CONTEXT CONSERVE CONSTRUCT

Ball State University
Urban Single-Family Division

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Profiles

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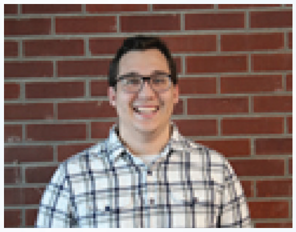

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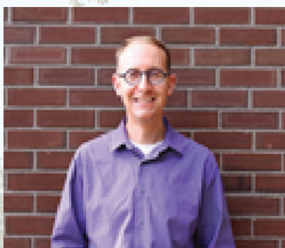

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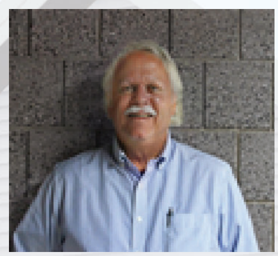

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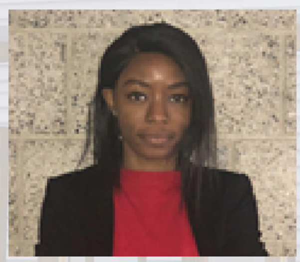

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Greater Muncie, Indiana
Habitat
for Humanity®

Greater Muncie Habitat for Humanity
Community Partner
CEO, Lindsey Arthur

CITY OF MUNCIE, INDIANA
1865

City of Muncie
Community Partner
Historic Preservation
& Rehabilitation
Commission

CONTEXT

Any new construction that takes place in the Emiliy Kimbrough Historic District should be compatible with existing structures in terms of its:
- style
- configuration
- scale
- materials
- setback
- roof pitch and shape
- and facade pattern.

CONSERVE

All DOE Zero Energy Ready Homes must meet ENERGY STAR requirements in their:
- envelope
- duct system
- water efficiency
- lighting and appliances
- indoor air quality
- renewable readiness

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- The living space provided should not exceed 1,230 square feet for a four-bedroom house
- Four-bedroom houses can have 2 full bathrooms
- Houses should be ADA accessible on first floor
- Houses should be able to be constructed with a volunteer force (comprised roughly of 50-60 year-olds in Muncie, Indiana)

CCC

Although it may seem challenging to design within the regulations of three separate entities, we at “CCC” embrace the guidelines of our community partners to create a beautiful building that will inspire new construction in an old neighborhood, act as a catalyst for net-zero design practices in a city that is in the midst of a major revitalization, and establish a prototype of a two-story construction practice for a non-profit volunteer force.

Introduction

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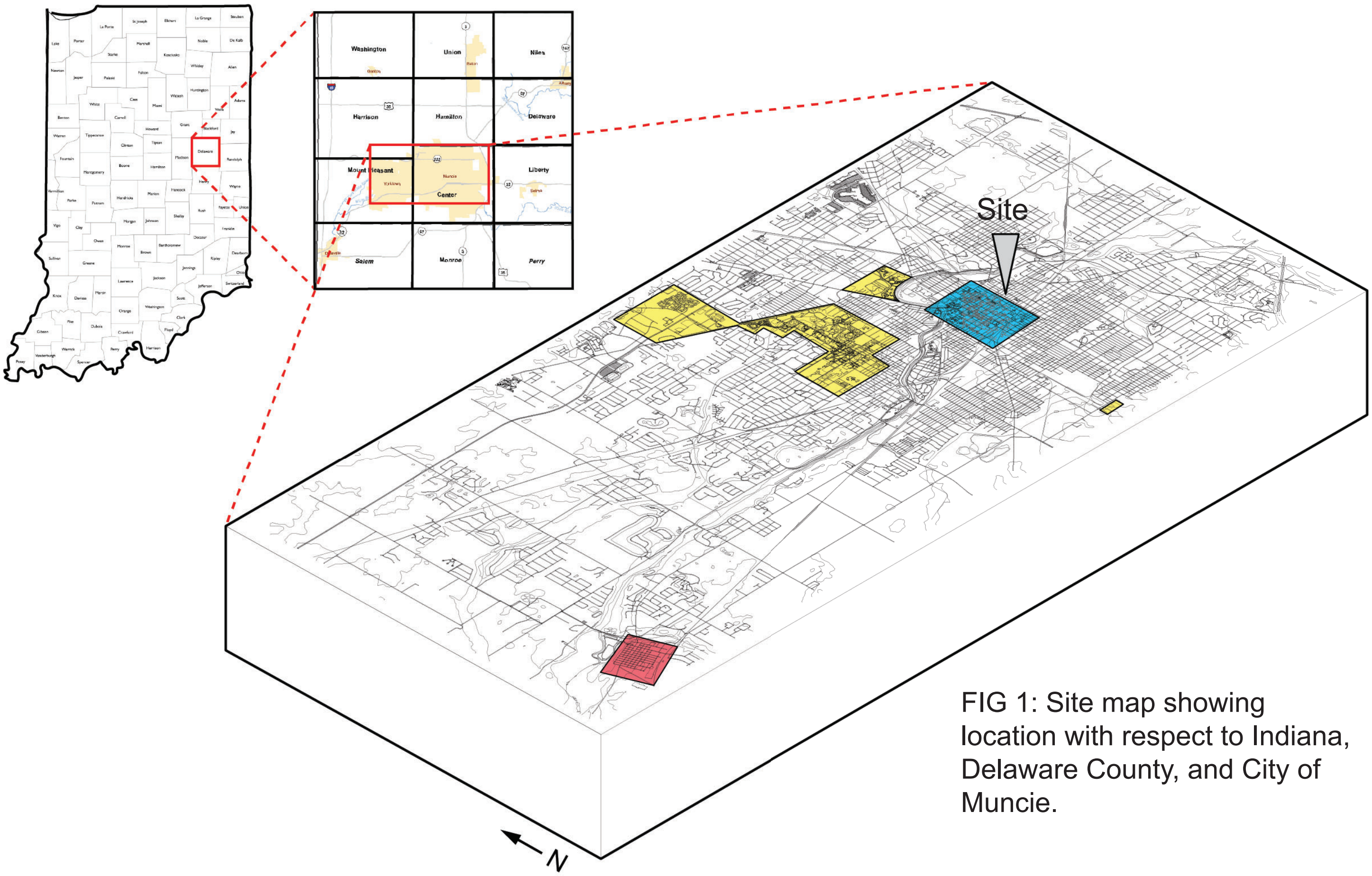

FIG 1: Site map showing location with respect to Indiana, Delaware County, and City of Muncie.

Site:

The project site location is a 37’x125’ parcel located at 717 E Main Street in Muncie, Indiana. The original house on this land parcel was recently torn down after being destroyed in an electrical fire. Since the fire, the house rubble has been removed and the site now remains as a grassy open space. In order to build a new construction home in the Emily Kimbrough Historic District, the new home must meet the Historic District Design Review Guidelines. One of the biggest design criteria that new construction must meet is that the home must be built taller than the lowest home height in the neighborhood and shorter than the highest home in the neighborhood. Because of this historical district requirement, we are tasked with building a two-story home, something that our community partner hasn’t done in over thirty years. Another constraint of the site is that the parcel is oriented North and South and is very narrow. Due to this constraint, the site is not ideal in collecting the maximum amount of solar collection. The site is also located in climate zone 5A, which is a cool humid climate. Because of this climate zone, Muncie experiences a large range of seasonal changes, with the summer months being often humid and warm to hot and the winters being cold to severely cold. The temperature fluctuation that occurs over the course of a year means that, it is important to control the thermal, water, vapor and air bridging in the wall, roof and foundation assemblies, using exterior cladding systems that are resilient in the different temperature ranges and fluctuations, and mechanical heating and cooling system that can heat and cool the home in a wide range of temperatures.

Neighborhood:

During the late 19th and early 20th centuries, the East end of downtown was the preferred neighborhood of the Muncie's most prosperous citizens. Most of the homes in this neighborhood were constructed after the discovery of natural gas in Delaware County in 1886 that caused a gas boom, transforming Muncie into the commercial and industrial center of the East Central region of the state of Indiana. Many of the people that profited from the gas boom built the homes in this neighborhood. One of these prevalent figures in the history of Muncie that built a home in the neighborhood is James Boyce, who is responsible for bringing the Ball Brothers to Muncie. Because of the success of the Ball Brothers' glass jar factory the family has been generous in their philanthropic support for Muncie institutions such as, they have invested generously into the community of Muncie, creating and/or supporting Ball State University, the local YMCA, Camp Crosley, Ball Memorial Hospital, the Masonic Temple, the American Legion, and the Minnetrista Cultural Center.

Some of the finest historic homes exist in the Emily Kimbrough district and includes styles such as, homes from Late Victorian and Post-Victorian. Over the course of the history of the neighborhood, architectural styles, such as Greek Revival, Italianate, Queen Anne, Free Classic, and Colonial Revival. These styles have created have created an eclectic group of architecture that shows how the shifting tastes of architecture have changed over time. This rich history and incredible collection of architectural styles and homes lead to the neighborhood being designated as a national and local historic district in the late 70's. This district is named after Emily Kimbrough, a Hoosier author that lived on Washington Street in the neighborhood when she was a child.

Architectural Styles in the Neighborhood

FIG 2: Emily Kimbrough Historic District

1. Colonial Revival
2. Free Classic
3. Italianate
4. Victorian Vernacular
5. Queen Anne

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Client:

Our client for this project is the Greater Muncie Habitat for Humanity relies on sweat-equity labor and donated items to construct a large portion of the home. For example, they receive a variety of free products from partnering companies that help reduce the total cost of the home. The sweat equity comes from the volunteers (typically ranging from 55-60 years-olds) who help with the interior, landscaping, painting, trim work, hanging of cabinets, putting on the siding, etc. Designing for easier construction methods and volunteer with limited skills and knowledge will allow the home to ultimately be built in a higher quality standard. In terms of the labor that is responsible for assembling the building, they currently pay contractors to pour the footers, foundation and slabs, lay block, run electrical, lay plumbing, installation of heating and cooling systems, hang drywall, shingling the roof. Greater Muncie Habitat for Humanity also rents all the necessary equipment, such as cranes to place the trusses, throughout the construction process. It is integral to the Emily Kimbrough Historic District that new infill projects be two stories, yet Habitat for Humanity Muncie hasn't built a multi-story home in over 30 years. Therefore, the client's needs and organizational structure presented several constraints that shaped and strengthened the proposal.

