts.”

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Ryker points out in her book, “Modern Homes + Alternative Energy: Of The Grid,” that while the initial cost of building an off-grid home may be higher, the payback period for the effort is often not long. State-issued rebates or subsidies are available for various alternative energy options. Generally, the lifetime maintenance and upkeep for an off-grid system is significantly less than the compounding cost of conventional energy supplier billing cycles.

Ryker continues to explain that depending on the level of municipal system independence, houses may be completely off-the-grid, or “grid-intertied.”

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Houses that are grid-intertied are still connected to municipal systems even though they have transitioned to alternative energy systems for their electric usage, heating, cooling, and domestic hot water. This may be due to city legal requirements, existing grid connections,

or contractual agreements with energy providers (buy-back program). Grid-intertied homes might not have monthly electricity bills, but still rely on municipal water/sewer services or natural gas for cooking.

3.2 Passive Systems

The core goal for off-grid buildings is to maximize passive systems and to minimize active systems. Maximizing passive systems reduces the need to heat or cool a space along with its attached operational costs. To accomplish this, homeowners must have a thorough understanding of the local environment, geographic location, their budget, and the governing legal conditions or community requirements in selecting the home’s energy systems. Adequate insulation and airtightness of the envelope is also essential to the success of off-grid thermal comfort, whether the owner is following Passive House standards or the Living Building Challenge standards for insulation materials and their assigned values.

Lori Ryker states that off-grid systems can be defined by the four elemental categories of earth, wind, sun, and water.52 Because the earth is not only heated by the sun in its atmosphere, but is also heated by its molten core, the earth maintains constant temperatures at incremental depths, with increasingly higher temperatures at deeper depths. According to John Kelly (COO of the Geothermal Exchange Organization), “the temperature of the Earth down 20 or 30 feet is a relatively constant number year-round, somewhere between 50 and 60 degrees [F].”53 Waste composting that generates heat from the aerobic decomposing process also falls under this earth category. At this depth,

the average home can tap into ground source heat without drilling down as far (or needing such an intensely powerful source) as geothermal heat.

Wind energy may be harnessed by large wind turbines, but may be less practical for the typical, singular-use homeowner, compared to other common modes of harnessing energy. According to Ryker, "most domestic-scale wind turbines are 80 to 120 feet tall with blades extending to 21 feet in diameter."\(^{54}\) Although these wind turbines produce exponentially more energy (depending on wind speed) than their PV panel counterparts, their production is optimal only at wind speeds between 8-20 mph, and the wind itself as a source can be unpredictable. Wind turbines also require regular maintenance and adjustments to counteract the wear and tear of the turbine’s spinning parts as well as of weathering forces. Europeans are the first to employ this mode of passive energy collection at a large community scale. They are now at a point in time when their turbine blades have reached the end of their life expectancy and require replacement. As a result, designers are now scrambling to invent creative ways to reuse these weathered blades as playground forms or telephone poles to circumvent this new landfill problem or costly recycling programs that produce lesser-quality materials.

Capturing the sun’s energy by photovoltaic (PV) array panels is currently the predominant homeowner method of collecting passive energy and is also the most reliably clean energy source with little to no maintenance requirements. PV panels have optimal production when they are angled perpendicular to the sun’s position during the summertime, and can harness the most direct exposure for the most daytime hours. Solar energy may also be captured using solar water heaters, where the water absorbs the sun’s

\(^{54}\) Ryker, “Modern Homes + Alternative Energy: Off The Grid.” p. 29
heat and is then directly used for bathing or indirectly used for radiant heat. In colder climates where the water would freeze, glycol is used in its place for indirect radiant heat use.

Lastly, hydro generators harness water to generate power and can be effective for homes that are near a water source. The constant flow of water can be more reliable than then wind, the use of water power to accomplish labor-intensive tasks was used in ancient Roman, Greek, Egyptian, Indian, and Chinese civilizations. Today, hydropower is used to generate power with minimal impact to the course of its water source, at both the macro scale for industrial use as well as the micro scale for homesteads. The collection of rainwater for non-potable use as well as the recycling of gray water also falls under this category. This non-potable water may be sustainably processed to become a potable source by a “living machine” system developed by Dr. John Todd in the 1980s.55

Off-grid houses in regions with more extreme, cold winter climates commonly supplement their heat supply with the use of a higher efficiency, non-catalytic or catalytic, wood or pellet stoves. These models are designed to produce heat with less firewood with minimal ash (an indicator of efficient combustion) and almost no smoke output. The EPA’s mandatory smoke emission limit for wood stoves is currently two grams of smoke per hour.56 With responsible harvesting, forestry maintenance, and renewal, burning wood sources for heat may be a sustainable energy choice. Additional back-up sources for off-grid emergency power supplies include gas or propane generators and DC battery banks with AC power output inverters.57

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55 Todd, “Who We Are: Building the next Generation of Natural Systems for the Treatment of Wastewaters and the Remediation of Degraded Water Bodies.”
56 US EPA, “Choosing the Right Wood-Burning Stove.”
Chapter 4

PRECEDENT STUDIES

4.1 Three Rivers

The largest off-the-grid community existing in the United States is located in rural Jefferson County, Oregon, a mountainous desert plateau with ample Sagebush and Juniper Trees.58 This growing, gated community is living proof that modern-day, off-grid, net zero living can exist at a large scale, and that it can appeal to new home-buyers. It began as a vacation destination in the 1960’s before it became known as Three Rivers Recreation Area, named after the three rivers, that run through it: the Deschutes River, the Little Deschutes River, and the Spring River.59 Spread over 4,000 acres of land, it includes 625 total independent property owners and 90 full-time residents.60 The population can swell to 5,000-6,000 during summer weekends by part-timers and visitors.61 The median house value at Three Rivers is $337,900 according to the World Population Review in 2022.62 Houses range from million-dollar mansions to mobile homes and shacks. Its full-time residents include doctors, welders, students, sales managers, property brokers, and retired professionals.63 Due to easy access to the rivers, boating is a popular recreational activity in this community, and many owners also own boats.

While the nearest utility pole or municipal hookup is miles away from the community borders, its inhabitants do not feel lacking in modern comforts. With 26 miles

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59 Sunriver Realty, “Three Rivers South Community Information”
60 Berkshire Hathaway Home Services, “Three Rivers Recreation Area, Oregon Real Estate: Find Your Perfect Home in Three Rivers Recreation Area!”
62 Data USA, “Three Rivers, OR.”
63 Offgridkindred, “Three Rivers Recreation Area, Oregon.”
of organized, paved roads, the area receives service from the US Postal Service, United Parcel Service (UPS), and FedEx, as well as propane, oil, and septic service. Cell phone service, satellite internet and cable are also available. The majority of owners power their homes with PV panels. A free-standing, 12-panel PV from Abney Solar Electrix can generate 3,200 watts of electricity. The upfront cost is around $25,000, but the investment earns incentivized tax credits from the Federal government and the state. In addition to the PV panels, the cost includes 16 Forklift batteries, an inverter, a diesel generator, and other necessary connecting electronics. Some residents supplement with wind turbines. Storage batteries and backup generators are standard essentials. Many utilize wood stoves for winter heating, and propane gas or diesel for cooking.

Private wells provide water for some homes. But for others, up to five homes can share an artesian well without becoming a public utility. Sharing in this cost is an economical choice as the wells need to be 600-850 feet deep and can cost around $20,000 to drill for and install. For those without direct access to any well, they can have their water hauled and delivered into their water storage cisterns by a friendly neighbor or by Jeff’s Water Service at $0.07 per gallon. According to Jeff’s Water Service, the average water delivery per week amounts to 1,000 gallons.

The community dynamics at Three Rivers is neighborly, with community activity buildings near the water recreational areas, yet largely independent without community memberships or fees. Residents are free to construct their homes to their own preference

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64 Matheny, “Off-the-Grid Living in Three Rivers.”
65 Ibid
66 Frazier, “'Off-Grid' Community Runs on Solar, Wind.”
67 Preusch, “Powering Up.”
69 Preusch, “Powering Up.”
70 Matheny, “Off-the-Grid Living in Three Rivers.”
without communal approval. Its paved roads are in a geometric, grid-like organization between its spread-out inhabitants – the layout is not a complete departure from typical suburban developments, despite not being connected to any municipal utilities. The community is still experiencing steady growth, and residents that move here do not regret their intentional choice to live off-the-grid. According to the Seattle Times, its residents are happy to be off the grid, and would like to stay that way, even if they were given the choice to connect to the grid.\textsuperscript{71}

4.2 Dancing Rabbit Eco Village

While Three Rivers is a sprawling development with independent homeownership on vast total acreage, Dancing Rabbit Eco Village, located in Rutledge, Missouri, follows the Dutch philosophy of community co-housing in affordable, clustered housing units. The houses are confined to 10-15 acres out of the total 280 acres of land.\textsuperscript{72} 160 acres of this land is enrolled in the Conservation Reserve Program for educative permaculture. This off-grid community began in 1997 and currently houses 50 full-time residents that either own or rent.\textsuperscript{73} Since the land is owned under a 501(c)2 nonprofit Community Land Trust, residents build and own their house, but pay a lease for their land at $0.01/sf/month in addition to their Village membership and optional monthly co-op service fees, which covers property tax and shared area maintenance. The average building footprint and land space is 2,500 square feet.\textsuperscript{74} According to their website, the community does aspire to someday grow to a small town of 500-1000 residents.

\textsuperscript{71} Marlowe, “Oregon Community Opts off the Grid.”
\textsuperscript{72} “Eco-Living | Dancing Rabbit Ecovillage.”
\textsuperscript{73} Ibid
\textsuperscript{74} Ibid
On the main page of the Dancing Rabbit website, they describe themselves as:

“a community of people dedicated to demonstrating a certain kind of lifestyle . . . that doesn’t use more than [their] share of resources or produce more byproduct than the systems of [their] environment can process . . . [by their] diets, food preparation, [passive] building design, construction, electricity production, energy use, water use and treatment, transportation, space heating, and more.”75

The community grows 26-49% of their food in organic gardens,76 will often prepare food and enjoy meals together at their large Common House kitchens to minimize food demand or waste, and they have a co-op vehicle share. Tractor and farm equipment are similarly shared so that individuals do not need to buy their own.

Although their homes are not certified under any of the green building standards, they homeowners are motivated to construct efficient, low energy demand homes that utilize passive strategies and that favor intelligent reuse of locally reclaimed, natural materials. Dancing Rabbit describes natural building as “a variety of building techniques that focus on creating sustainable buildings which minimize their negative ecological impact. Natural buildings often rely on non-industrial, minimally processed, locally available, and renewable materials and can also utilize recycled or salvaged timber materials.”77 Their philosophy of sustainable homes and lifestyle could be described as a blend of the Earthship homes and the Living Building Challenge.

Dancing Rabbit homes include the use of rammed earth, clay, wood (timber, post and beam, wattle and daub), stone (earth bag), straw (strawbale, slip straw), and adobe or cob (a sculptural mix of sand, clay and straw).78 All these house construction techniques

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75 “Eco-Living | Dancing Rabbit Ecovillage.”
76 Ibid
77 “Natural Building | Dancing Rabbit Ecovillage.”
78 Ibid
yield a wide array of home styles, sizes, shapes, and aesthetics within this community. The preferred wall insulation of choice is blown-in cellulose. These homes are typically finished off with natural earth plaster or lime plaster walls, earthen floors that are coated multiple times with linseed oil, and some have a living roof that the community livestock (goats, sheep chicken, and rabbits) can access and enjoy.