Occupant:

Greater Muncie Habitat for Humanity begins the process of building a home by selecting a family. Habitat receives a wide array of applicants, from single people with no children to young families with children to people over 60. One constraint through this selection is that many of Habitat clients stay in their home for 15 years and longer. Because of this time frame and wide age demographic, designing an ADA compliant home is a very exciting opportunity to help support Habitat's mission of building a home for every walk of life. Habitat is a nonprofit, therefore, they must sell the finished home at the appraisal value and not the developmental cost. Typical Habitat for Humanity Muncie homes are in a nonprofit 503 (c) (3). Because of the occupants that typically buy Habitat homes the ost is important. The challenge is how to shift some of the design focus away from first cost to opperational cost to make an argument for ZERH homes. It is very important to build a home that is built to be efficient through its selection of materials, amount of materials used, solar orientation to maximize PV collection, mechanical systems and minimized plug loads with energy efficient equipment, in order to build a less-costly yet net-zero ready home.

Compliance:

- Indiana Residential Code (IECC 2009)
- Comprehensive zoning ordinances for the city of Muncie, Indiana
- Historic Emily Kimbrough Neighborhood Design Review Guidelines
- Habitat for Humanity's U.S. Sustainable Construction Standards
- U.S. DOE Zero Energy Ready Home Requirements (Rev. 06)
- - Energy Star Qualified Homes V.3
- - Duct system within thermal and air barrier
- - Energy Star Qualified Lighting, Appliances, and Ventillation
- - Certified under EPA Indoor airPLUS
- - DOE PV Ready Checklist
- - EPA WaterSense Single-Family New Home Specification
- - Envelope: Fensestration meets Energy Star requirements/other assemblies meet 2012/2015 IECC

Design Goals

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Create a net-zero housing prototype for Habitat for Humanity that can be reconstructed with their current volunteer force and financial limitations

- Meet a typical price point for a potential renter/homeowner
- Comply with Habitat for Humanity's construction standards
- Exceed Habitat for Humanity's current sustainability practices

Strengthening the East Central Neighborhood

- Set a precedent for infill housing in a neighborhood that has very limited new construction
- Bring more residents to the neighborhood by offering new construction housing stock
- Proactively offer affordable housing options in a neighborhood that is going through revitalization
- Demonstrate that we can design an infill project that is sensitive to the historic district

Improving a vacant lot

- Address historical homes' proportions and architectural features without duplication
- Bring a more contemporary feel to the neighborhood as to not compete with the authenticity of the existing buildings
- Use traditional materials in a contemporary way
- Show the opportunities of how passive and active systems can be incorporated into a home on such a small, parcel of vacant land

Work with Greater Muncie Habitat for Humanity's current construction practices and material choices

- Redesign a more aesthetically interesting architectural language for Greater Muncie Habitat for Humanity
- Consider the materials Greater Muncie Habitat for Humanity receives through donations
- Discuss with Greater Muncie Habitat for Humanity the value of certain materials that they don't typically use and why these materials' energy performance and aesthetic qualities deem them fit for the project

Introduce passive strategies, active strategies, and future growth over the course of three phases of design

- Place all plumbing on a central core that will help reduce the amount of space devoted to plumbing and the amount of materials needed
- Use passive systems to help reduce energy loads that will allow for minimal active systems to reach the net-zero energy total
- Design with passive elements, like cross ventilation and a sunroom on the second floor, that will help reduce heating and cooling loads
- Provide a master plan for the owners that will encourage future expansion of a garage or other exterior structure that will allow them to make the space their own while increasing the solar array on site

Market Potential

Habitat for Humanity Muncie is a non-profit that aims to provide affordable housing for everyone in the community, which promotes positive and lasting social, economic and spiritual change within. An interesting aspect of all of the tradition homes that Habitat for Humanity Muncie builds that needs to be considered is that the last time they built a two story home was over thirty years ago. Due to the Emily Kimbrough Historic District Neighborhood requiring that all homes of new construction need to be built taller than the shortest home, but not taller than the highest home, Habitat for Humanity Muncie has to build a two-story home. The current demographic of the families that are selected for Habitat for Humanity Muncie to build a home for are usually single families without children, a home in this neighborhood becomes an opportunity to support a different demographic of people within the community.

While the opportunity to help build the community comes through the use of sweat equity of volunteers that help build Habitat for Humanity Muncie homes, the demographic who helps construct these homes needs to be considered during the design process of this project. Historically, Habitat for Humanity Muncie volunteers range in age from 55-60. Due to this demographic range, it is important to consider building homes that are easy to assemble and are easier on the physical side of the construction process.

Traditionally, Habitat for Humanity Muncie families stay in their new homes for 15-20 years. Habitat for Humanity Muncie also aims to provide homes with lower utility bills because a typical Muncie Habitiat family of 4 makes on average $17,000-$32,000 a year. Because of this, it is important to consider certain design strategies and equipment that can be used to help reduce the amount of money the families pay to cover utilities. It is also important to consider that because Habitat for Humanity Muncie is a non-profit organization, there is a budget for the home. Because of this budget, the house needs to be built as efficiently and with the highest quality while on a low budget due to the fact that a Habitat for Humanity Muncie home is sold for the appraised value, and not the developmental cost.

- There is limited housing stock for sale in Muncie
- There is a severe lack of new construction available to buyers
- This project attempts to keep filling in the blighted areas of Muncie and help fuel new housing stock
- Revitilization in the Emily Kimbrough Historic Neighborhood makes it attractive to buyers

Market Potential

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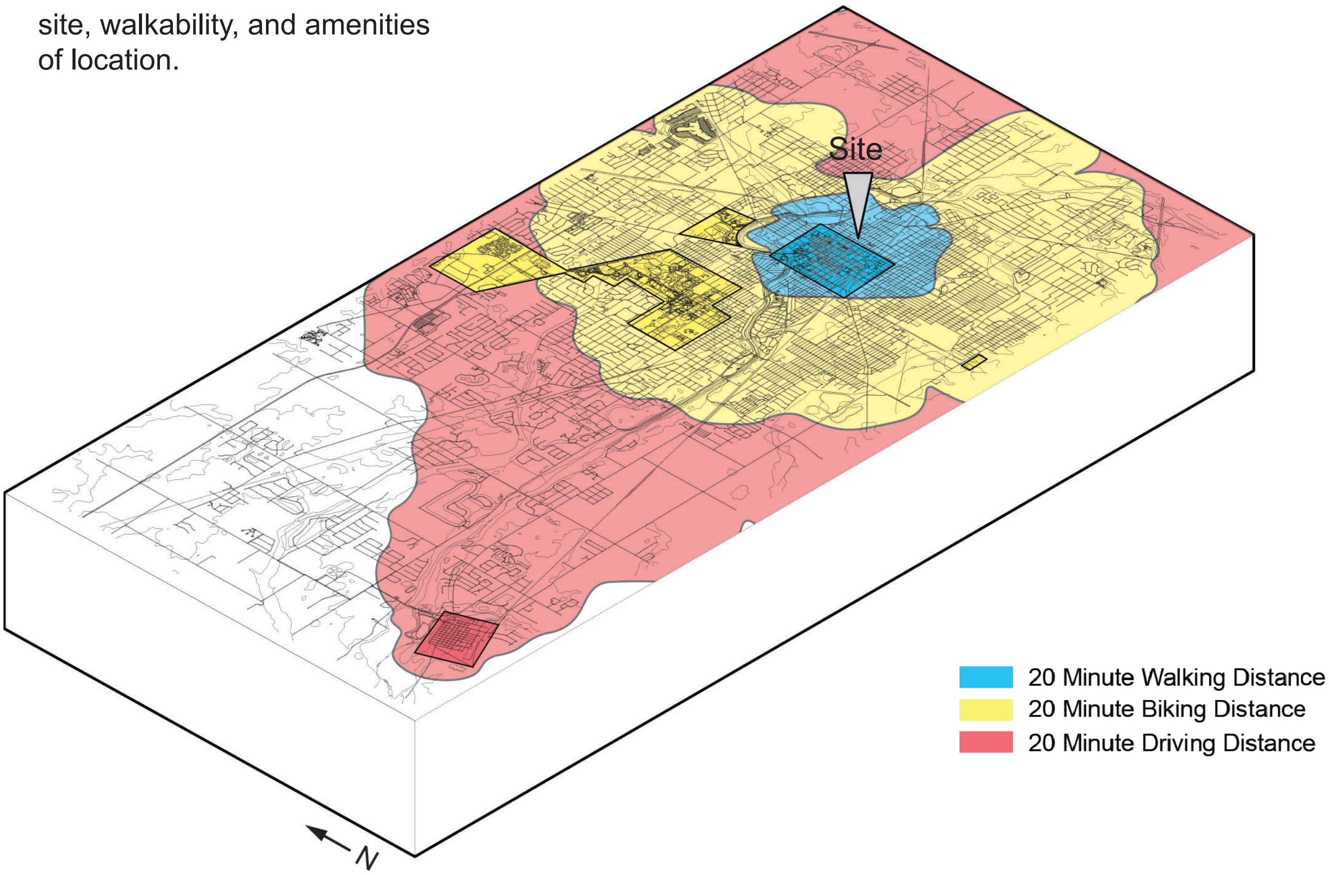
FIG 3: Travle distances from site, walkability, and amenities of location.



The Historic Emily Kimbrough District located in the East Central Neighborhood of downtown Muncie, Indiana is adjacent to a wide range of key amenities available to all age groups. Within 20 minutes of walking, biking, or driving, homeowners in this neighborhood can visit community makerspaces, arts centers, a newly revitalized downtown urban core, an expanding library and market pavillion, Ball State University, and a large community park and outdoor event space (see diagram for just a few of the many amenities available in the area). This array of conveniences is important since Habitat for Humanity and the Historic Emily Kimbrough District both service a range of demographics, and typical Habitat for Humanity homeowners only stay in their homes for an average of 15-20 years. Since this area of Muncie is accommodating and attractive to many different types of people, Habitat for Humanity should have no problem finding families, students, or singles to fill this house that is an atypical model for Habitat.