According to their site, Dancing Rabbit paid special care to learn how to construct sturdy and lasting foundations with minimal use of concrete, a carbon footprint that they wish to avoid. For this, they have opted to use “frost-protected, shallow foundations” that utilize a well-tamped, “rubble trench”\textsuperscript{79} of local limestone gravel, lined with 2” EPS insulation on both sides, and with a perforated drainage tubing running through it to prevent frost heaves. Metal skirting also lines the trenches to discourage tunneling rodents from inviting themselves into these homes. Foundations above ground are constructed with “\textit{Urbanite (reclaimed busted concrete hunks, pieced together and mortared in place), gravel bags (polypropylene bags filled with gravel, stacked brick-style), and poured concrete or block stem walls (often using insulated forms).}”\textsuperscript{80}

Electricity is provided by freestanding PV panel arrays and small personal wind turbines, with battery storage units and backup generators. For heating, residents maximize on passive solar home design as well as Rocket Stoves for wood burning.

For the eco-village’s water use, Missouri experiences abundant rainfall and the Dancing Rabbit homes use stainless steel roofing for rainwater catchment into personal rain barrels or underground, 55-gallon, food-grade polyethylene drum cisterns. They

\textsuperscript{79} “Natural Building | Dancing Rabbit Ecovillage.”
\textsuperscript{80} Ibid
utilize roof washer attachments ("a standpipe with a valve at its base") at the gutter downspouts so that the first few gallons of rainwater, which are the dirtiest, are diverted away from the storage units first before storage begins. The village has also invested in underground 2,000-gallon polyethylene and 14,000-gallon concrete cisterns for co-op communal access.

Lastly, rather than individual septic systems, Dancing Rabbit has a co-op "humanure” system of composting toilets. Simply explained, this system is basically a 5-gallon bucket system that is sprinkled with sawdust or straw after each use, and then emptied regularly into the co-op composting bins. The waste is left to decompose for one to two years at a regulated temperature and yields a pathogen-free, dirt-like organic matter that can be incorporated into garden soil. Joseph Jenkins at the Dancing Rabbit has a published book, “The Humanure Handbook,” that details their research, science, and systems on composting human waste.

The Dancing Rabbit Ecovillage participates in regular, published “Eco-Audits” that compares their resource use to the average American. Dancing Rabbit has also “hosted researchers from around the world resulting in a number of published research projects.” The current Dancing Rabbit Eco-Audit on their website indicates that their members use 95% less natural gas, 92% less water usage per day, 93% less solid waste, and 82% less electricity.

81 “Water Catchment at Dancing Rabbit | Dancing Rabbit Ecovillage.”
82 “Humanure at Dancing Rabbit | Dancing Rabbit Ecovillage.”
83 Ibid
84 “Research at Dancing Rabbit | Dancing Rabbit Ecovillage.”
85 Ibid
4.3 Andrew Michler’s MARTaK Residence

This case study is based on a video-recorded interview of architect Andrew Michler and a descriptive tour of his single family home, located in Loveland, Colorado. The MARTaK home is Michler’s first off-grid, passive house remodeling project. He completed it while writing his “Hyperlocalization of Architecture” book. The annual temperature averages in Loveland can reach a high of 85°F to a low of 13°F. While he admits that he made many mistakes during the two-year construction period of this project, the cost of these mistakes were fortunately offset by his own labor in construction. He approximates that in the end, the total cost of the project is 15% more than an equivalent house. Post-construction, he attests that the home requires very low maintenance and that his daily living energy cost can be counted in pennies -- averaging $0.50 a day for propane year-round, primarily for cooking. The MARTaK house is twice as energy efficient as Passive house requirements and is now Passive House Classic certified. Michler describes his home as a “thermal battery bank,” like a thermos that is capable of retaining heat for days.

To start, Michler repaired and expanded his home’s original foundation with a rammed earth tire wall, covered with eighteen inches of insulation. The floor of the foundation is also composed of rammed earth tires that are laid horizontally like bricks.

For the frame and exterior of the house, Michler used 2x4 lumber with a layer of plywood on the outside that is taped and airtight from the floor to the roof. The cavities of this frame partially contain 16” of cellulose insulation and mineral wool board. Michler intentionally stayed away from insulating foams to adhere as closely as possible to the

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87 U.S. Climate Data, “Weather Averages Loveland, Colorado.”
cradle-to-cradle methodology. The exterior of the house is clad with picket fence lumber as a humble palate and aesthetic that blends in with its rural wooded setting.

The south-facing windows for MARTaK are triple-paned with low conductive framing and spacer materials. The frames of the building’s windows and doors are buried inside the wall insulation, to minimize thermal bridging and potential heat loss or gain at the edges. The main door itself is airtight. He claims that even during the coldest winter temperature, one cannot feel the temperature difference in the home, standing next to a window or to the door. During the summer, a large deciduous tree on the south side of the house provides canopy shade to minimize solar heat gain and keep the interior cool.

The house itself is a simple wedged shape to minimize exterior wall surface, with no windows on its north side – this north side is nestled against sheltering, higher land. Its slanting roof is finished with unpainted galvanized steel and houses two downspouts that directs rainwater into a sediment filter and then into an off-pipe that then collects into a 1,500-gallon storage tank that is tucked under a deck. The roof also holds a modest array of PV panels that more than fulfill the home’s energy requirements, as Michler and his wife only consume a modest 60 watts per day (0.06 KWh) during off-heating seasons. Interestingly, they have never been in need of a backup generator. The entrance of the house is located at its east side, framed by cut lumber from the clearing of the site that is also structural support for its dramatic roof overhang.

Michler claims that his HRV (heat recovery ventilation) system, normally not a heating or cooling source for a home, provides his home with sufficient winter warmth and coolness during the summer. Michler recycled pipes from a previous project to bury into the ground and connect into the HRV intake, a method known as an earth tube
passive system, so that the air is pre-heated by the ground during the winter and is pre-cooled during the summer before it reaches the system and then into his home.

The first floor of the interior of the house is an open floor plan without defined spaces, with exception to the main bedroom and bathroom. The entrance, kitchen, and bathroom have slate tile flooring for moisture durability, but the rest of the ground floors are finished with plywood that is coated with seven coats of polyurethane, in keeping with the home’s theme of basic finishes. The modest kitchen has a concrete countertop and multi-functional covering over his stovetop (for additional counterspace or as a cutting board), with propane fuel for cooking. The upper cabinets are constructed with plywood and sliding greenhouse polypropylene glass panels for its doors. Due to the thickness of the insulated exterior walls, the deep windowsills become extra seating and hangouts, sometimes even an extra desk for Michler’s work. High small windows in the main bedroom and larger low windows in the open living space serve as effective cross-ventilation during the warm months. Taking inspiration from the Japanese, the space under the stairs to the upper level contains storage, with removable plywood boxes that also serve as extra seating or side tables.