Market Potential

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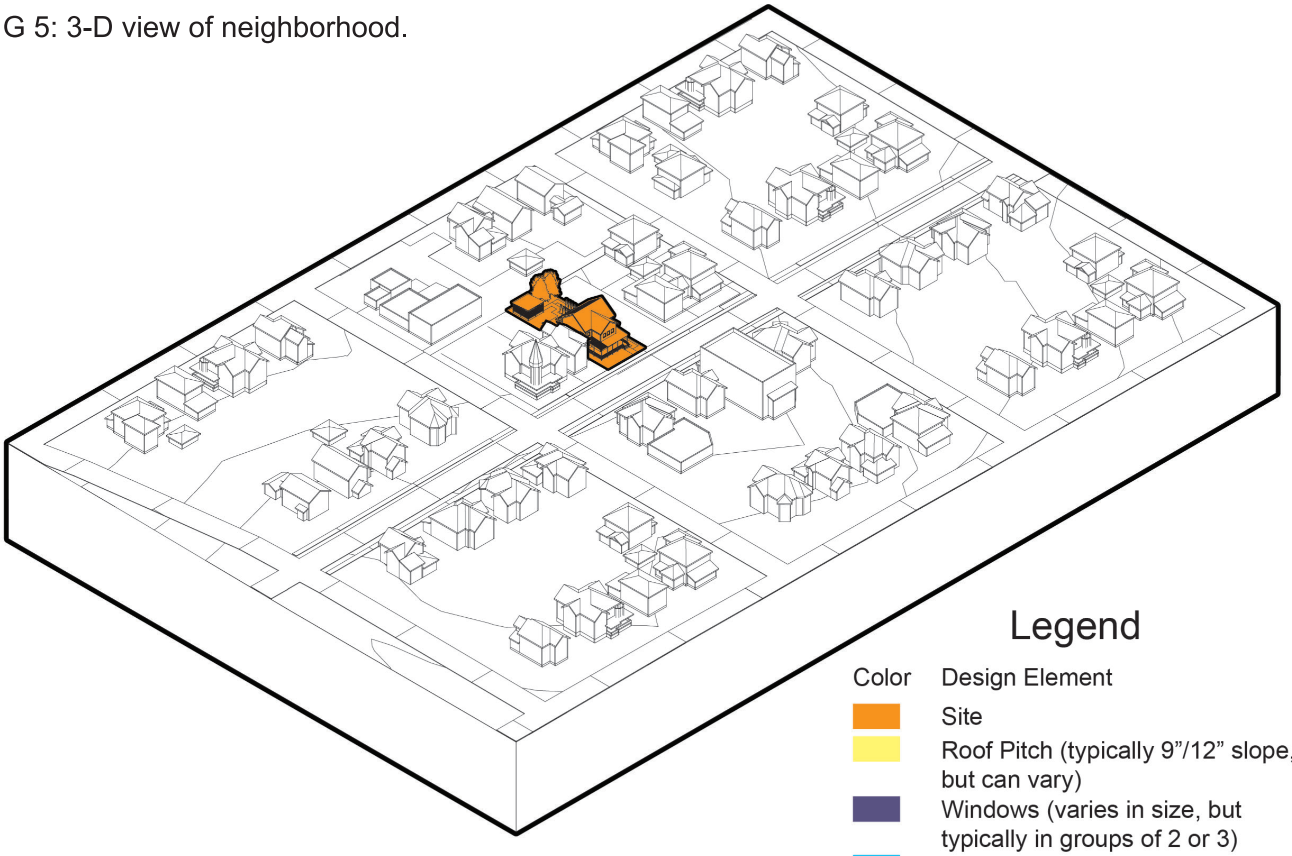
1. MadJax - Community Makerspace
2. Cornerstone - Arts Center
3. YMCA of Muncie
4. Revitalized Downtown Muncie
5. Maring-Hunt Library and Pavillion
6. Ball Hospital
7. Ball State University
8. Minnetrista - Community Park
9. Revitalized Downtown Yorktown

Dashed boxes are related to colored areas of previous page graphic.

FIG 4: Local amenities.

FIG 5: 3-D view of neighborhood.



Legend

Color	Design Element
Orange	Site
Yellow	Roof Pitch (typically 9”/12” slope, but can vary)
Purple	Windows (varies in size, but typically in groups of 2 or 3)
Blue	Front Porch (1/2 or fully wrapped)
Red	Recessed Entrance
Green	Street Stepback (5-10 ft)

FIG 6: Analysis of charater defining features of homes in neighborhood.

Design Process

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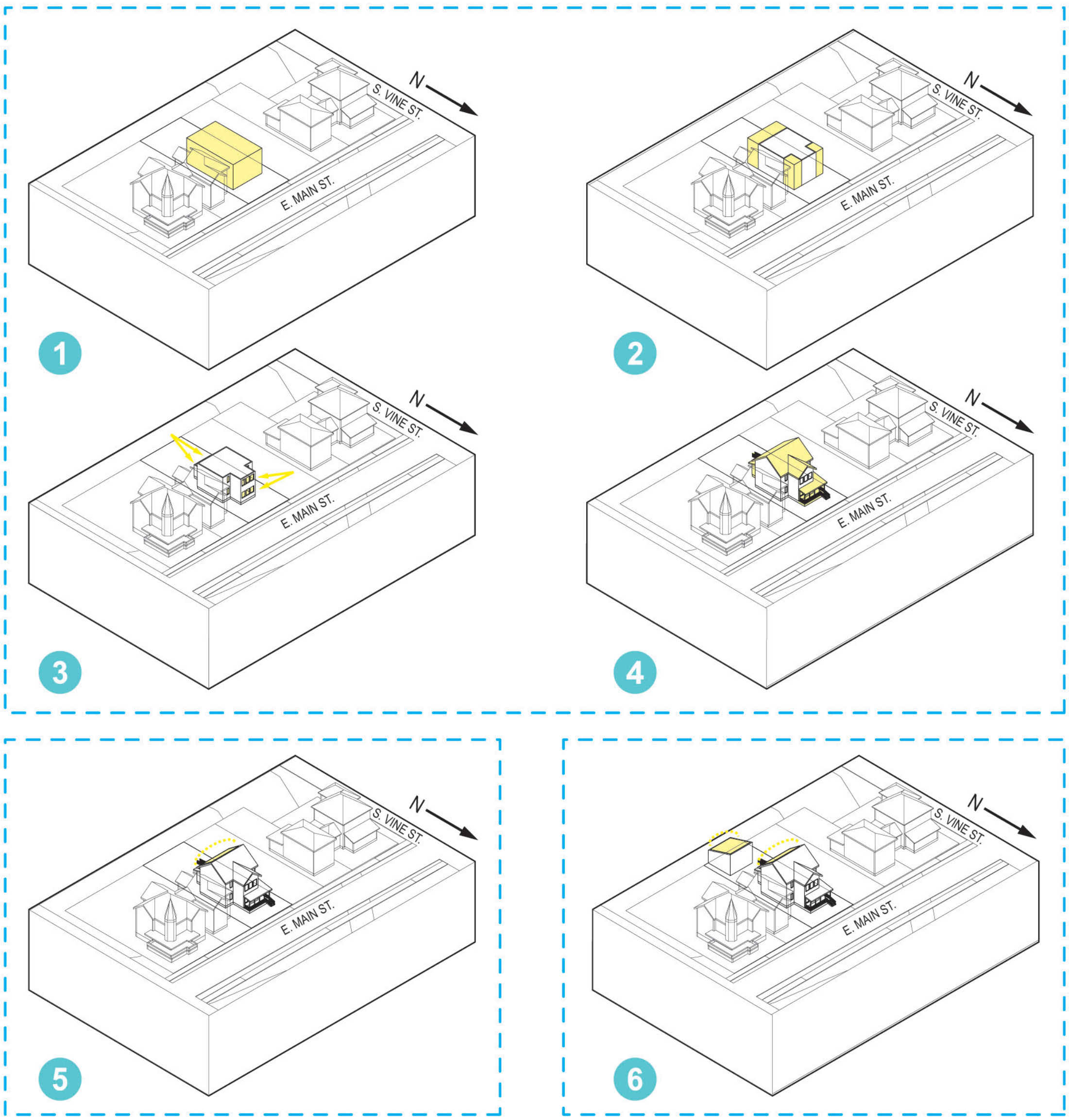
Phase A



Phase B

Phase C

Phase A

1. Begin with a square footage that is appropriate to the Solar Decathalon program (about 2,500 square feet).
2. Subtract from the original form to adhere to the proportions of the rest of the houses in the historic district, per city regulations.
3. Use these subtractions to let in natural daylight from the North and South.
4. Add on an appropriately pitched cold roof with attic insulation, and a front and back porch to adhere to the proportions of the rest of the houses in the historic district, per city regulations.

Phase B

5. Add additional photovoltaic panels and Energy-Star appliances that may be outside of Habitat for Humanity's budget.

Phase C

6. Provide different iterations of a master plan for the homeowners that will encourage expansion on the property (garage/shelter) and provide more space for additional photovoltaic panels

FIG 7: Summary of design process and three phase implementation.

Result

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FIG 8: 3-D diagram of exterior design features.