The second floor is constructed out of structural 2x4 Nail Laminate Timber (NLT) for its floors, where the 2x4 lumber members are laid horizontally on its 2” side, so that its 4” faces are nailed together to create a solid flooring surface. This NLT also serves as vertical, structural walls on the first floor. The second floor is an open space with sloped ceilings that serve as a unique sleeping space for family visitors or grandchildren. At the top of the staircase, a netted floorspace allows sunlight and ventilation to the top floor. It is a fun place to interact with ground floor friends, or a spot to take an airy nap.
Michler’s video interview ends with a last view of the home’s main entrance porch space under its sheltering overhang, where Michler often likes to view his natural surroundings with his morning coffee. He concludes that “living off-grid re-examines your relationship with yourself and with the natural landscape.”

4.4 The R.W. Kern Center

On a non-residential and more formal level, the R.W. Kern Center (RWKC) at Hampshire College in Amherst, Massachusetts (Figure 4.1), is Living Building Challenge Certified. Their building sets a useful example of how their building systems are set up. They are the 17th building to receive the Living Building certification in the world.99 This 17,000 square foot, two story, stone and timber educational campus building was designed by Bruner/Cott & Associates, Inc. with construction completed by Wright Builders in 2016.90

Although The RWCK is required by law to be municipally connected for electric and water, it is net positive in energy (PV Panel array on their roof, Figure 4.2) as well as net positive in water (achieved through rainwater catchment).

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Fig. 4.1: R.W. Kern Center91
Fig. 4.2: Aerial View, PV arrays92

Image credit: R.W. Kern Center at Hampshire College

88 Dirksen, Designer Builds Efficient Off-Grid Passive House in Colorado.2
89 “About Our Living Building | R.W. Kern Center."
90 Bruner/Cott Architects, “R.W. Kern Center.”
91 “About Our Place Living Building | R.W. Kern Center.”
92 “About Our Energy | R.W. Kern Center.”
They have independent, on-site blackwater processing and manage 100% of their stormwater and graywater. The RWKC summarizes their energy efficiency strategy at their Hampshire College website:

“The R.W. Kern Center’s sustainable design begins with strategies appropriate for a cold climate: optimized building orientation for solar access, robust insulation, an air-tight envelope, exterior shades, and triple glazed windows help mitigate against large swings in temperature and humidity typical of the New England climate. The RWKC’s envelope maximizes thermal efficiency, incorporating both low-embodied energy and LBC-compliant materials. The double-stud cavity wall and roof are [each] filled with cellulose to achieve assembly values of R-40 and R-60, respectively. Tall operable windows help achieve a fully daylight building with a window to wall ratio of 36%. An inverter-driven heat pump system provides heating and cooling to the spaces, separate from the heat recovery ventilation system. By reducing the building’s design energy use, a 118-kilowatt rooftop solar array generates more than enough energy on an annual basis.”

For their rainwater catchment, the building’s aluminum-ridged roof is angled optimally towards the south for their PV panels, with its aluminum ridges running in the same direction as the rainwater that flow into hidden gutters. These robust gutters run along the roof eave and are slightly angled down toward its downspouts on both ends. According to Sarah Draper, the Center’s Director of Educational Program and Outreach, the gutter was covered with a protective mesh at one point but was removed due to clogging issues by the mesh that impeded rainwater collection.

Large, 5,500-gallon94 (12’ in diameter and approximately 12’ deep) concrete cisterns capture the rainwater from the roof downspout. The water is passed through a centrifugal Wizi Filter for large debris, and then a first-flush compartment that diverts the first 125 gallons of water that contain finer rooftop contaminants, like pollen or fertilizer

93 “About Our Energy | R.W. Kern Center.”
94 “About Our Water | R.W. Kern Center.”
dust, into nearby raingardens, before the cistern begins the water collection. The top third of this cistern is visible above-ground (Figures 4.3-4.4).

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95 “About Our Water | R.W. Kern Center.”
A tube inside each cistern floats about 12” below the water surface to pump the collected rainwater into the building basement for further treatment. Once the rainwater has passed through 5-micron filters, 0.3-micron filters, and then UV light filters in the basement (Figure 4.5), it is stored into potable water tanks for building use. Draper notes that the use of rainwater is currently on pause due to recent test results that indicate slight levels of bacteria in the potable water tank, and therefore does not currently pass the Massachusetts code requirement to allow the use of this water in their café.

Stormwater is diverted by landscape swales to gently guide the water into designed rain gardens with wetland plantings (Figure 4.6).

Greywater treatment from handwashing and cafe usage at the R.W. Kern Center follows a very similar method utilized by Earthships. The greywater passes through a perforated, standard 3/4” pipe that is buried 4-6” deep along the inside edge of the indoor planters that are located at the perimeter of the center’s atrium along its curtain wall (Figures 4.7 and 4.8). Some of this water is absorbed and used by the plantings. The rest filters to the bottom of the planter through about 4’ of sandy loam and into another perforated pipe that is slightly pitched toward its drainage exit into two holding tanks in the basement that further filter the water from coffee grounds and grease to allow some
Figure 4.7: View of the greywater planters from above
Image by Author

Figure 4.8: Greywater Plantings
Image by Author

Figure 4.9: Greywater Holding Tanks
Image by Author

Figure 4.10: Opened Tank
Image by Author

Figure 4.11: Anaerobic Wetland
Image by Author

Figure 4.12: Wetland Maintenance Trap
Image by Author
aerobic decomposing (*Figures 4.9 and 4.10*). From there, the water is pumped out of the building into the site’s wetlands for anaerobic decomposing (*Figures 4.11 and 4.12*). Excess water enters a sampling chamber and then it is deposited into a leach field.96

Finally, the R.W. Kern Center does not have a septic or a sewage disposal system for their black water. They employ six composting toilets that directly drop into two composting bins in the basement (*Figure 4.13*). Negative air pressure is maintained in the toilets so that any odors are drawn downward into the composting bins and kept out of occupant spaces. The composting bins are regularly sprinkled with sawdust and mechanically stirred, while an aerating pipe from the roof facilitates the aerobic decomposition of the waste matter. Leachate is pumped out of the bins into storage tanks to maintain the ideal level of moisture for the decomposing process. These leachate tanks are emptied out by a septic service four times a year, on average, and transported to the local waste treatment plant. The remaining compost product is used to benefit the landscape gardens and a developing orchard.