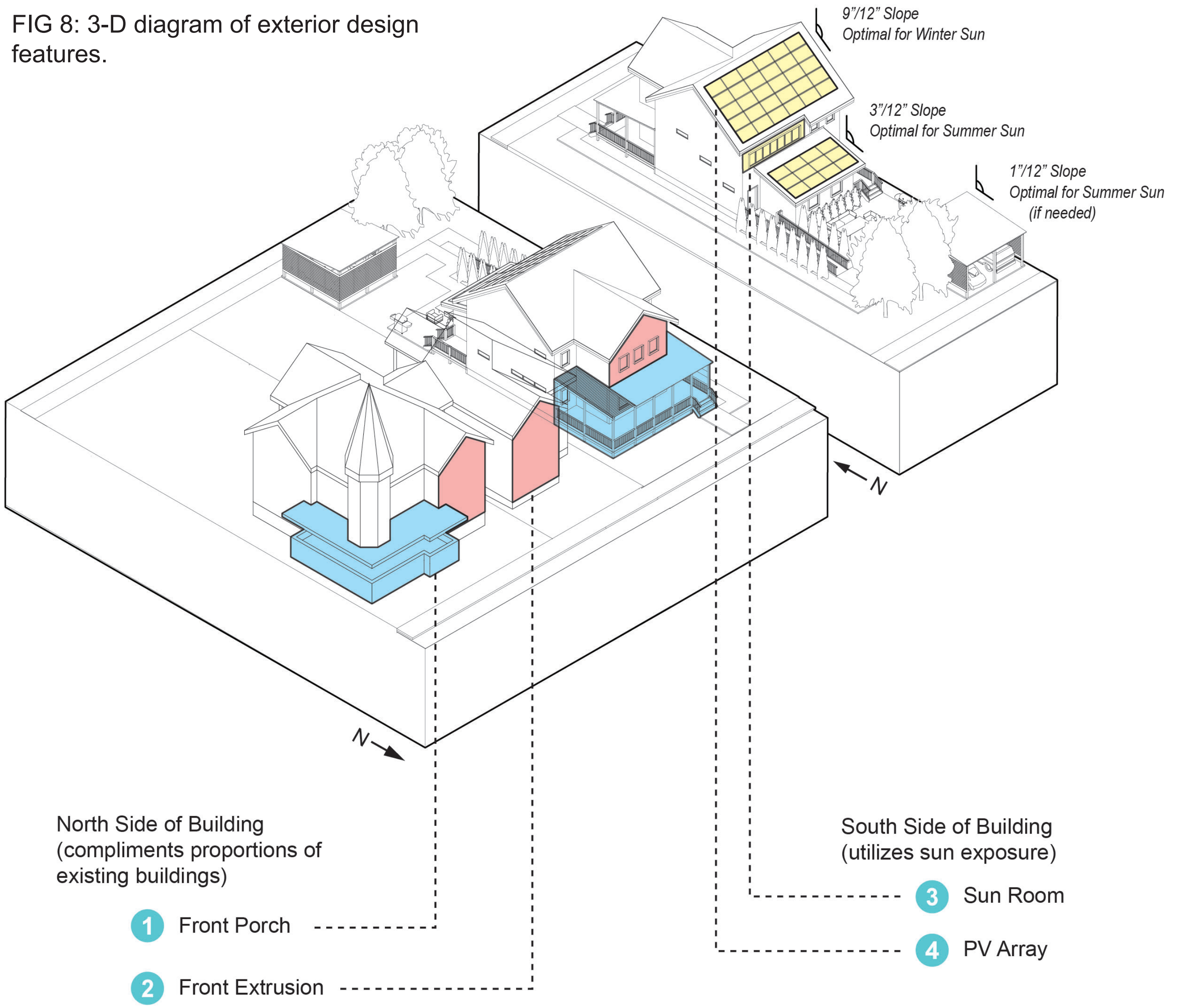

FIG 9: North and South Renderings

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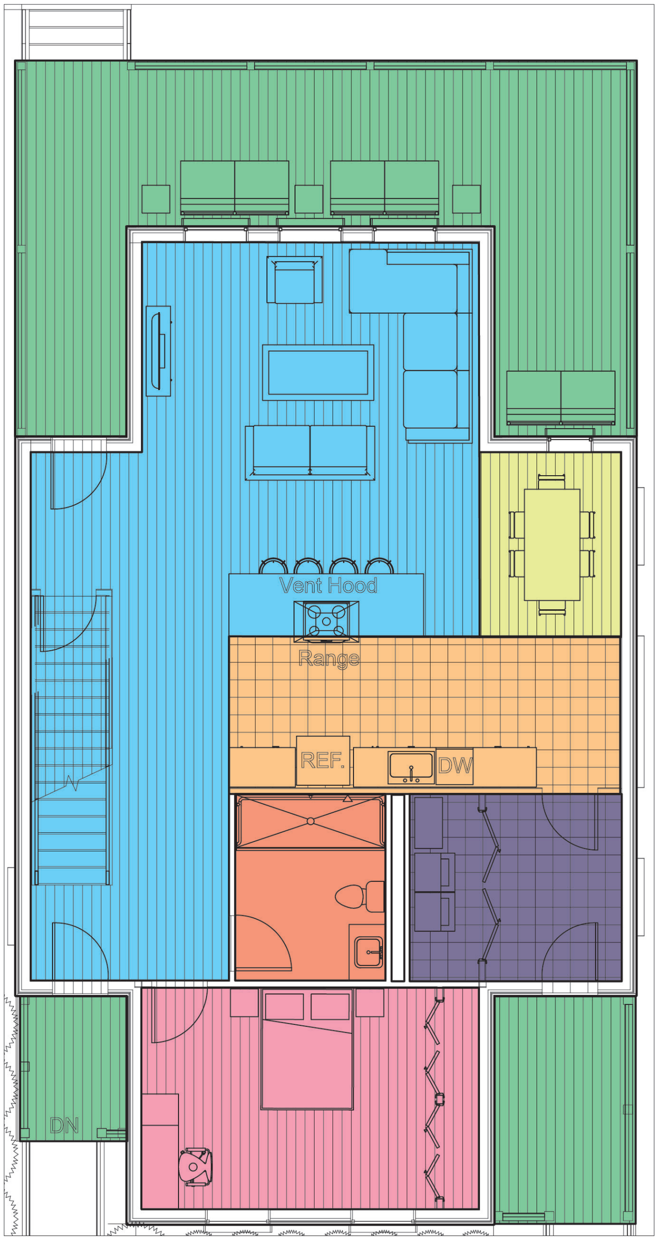
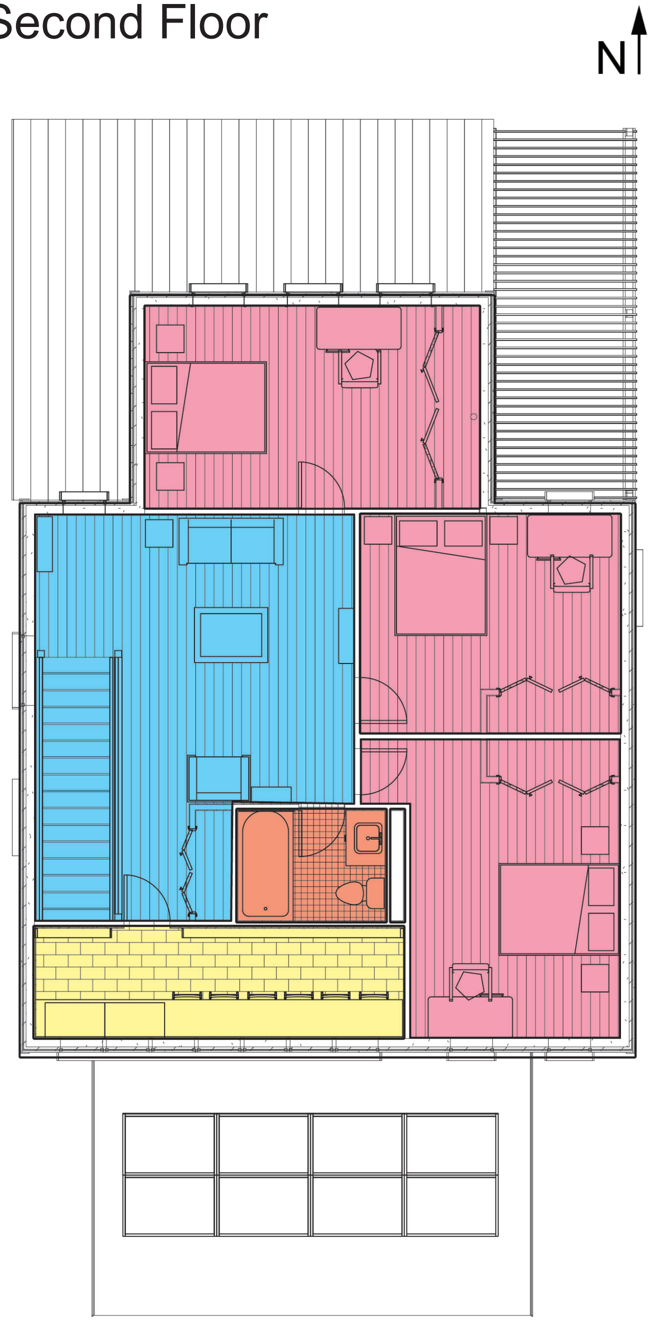
First Floor



Second Floor



Legend

Living Room	Bathroom
Kitchen	Bedroom
Dining Room	Mechanical Room
Porch	Sun Room

FIG 10: 1st and 2nd Floor Plans

Materials

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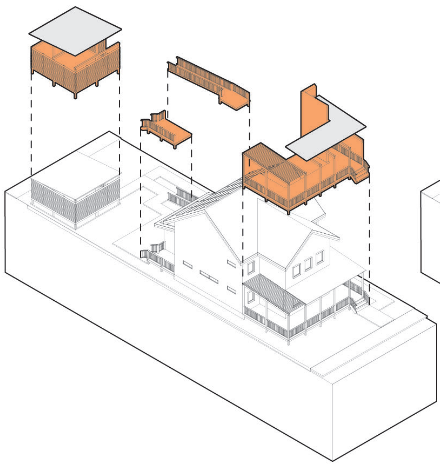
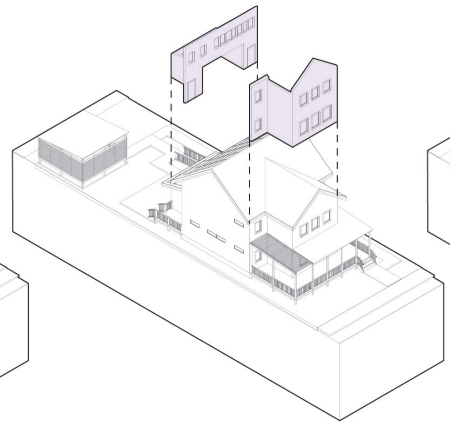
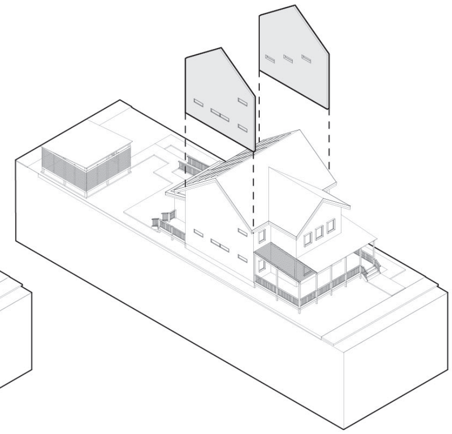
1 RED CEDAR

2 HARDIE BOARD

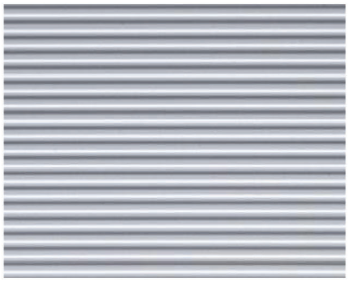
3 CORRUGATED METAL







Exterior Facade Materials:

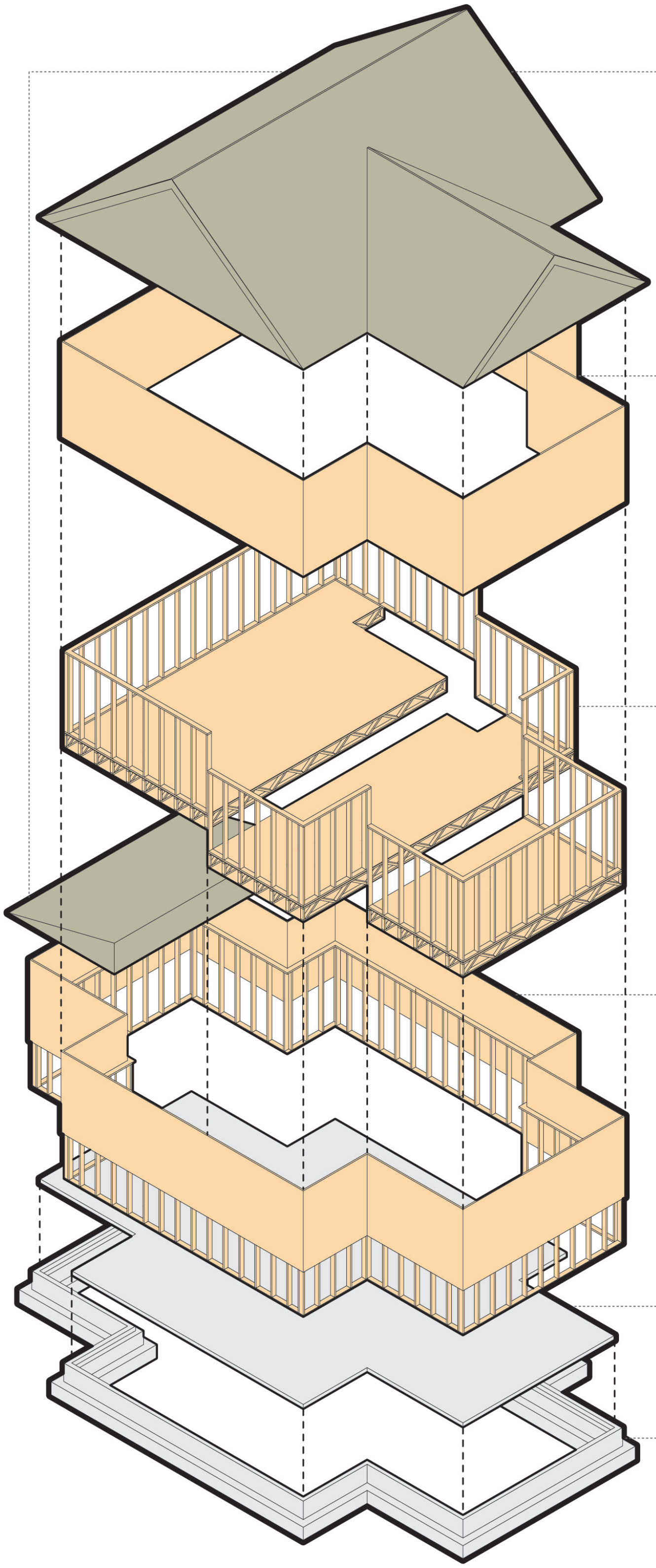


Red Cedar siding will compliment the wooden siding and trim of the neighborhood while introducing a more contemporary highlight to our front entrance, front porch, back porch, and carport. Once trated and installed, red cedar will need minimal upkeep to maintain its natural aesthetic.

Hardie Board siding will also compliment the horizontal siding of most of the houses in this district and, since Habitat for Humanity receives free donations of Hardie Board, it will provide a cost efficient alternative to the traditional wooden siding most of the houses in this area use.

Corrogated metal siding will be used only on the East and West facade where our house comes within 2-5 feet of an adjacent historic house. This metal will be able to last without any maintanance, which could prove to be difficult in such a tight space.

FIG 11: Exterior Facade Materials



6 Roofs (to be assembled by a hired contractor)
- prefabricated wood trusses lifted into place by a crane and then roofed by a contractor

5 ZIP Sheathing
- easy to install for volunteers
- very durable
- contains built-in air, water, vapor, and thermal control layers
- reduction in air leakage compaired to typical Habitat walls and roofs
- reduced thermal bridging
- places contol layers on the outside of the structure for durability

4 Prefabricated Second Floor
- assembled into 3 separate sections
- lifted onto first floor frame
- wouldn't need to pay a contractor to frame second floor
- reduced liability with having volunteers frame a second floor
- wood floor joists allow for easy running of HVAC and ductwork

3 First Floor Assembly Using Advanced Framing Techniques
- standard for Habitat construction
- use 2x6 in. studs to include added insulation and reduce thermal bridging at studs
- easy for volunteers to work on

2 Insulated Slab (to be poured by hired contractor)
- intigrated radon mitigation below slab

1 Concrete Footing (to be poured by hired contractor)
- no crawl space

FIG 12: Exploded Axomometric Drawing of Inovations in Construction Assembly

Innovation - Sun Room

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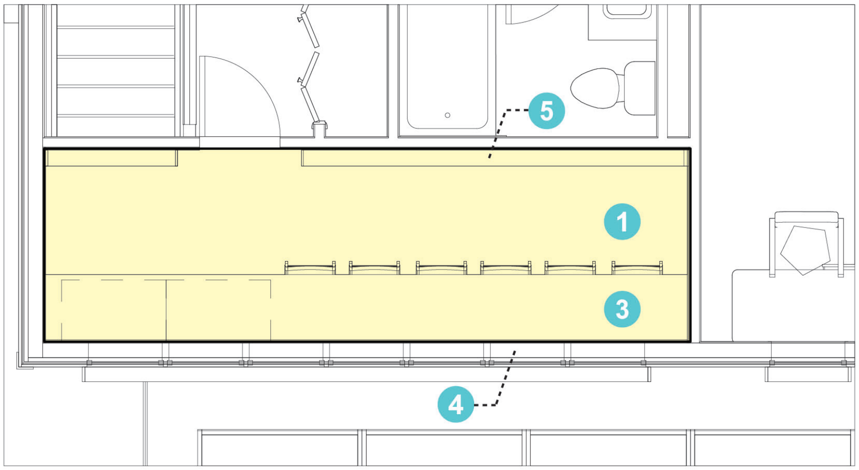
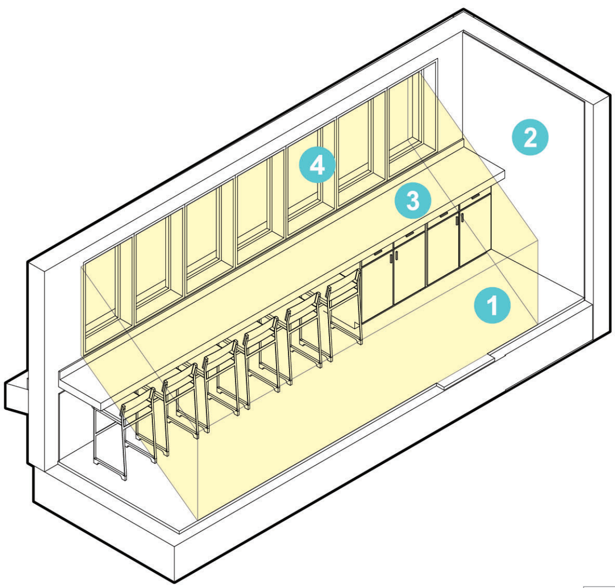
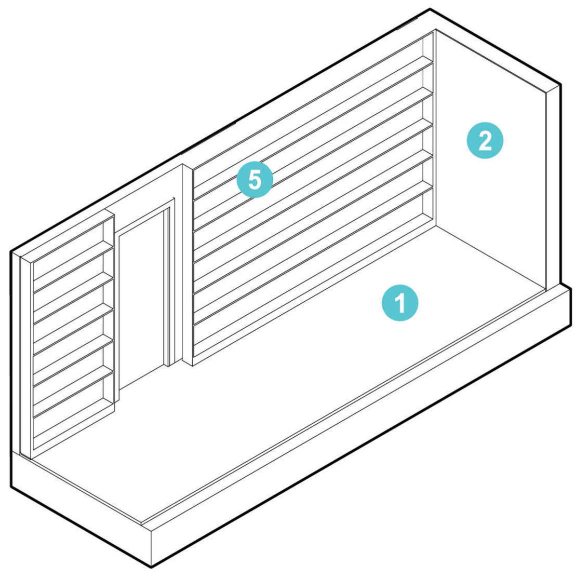
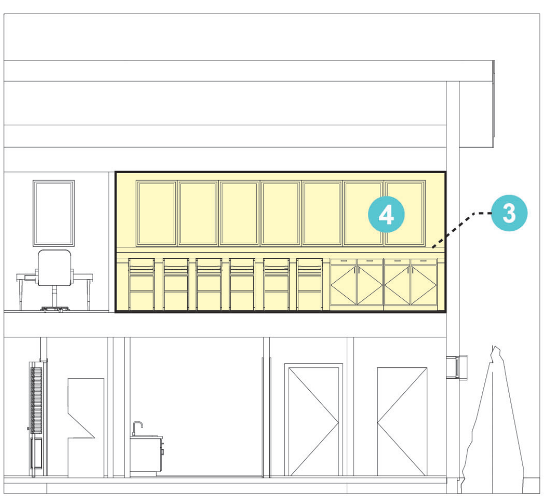