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96 “About Our Water | R.W. Kern Center.”
Figure 4.15 from R.W. Kern Center at Hampshire College’s website below provides a useful visual summary of all the R.W. Kern Center’s water management systems.

Figure 4.15: “About Our Water”
Image credit: R.W. Kern Center at Hampshire College

97 “About Our Water | R.W. Kern Center.”
CHAPTER 5

DESIGN SITE ANALYSIS AND PROGRAM

5.1 Dudley, Massachusetts

The small town of Dudley in Massachusetts (Figure 5.1), located just north of the Connecticut border between the French and Quinebaug Rivers, is an ideal suburban setting that is not densely developed or populated. Dudley has a total population of about 11,500 people on about 20 square miles of land, population density of 572 people per square mile, with median house values at $274,300, median age of 38 years, and 2.56 persons per household.98

Figure 5.1: Central Massachusetts and the Town of Dudley in Massachusetts
Image credit: Rcsprinter123 – Own work, CC BY 3.0,99 Altered by Author

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98 “U.S. Census Bureau QuickFacts.”
99 Rcsprinter123
Dudley was originally inhabited by the Pegan Tribe of the Nipmuck Native Americans, who called their land “Chobonokonomum.” According the Town of Dudley website, “the Nipmucs sold a large tract of land in south central Massachusetts to colonial investors, but reserved for themselves [until it was sold in 1721] five square miles between Dudley Hill and Lake Chaubunagungamaug” in 1681. In 1732, the town was officially established and named after colonial-Massachusetts governor Thomas Dudley. Dudley was largely an agrarian and a dairy farming community, until it built large mills to manufacture cotton and wool textiles during the industrial revolution. In 1832, the portion of Dudley east of the French River, along with several of its mills, became incorporated as the Town of Webster. The Norwich and Worcester Railroad along the French River’s west bank attracted French Canadians, Irish, and Polish immigrants to Dudley to work in its textile mills.

Today, Dudley is a quiet residential area with scattered farm stands and few small businesses, like the Park ‘N Shop supermarket, Home Outlet, Kerrin Graphics & Printing Inc., and Sturbridge Coffee Roasters café. Gentex Optics Inc. and McGee Toyota of Dudley are the larger businesses in Dudley. Dudley has four public schools for children from pre-school to high school. On 50 acres of land on Dudley Hill, that was historically the center of town, is Nichols College (originally Nichols Academy) which was founded by Amasa Nichols in 1815, a wealthy cotton mill owner. Nichols College is currently an accredited, four-year, private institution that offers certificate programs as well as

100 “Dudley: A Brief History”
101 Ibid
102 Ibid
103 Ibid
associates, bachelors, and master’s degrees at their School of Business and School for Liberal Arts and Sciences.\textsuperscript{104}

The Town of Dudley’s website indicates that the town is encouraging sustainable agricultural, bee-keeping, dairy and other livestock farming, as well as forestry back into the culture of the town. It states: “the Town of Dudley has the 2\textsuperscript{nd} Highest Agriculturally Protected Lands, next to Amherst, MA,” where farming is considered a right according to a Bylaw that was established in 2016.\textsuperscript{105} The site continues to define all categories of farming and urges that “Farming and Dudley are synonymous with each other. Clean Air, Clean Water and preservation efforts have allowed Dudley to be at the forefront of supporting farming operations and family farms. If you have an agricultural type business that is dependent on good farm land, good clean water and agriculture in general, you need to visit Dudley and consider moving your operations here.”\textsuperscript{106}

5.2 The Site in Dudley

The site for this project contains three lots along West Dudley Road and its intersection with Southbridge Road. The land sizes for Lots 20, 21, and 22 are 0.36, 2.8, and 2.02 acres respectively, for a combined total of 5.18 acres, or 225,640.8 square feet.\textsuperscript{5}(Figure 5.2, 5.3, and 5.4). It is undeveloped, wooded land with the Quinebaug River running along its eastern border. Homes connected to the municipal grid have been built on the surrounding lots along Southbridge Road. Industrial Transfer & Storage Inc. is

\textsuperscript{104} Nichols College, “History & Accreditation”
\textsuperscript{105} Town of Dudley, “Agriculture”
\textsuperscript{106} Ibid
located directly across the road, northwest of the site, blocking the site’s view of the Quinebaug Reservoir.

**Figure 5.2:** GIS Zoning Map of Lots 20, 21, and 22
The Town of Dudley, MA Mapping Site

**Figure 5.3:** Google Earth view of the site with Residential homes (orange), Business buildings (purple), the Quinebaug River Rail Trail (green), flood line (blue), and vehicular traffic (yellow)

**Figure 5.4** Site at the corner of West Dudley Road and Southbridge Road
Images by Author

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107 “CAI Axis GIS.”
The Quinebaug Reservoir is a 31-acre reservoir that was completed in 1919. Its dam is 55’ and 144’ in lengths, and its “Run of River” mode powers three turbine generators installed by the Low Impact Hydropower Institute that generate 95 kW, 120 kW, and 0.31 MW of power. The “Run of River” mode means that the reservoir waterfalls into the Quinebaug river below (Figure 5.5). Along the reservoir part of the Quinebaug River is a 5.7-mile long Quinebaug Park & River Trail and the Quinebaug River Valley Rail Trail that leads into downtown Dudley (Figure 5.6).