FIG 13: Sun Room Diagram

1. 1/2 in. Floor Tiles
2. 1/2 in. Wall Tiles
3. 4 in. Concrete Countertop
4. South-facing Windows
5. Recycled Glass Water Bottle Storage (for additional thermal mass)







Resilience

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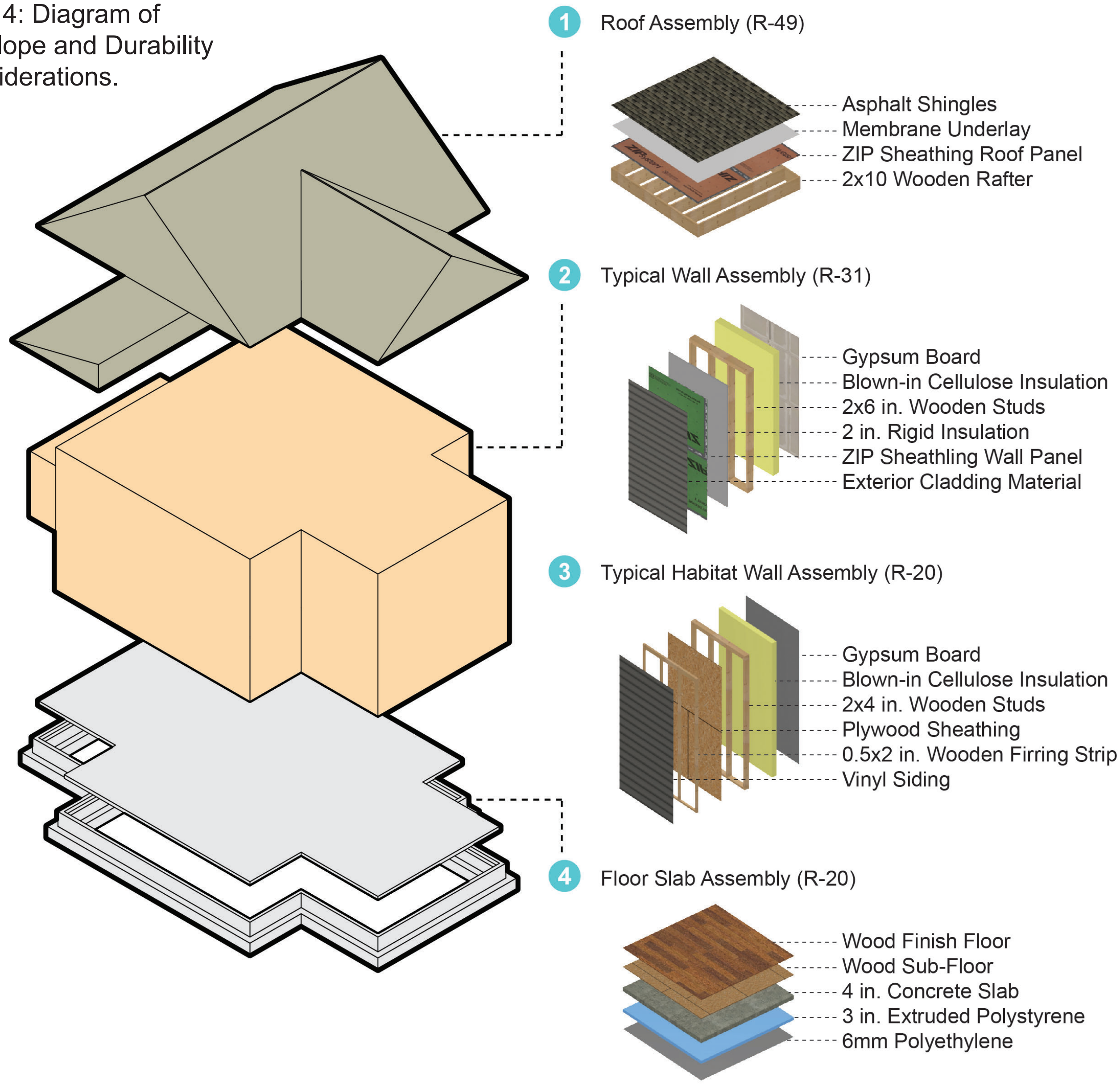
FIG 14: Diagram of Envelope and Durability Considerations.



Typical construction materials consist of vinyl siding, hardie board, and minimal insulation. We discussed how a new net-zero construction home would require higher performing wall systems, such as ZIP sheathing, to be used. The use of ZIP sheathing and tape in the wall system allows for three beneficial areas: The first is that the system is easy to install and very durable (ZIP sheathing has a 30-year warranty, meaning the new home-owners will be responsible for very little maintenene on the house). The second benefit is that the ZIP sheathing acts as barrier for air, vapor, and water and packages all four control layers into one panel. The third benefit is that because these three barriers are integrated into one system, there is a reduction in air leakage, which leads to a more energy efficient home.

Engineering

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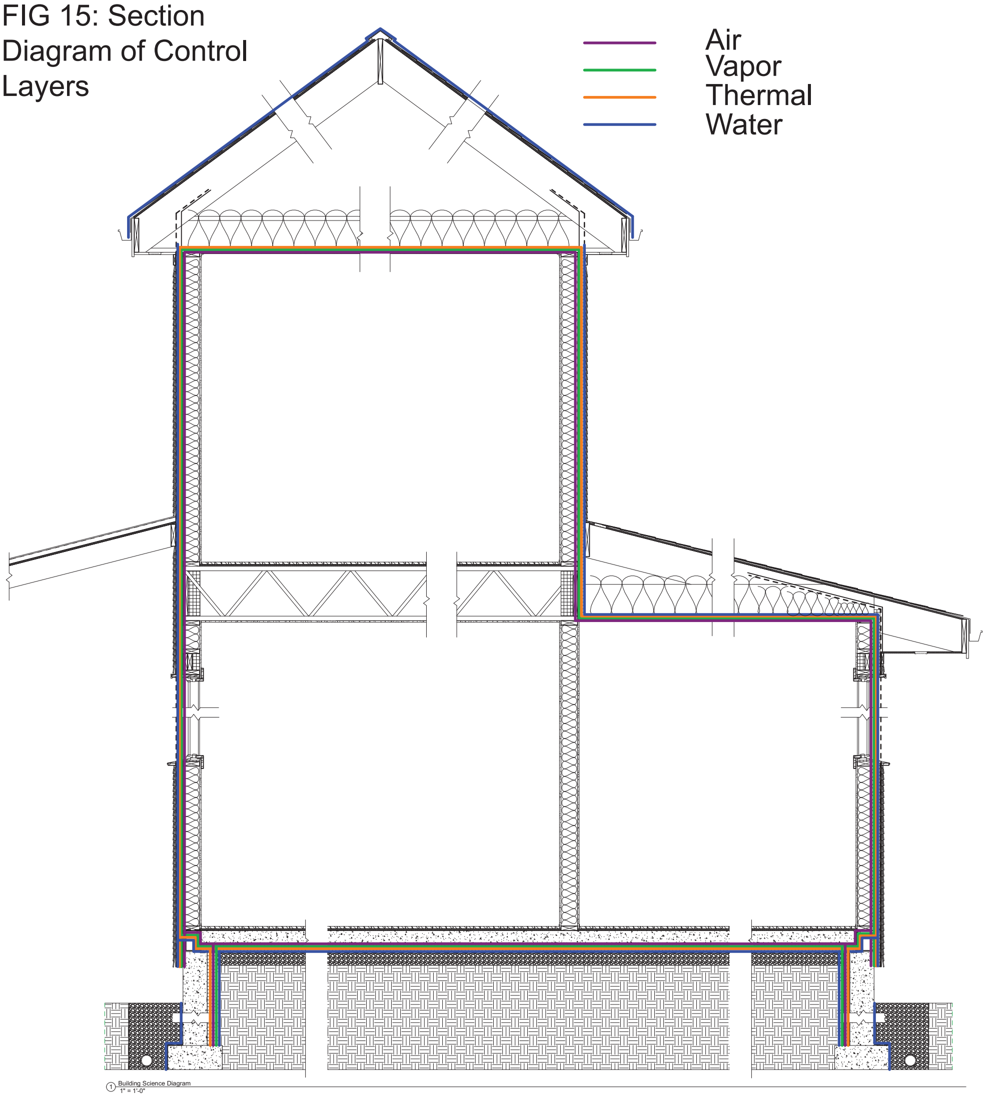
FIG 15: Section Diagram of Control Layers



Because Habitat for Humanity Muncie hasn't built a second story home in over thirty years, we aim to create a new standard for how Habitat for Humanity Muncie will begin to construct a new typology of two-story homes that are net-zero ready. The first step in developing this new typology is through the construction methods that Habitat for Humanity Muncie would follow to build the second story. Because Habitat for Humanity Muncie lacks the correct management and insurance liability coverage to build a second story, they would hire contractor's rather than risk having the volunteers work on the second story of the home. Because we want to utilize as much of the sweat equity of the volunteers on site and reduce the amount of time that contractors are needed on site, we plan to have the second story floor and wall systems to be designed in a way that will allow for prefabrication to be completed at ground level. When the contractors come in with a crane to place the roofing system on the home, they will be used to lift the prefabricated wall and floor systems into then assembled into place.