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108 “LIHI Certificate #76 – West Dudley Hydroelectric Project, Massachusetts | Low Impact Hydropower.”

109 Ibid
This tranquil trail was once a railroad for “the Southbridge & Blackstone line of the Providence & Worcester Railroad,” and is now preserved and maintained as a Massachusetts state park. Local residents can often be found fishing or kayaking in the Quinebaug water, or walking and biking along the Park & River Trail during the warm months.

For vehicular traffic, West Dudley Road is a residential, single lane-road that experiences pass-through traffic and fast drivers, as well as semi-trucks and logging trucks. There are no pedestrian sidewalks along either side of this road, although residents do walk by regularly. Southbridge Road, or Rt. 131, runs north toward the town of Southbridge and south toward Thompson, Connecticut. It is a relatively busy single lane road.

Figure 5.7 below illustrates the solar paths over the site, Figure 5.8 shows that the prevailing winds onto the site are from the west.

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110 “Quinebaug Valley Rail Trail | Massachusetts Trails | TrailLink.”
111 solardat.uoregon.edu/SunChartProgram.php for zip code 01571, time zone UTC -4
5.3 Dudley Zoning Laws

Referring to the previous Figure 5.2 zoning map of the site, lots 10, 21, and 22 are zoned as RES-43, single family residential and business (color coded in yellow). The land directly across from it on West Dudley Road is zoned as IND-43, industrial (color-coded in pink). The land across the Quinebaug River bridge is zoned as IND-13, industrial (color-coded in purple).

According to the May 2022, “Zoning Bylaw of the Town of Dudley Massachusetts,”\textsuperscript{113} the front yard setback from a lot’s front property line should be at a minimum of 40’. The back yard and the lot sides should each have a 25’ setback. The building on a lot cannot exceed 20% land coverage or a height of 35’ (see Figure 5.9). Section 7.01.00 limits driveways to 2 per property, or a maximum of 2 houses sharing a single driveway. A driveway must be between 10’-20’ in width, a minimum of 2’ from a roadway intersection corner, and have less than a 6% grade from the curb cut to the end (or 50’).

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Dudley_Zoning_Setbacks.pdf}
\caption{Dudley Zoning Setbacks, Maximum Land Coverage, and Maximum Building Height}
\end{figure}

\textsuperscript{113} “Zoning Bylaw of the Town of Dudley Massachusetts”
For private energy conversion systems, section 3.04.02 states that PV panels cannot exceed 25 kW per unit and must have a 1:1 apparatus height setback if it is installed in the ground. Similarly, wind turbines must also have a 1:1 apparatus height setback, but have a 4’ tall fence around its base with a self-latching gate, and have automatic breaking when the wind exceeds 40 miles per hour, according to section 3.04.02.

The introduction of the July 2018, “Private Well Guidelines” from the Commonwealth of Massachusetts states that:

“a private water supply provides water for human consumption and consists of a system that has less than 15 service connections and either:

(1) serves less than 25 individuals, or (2) serves an average of 25 or more individuals daily for less than 60 days of the year.”  

On page 21, the guideline directs that these artesian wells should have a 10’ setback from all property lines, be distanced at least 5’ from a building, and have a 5’ clearance under any building protrusions. The wells must also have a 25’ minimum lateral setback from roadways as well as from the normal high watermark of any pond, river, lake, stream, ditch, or slough.

5.4 Preparatory Calculations

5.4.1 Photovoltaic Panels

A south-facing 25kW system that receives at least 5 hours of sun exposure produces approximately 100kWh/day, or 3,200kWh/month of electricity.  

\[\text{The optimal}\]

114 “Private Well Guidelines,” p. 1  
115 SunWatts, “25 KW Solar Kits.”
fixed panel tilt in Dudley, derived at 90 degrees from the site’s solar equinox position, is at 42 degrees. If the panels are manually adjustable, solar collection can be optimized by month, varying from 61 degrees at Summer Solstice to 23 degrees at Winter Solstice.

According to the National Grid, the average Massachusetts residential monthly consumption is about 600 kWh/month.\textsuperscript{116} This means that a 25kW system can support up to 5.33 average households. Since the site is comprised of three lots, up to three 25kW systems can be installed according to the Dudley zoning laws as stated in Chapter 5.3, resulting in a potential, maximum energy coverage for 16 households on this site.

### 5.4.2 Rainwater Collection

The average rainfall in Massachusetts is at 48 inches per year.\textsuperscript{117} This means that there are 4 cubic feet of rainfall per square foot per year, which converts to 30 gallons of water per square foot per year. Therefore, each horizontal square foot value of roof is capable of collecting 30 gallons of water per year.

According to UMass Amherst’s Center for Agriculture, Food, and the Environment, the rule of thumb for total greenhouse gardening water usage averages to 0.4 gallons per square foot per day, a peak-usage value for the warmest day.\textsuperscript{118} This converts to 146 gallons per square foot per year.

This means that each square foot of greenhouse will require 4.9 horizontal square feet of roof surface to capture the sufficient total amount of rainwater for greenhouse food production use.

\textsuperscript{116} National Grid, “Electric Rates Set to Decrease May 1 for National Grid Customers in Massachusetts.”
\textsuperscript{117} ResilientMA, “Changes in Precipitation.”
\textsuperscript{118} University of Massachusetts Amherst, “Sizing the Greenhouse Water System.”
5.5 Site Program, Goals, Intentions

In alignment with Malcolm Well’s desire for minimal disruption to the landscape environment as well as fulfilling beyond Dudley’s zoning maximum for building land coverage, the site development will not exceed 20% tree removal (20% of 5.18 acres is 1.036 acres, or 46,000 square feet) and include minimized vehicular pavement. This circulation surface should be constructed out of a permeable pavement, like gravel or laid pavers. This project can use the lumber from its on-site trees, either rough cut onsite, or sent to a local sawmill facility.

To stay under the 20% land coverage perimeter, this project will consist of 9 homes that share resources to split initial building costs as well as drive long-term maintenance costs down for each resident. Two 25kW PV panel systems will be sufficient to power these 9 homes.