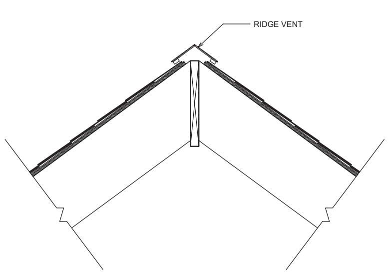


FIG 16: Detail Cold Roof Vent

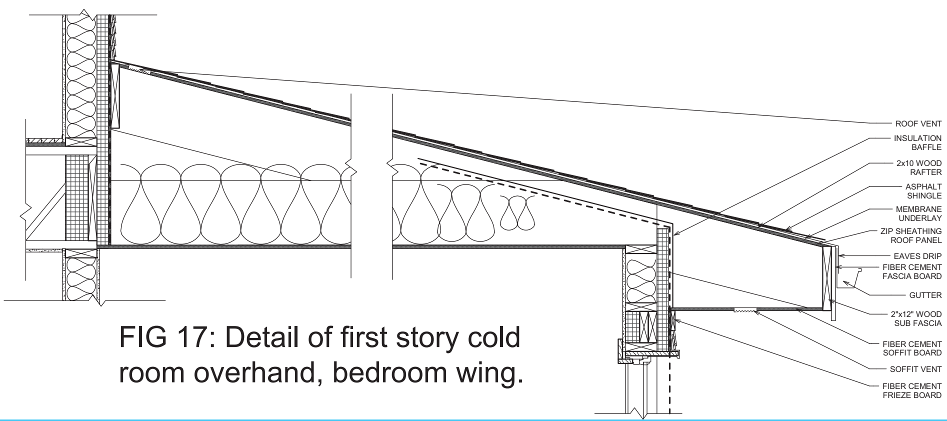


FIG 17: Detail of first story cold room overhand, bedroom wing.

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FIG 18: Wall Section

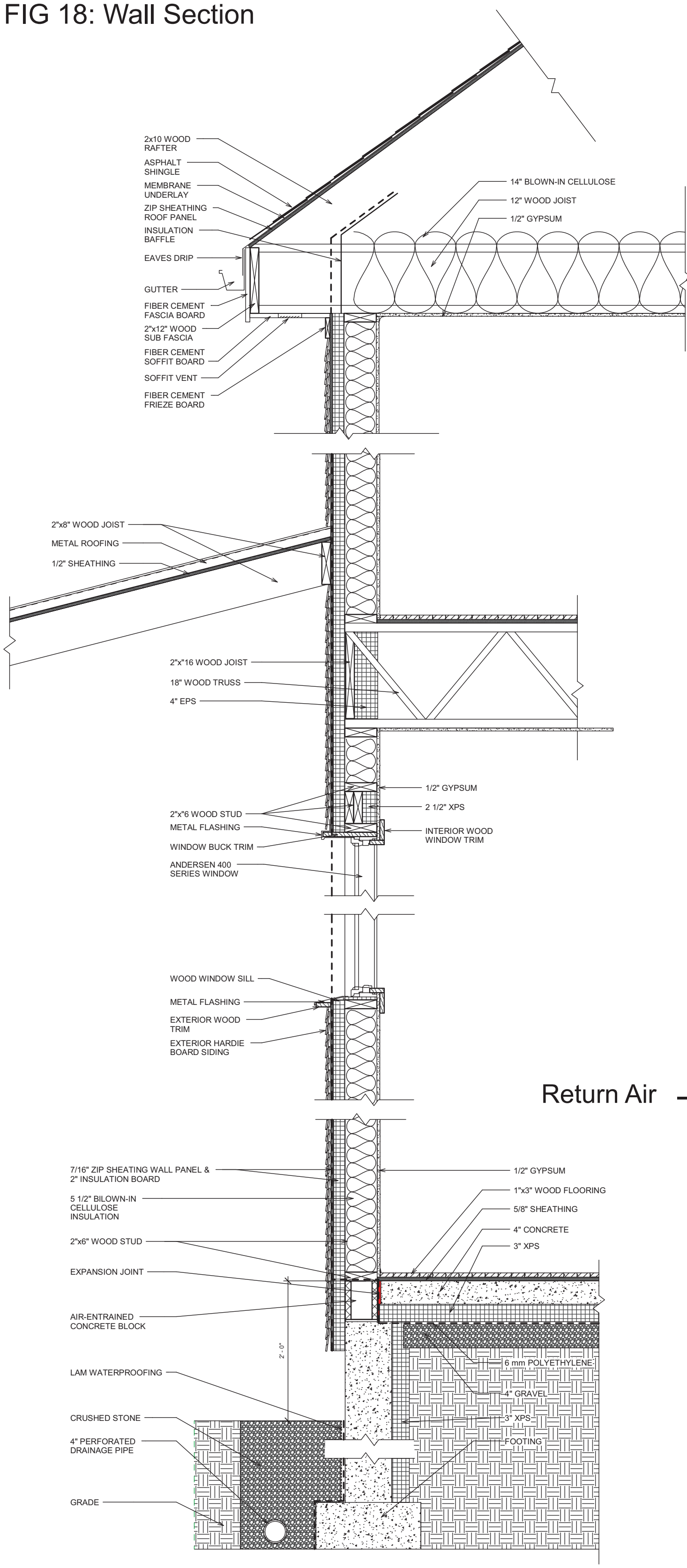
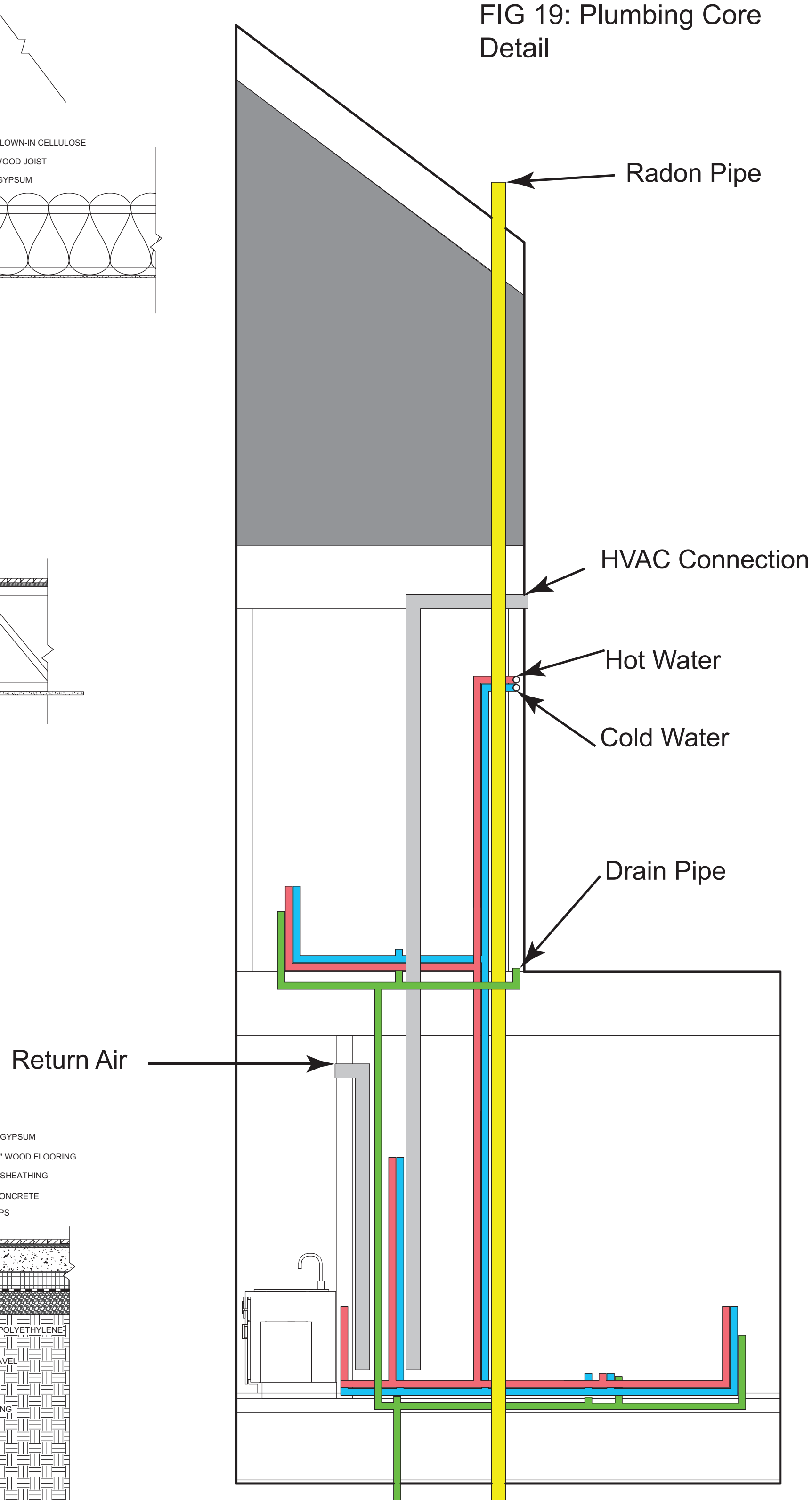


FIG 19: Plumbing Core Detail



Comfort and Environmental Quality

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CONSTRUCT

There are many systems working together in this home to produce better efficiencies in energy performance. Overall the home is generally regulated by both ducted and unducted air-source VRF and work in conjunction with the ERV, which takes care of the homes whole house ventilation and recovers latents and sen. However, we have made some hybridizations to the home like adding a sun room with tile on the floor and walls to collect and sequester solar heat coming into the home. We decided on the ERV and VRF units rather than a traditional gas furnace or other more traditional system, because they are very efficient and keep the home owner from having much of a gas or other alternative heat energy bill. We also found that these systems use less ductwork in the home than traditional systems, and we were able to add other energy conservation methods to the home that they would work with well. In addition, the sun room is also a place where shelves can house recycled bottles filled with water to add to the thermal mass in the room as a cheap and light weight solution on second floor. This allows it to have no need to run or not run as often to keep the home warm, thus keeping the electric and gas heating back up bills low. Lower bills will allow the low-income homeowner to save more money for both life and making the additional changes to the home that will add efficiencies and value.