Like the Dancing rabbit co-housing community, there should be a balance of common area opportunities and separate individual/private space. The common areas should include a common house or spatial structure for larger gatherings and activities, outdoor gardening for shared food production, and community parking.

Since the Quinebaug River and its Park and River Trail is such a pleasant feature adjacent to this land, residents should have equal access and views to the river.

In reference to the United States Census Bureau statistic, which states that the average household in Dudley has two to three people, the housing and building systems program for this project (Figure 5.10, on the following page) will include 1-4 bedroom homes: four, single story, 1-bedroom houses, each at 900 square feet; four, double story, 2-bedroom houses, each at 1,500 square feet; and one, double story, 3–4-bedroom house,
at 2,000 square feet. Each house should have its own composting toilet system, PV battery storage, and indoor greywater planters (step one out of three for greywater treatment).

Figure 5.10 Thesis Project Program and Building Systems
Each housing grouping should have a greenhouse for year-round food production, as well as a shared artesian well, rainwater collection and processing, basement greywater filtration tank processing (step two out of three for greywater treatment), and a 25kW rooftop or ground solar array.

Finally, as stated before, the community will share a common social space, outdoor gardening, final outdoor greywater processing wetlands, and sheltered parking.

Following this thesis program, the mini-community will be completely self-sufficient and independent from Dudley’s municipal grid in energy, potable water, greywater processing, and blackwater waste management.
CHAPTER 6
DESIGN PROCESS: MASSING AND SITE ITERATIONS

6.1 Initial Site Planning Iterations

The project’s first dozen diagrammatic iterations (Figure 6.1) loosely explored numerous possible general site layouts: are the homes clustered or spread out? How are they orientated on the site? What is their relationship with each other vs. their relationship to the river or to the road? How does onsite vehicular or pedestrian traffic

Figure 6.1 Initial Dozen Site Planning Iterations
circulate to access the homes? Where does the community place their communal center and gardening space? These first site iterations began with basic, rectangular homes in orange, a red common house, a green greenhouse, light green garden space, and manually adjustable PV panels arranged on the ground.

6.2 Radial Cluster: Initial Massing and Floor Planning Iterations A and B

Inspired from the clustering configurations in the last row of Figure 6.1, an exploration of a non-conventional, radial home layouts emerged, where the homes surround a central garage and greenhouse that also connected their shared water processing systems (Figures 6.2, 6.3, 6.4).

![Figure 6.2 Radial Cluster Site Plan Iteration A](image)
In the next iteration of this radial cluster, the greenhouse is removed from above the garage and replaced with a sawtooth rooftop that collects rainwater and also houses PV panels. The greenhouses are integrated in between housing units for ground floor access instead. This iteration also attempts to incorporate earth sheltering and green roofs.
Figure 6.6 Radial Cluster B Greywater Processing and Rainwater Collection Diagrams

Figure 6.7 Radial Cluster Iteration B Massing Illustration
This earth sheltered radial cluster massing iteration ended up not being the ideal configuration for its awkward landscaping as well as the garage becoming the central space, rather than a more pleasant outdoor landscaping space. It also presented problems with the inability to orientate each housing unit for optimal passive solar gains during the lengthy, New England cold weather season.

6.3 Cardinal Clustering: Massing and Floor Planning Iteration C

This iteration was short-lived for the amount of land space that it occupied onsite as well as its rigid, formal configuration. But it was a useful exercise of aligning greywater systems between the units, as well as its connecting relationship with central greenhouses. In this iteration, the main greenhouse and central landscaping became the common space for gatherings and activities, while the parking garages with rear access become less focal.

*Figure 6.8 Cardinal Clustering Iteration C Floor Plan*
6.4 Fanning Clusters: Massing and Floor Planning Iteration D and E

This iteration (Figure 6.11) was the most successful and defined the essential configuration, orientation, and relationship with the landscape that would carry into the design proposal.
In the next step, the housing units were shifted together in such the way that they had more deliberate shared walls to accommodate joint ventilation as well as plumbing for both potable well water and grey water processing. The joint walls also reduce internal heating and cooling energy losses. The resulting site plan began to take shape (Figure 6.12) with central landscaping and gardening, as well as a common area gazebo.

![Figure 6.12 Fanning Clusters Iteration E Site and First Floor Plan](image)

The building shape and orientation were influenced by the following diagrammed solar and river/central landscape view motivations (Figures 6.13 and 6.14).

![Figure 6.13 Solar Orientation](image)  
![Figure 6.14 Views Orientation](image)
CHAPTER 7
THE FINAL HOUSING SYSTEM AND SITE DESIGN

7.1 Final Site and Roof Plan

The final site and roof plan (*Figure 7.1*) has two vehicular entries into the site. Since the entries also function as exits, an emergency vehicle turn-around is not needed. The three sheltered parking areas accommodate a total of 20 parking spots, for 16 total housing bedrooms. Guests to this site also have the opportunity to park alongside the drive.

*Figure 7.1 Final Site and Roof Plan*

From parking and arrival, the site opens into a landscaped native-garden entry, food producing gardening plots, and a greywater wetland plot divided by a path that
circulates around a community apple tree and leads to a grand community pavilion. This pavilion houses a large fireplace and wood-burning pizza oven.

Each house rooftop is sloped toward the sun to accommodate solar panels. The sawtooth rooftop of the sheltered parking also accommodates solar panels. The resulting maximum capacity of solar panels that this design can support is almost 2.5 times the calculated required amount. Residents at this off-grid community have the option of installing only what they need or installing more to become net positive. Perhaps the surplus from being net positive may be packaged in some way to beneficially supplement the surrounding gridded community, while remaining off-grid.

7.2 Building Configurations and Perspective Elevations

Figure 7.2 includes a diagram that illustrates how the 1-bedroom homes are stacked and connected to the 4-bedroom home, with the cluster of 2-bedroom homes on the other side of the central landscape. The corresponding west entry (top right) and east river (bottom right) perspective elevations are shown next to the Units Diagram.

Figure 7.2 Final Housing Units Diagram and Site Perspectives
The overall footprint for the houses, pavilion, and covered parking combined is 11,836 square feet. The entire land development, including the drive, occupies 31,952 square feet of the site. Both of these totals are well under the 20% land coverage maximum of 46,000 square feet; this design requires that under 20% of the site trees to be cleared away.

Figure 7.3 is a compilation of north and south perspective elevations pairs, one pair for the north cluster of homes (right column) and one pair for the south cluster of homes (left column). The middle row of two perspective elevations are the building elevations that face the designed site’s central landscaped common space.

*Figure 7.3 Final Southeast Perspective View, North and South Perspective Views*
7.3 Final Floor Plans

The two artesian wells that pump potable water into the fanning north and south home clusters can be found in the ground floorplan (Figure 7.4). The entrances into each home are also indicated by red arrows in this floorplan.

The north cluster bedrooms are located to the north, the quieter side that also receives ambient northern light. The bathrooms are also located on the north side to save the sunny southern daytime spaces for the kitchen, dining, and living rooms in both clusters. These semi-private, social spaces are gently angled eastward for the river view.

In the second floor plan (Figure 7.5), the 1-bedroom units on the second floor replicate the first floor in the north west cluster. Each of the bedrooms of the northeast 4-bedroom home have full to partial view of the river. The bedrooms of the 2-bedroom homes in the southern cluster are orientated south-east for view and away from the central community space for quietness. An interior view of a second floor dining room in
a 1-bedroom, northern cluster home illustrates the use of the indoor greywater planters, located under windows that have a nice natural view to the outside and of the river.

Figure 7.5 Final Second Floor Plan, 2nd Floor Dining Interior View, View of the Quinebaug River

7.4 Building Systems

The diagrams in Figure 7.6 detail how the rainwater is collected off of the roof, into joint cisterns, and then filtered and UV processed in the basement for potable use. It also details how the greywater is processed in three steps: (1) indoor planters, (2) basement filtration tanks, and then (3) discharged into designated, downhill wetlands – one in the central landscaped area for the northern cluster, and one at the southern tree border for the southern cluster.
The final sectional diagram (Figure 7.7) addresses the buildings’ solar orientation, envelope materials, ventilation, heating, and cooling systems. The southern roof overhang for each building is more significant than the north to effectively defend its windows from summer solar gains, but allow winter solar gains. The winter shadow casted by the southern cluster also clears the front of the northern cluster, allowing the northern cluster to still receive full sunlight. The gardening plots in the central landscape should also receive sufficient summer and equinox sunlight for productive vegetation.

The building envelope includes a metal roof that is hybrid insulated, double-stud walls with sustainable HempWool insulation, and vertical, Rice Hull shiplap siding for cladding.
Figure 7.7 Final Building Systems: Passive Solar, Envelope, Power, Ventilation, Heating and Cooling

PV panels are located on the roof that feed into battery storage in the basement. The mini-splits that cool and heat the space feeds from these batteries, as well as the HRV systems and water heating systems. A heat pump for radiant floor heating provides a baseline source of winter heat.

Lastly, the second floor bathroom water closets are indirectly stacked (or offset) above the first floor water closets for direct drop deposits into their composting unit in the basement.
CHAPTER 8
POST-DESIGN DISCUSSION AND EXPANSION

8.1 Revisiting Design and Research Considerations

A general accolade for this project included the belief that neighboring homes would look toward this mini-community for help in the event of a local power outage or related weather disasters. A good addition to its design could be a communal shelter space. Revisiting the potential surplus of solar energy production, perhaps the community could also offer vehicle charging stations to its neighbors beyond its own resident needs. Other design considerations to revisit may be to develop a stronger aesthetic “trademark” architectural statement, as well as to promote the longevity of the homes as our society continues to transform into the next decades.

Some additional research to further enrich this project’s design development could be to investigate indigenous off-grid groups in the United States as non-capitalist communities that live this way out of necessity, as well as for their historical connection to our land and its resources.

Another design consideration to investigate and clarify could be the mini-community’s social construct. Would it have a governing co-op committee that handles property management and the yearly property taxes, or would each resident have complete autonomy and ownership over their portion of the property? This may be a question that only interested parties and potential residents can answer, according to the way that they wish to live.
8.2 “What Ifs” and Beyond

A discussion that arose post-design involved the question of project funding to aid in affordability. How much of this project could be federally funded or state funded though green deals, grants, or incentive programs? More research and probably some activist pursuit would need to happen to answer this question, as well as to amass interest into moving this project into reality. Massachusetts is very interested in moving itself toward Net Zero within the next few decades. Projects like these can help to achieve this goal faster, so its representatives may be open to offer resources or funding to help the process along.

Another thought to improve upon affordability for a mini, off-grid community like this by the average, middle-class resident could be achieved through the development of a co-op business structure, in addition to its governing social structure. Perhaps the site could generate an income for the community, for example, via selling the production of food like CSA (community supported agriculture) programs. Perhaps another space needs to be created in the site for raising small livestock like poultry. Or, like the Dancing Rabbit Ecovillage, the community could offer temporary residence and classes in sustainability, as modeled by the community itself. Leaning further into sustainability and into health, what if the site had a few outdoor sauna units in close access to the river so that the this mini-community could offer careful hot/cold Scandinavian health treatments?
CHAPTER 9

THESIS CONCLUSION

The goal of this thesis is to explore the normalization of off-the-grid housing in suburban settings. It should not be reserved for those who have the luxury to retreat “into the wilderness,” or require one to entirely disconnect from contemporary suburban lifestyles. The technology exists to create off-grid communities that are self-sufficient and minimize their impact on the local environment. As such, the aim of this thesis is to propose a thoughtful design for off-the-grid housing that is replicable and that serves to counteract misconceptions, as well as to educate people about what off-the-grid housing could be. A self-sufficient property or mini-community can exist within existing gridded communities without disrupting the local community. Critically, a home that is free of municipal bills and reliance on fossil fuel based power reduces the lifetime financial burden, while increasing functional security and longevity, for its owner and future generations in that home.
BIBLIOGRAPHY