We were able to speak with a HVAC expert who helped us to understand the layout requirements for each system type. For the first story of the home, it is ducted, there are only two rooms that needed systems and we wanted as little ductwork as possible, plus our system down stairs works with the system upstairs. The upstairs system is ductless, minus the unit that communicates directly with the operating system downstairs. This allows the home to have less leakage in the ducts and while the upstairs units are more expensive, with the added cost of the duct work it would have been a close cost number. The upstairs systems are in each room allowing each user to heat or cool to what is their liking, but the systems also communicate to regulate the overall heating and cooling of the home.

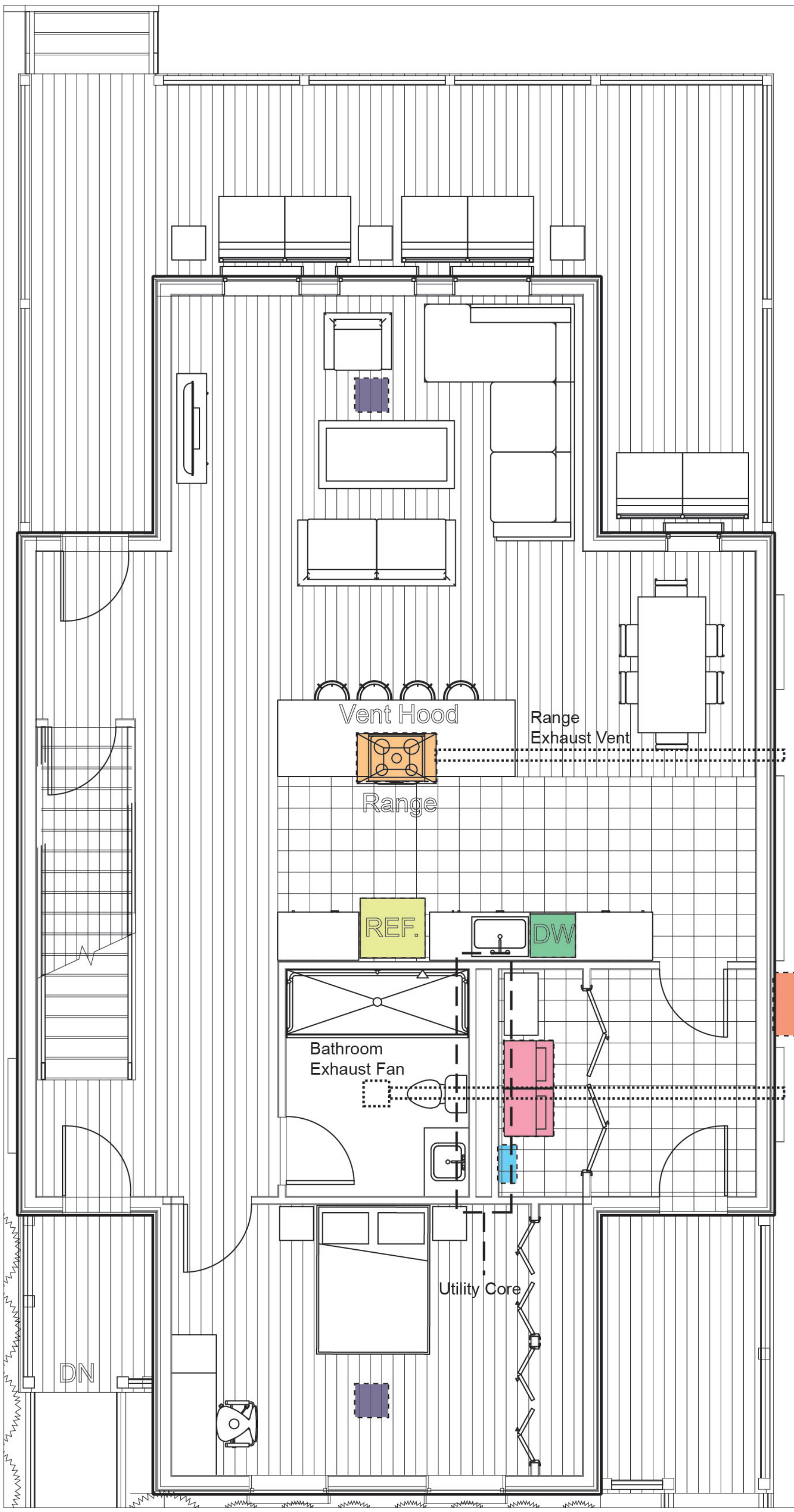
Our home design addresses environmental quality with methods already used by our community partner to ensure better air quality in the home. By using materials with low or no VOCs we can have a more healthy home for our future users, which is incredible important should they have any medical conditions they live with. To do this, we intend to use low VOC paint, little to no carpet and formaldehyde free wood products. Another comfort factor that our home has to offer is the overall layout. It is a spacious but minimal home. There is an intimate formal living space to entertain on the first floor with and expansion of seating to the dining and kitchen island. On the second floor, the home offers a family room for relaxation, activities such as play for children and the open plan helps provide good air quality through circulation. The second floor also houses the sunroom, which in the cool months will become a great warming location to sit and act as an extension of the upstairs family room.

FIG 20: 2nd Floor Family Room.

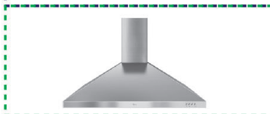
Operations - First Floor

CONTEXT
CONSERVE
CONSTRUCT

FIG 21: Appliences



Samsung
Wind-Free 4 Way Cassette
- heating capacity= 10,000 BTU/hr
- cooling capacity= 9,000 BTU/hr



Whirlpool
36” Convertible Wall Mounted Range Hood

Samsung
5.8 cu ft Electric Range
- 1.2 kW-3.0kW Ceramic Cooktop
- 1,250-3,000W Oven

Samsung
18 cu ft Refrigerator
- 364 kW/yr

Samsung
44 dBA Dishwasher
- 239kW/yr

Samsung
DVM S Eco
- heating capacity= 54,000 BTU/hr
- cooling capacity= 48,000 BTU/hr

Samsung
2.2 cu ft Washer
- 85 kW/yr
Samsung
Ventless Electric
4 cu ft Dryer
-148 kW/yr

Rheem
RTEX-27
- 27 kW model flow rate (up to 6.6 GPM)
- 99.8% energy efficient

Operations - Second Floor

CONTEXT
CONSERVE
CONSTRUCT

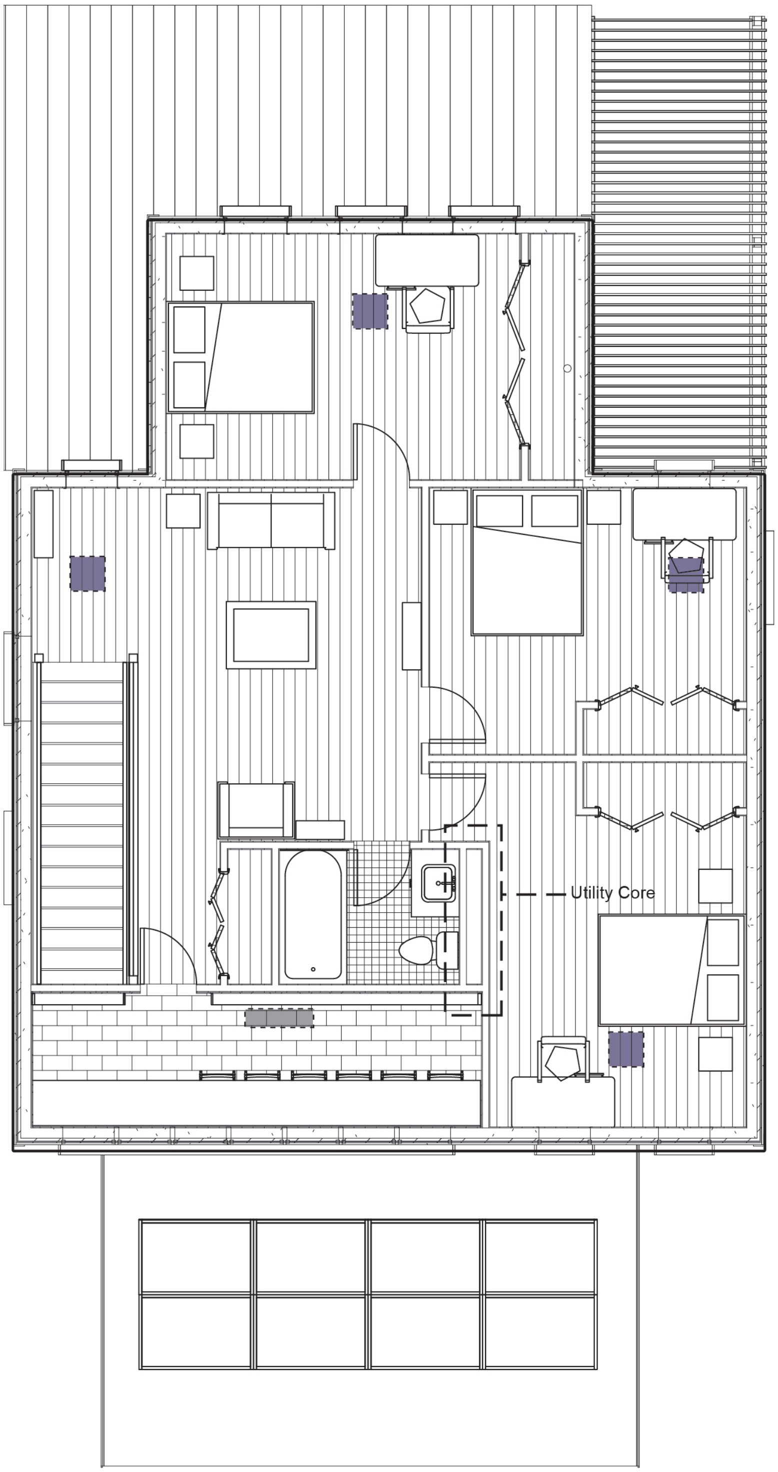


FIG 22: HVAC

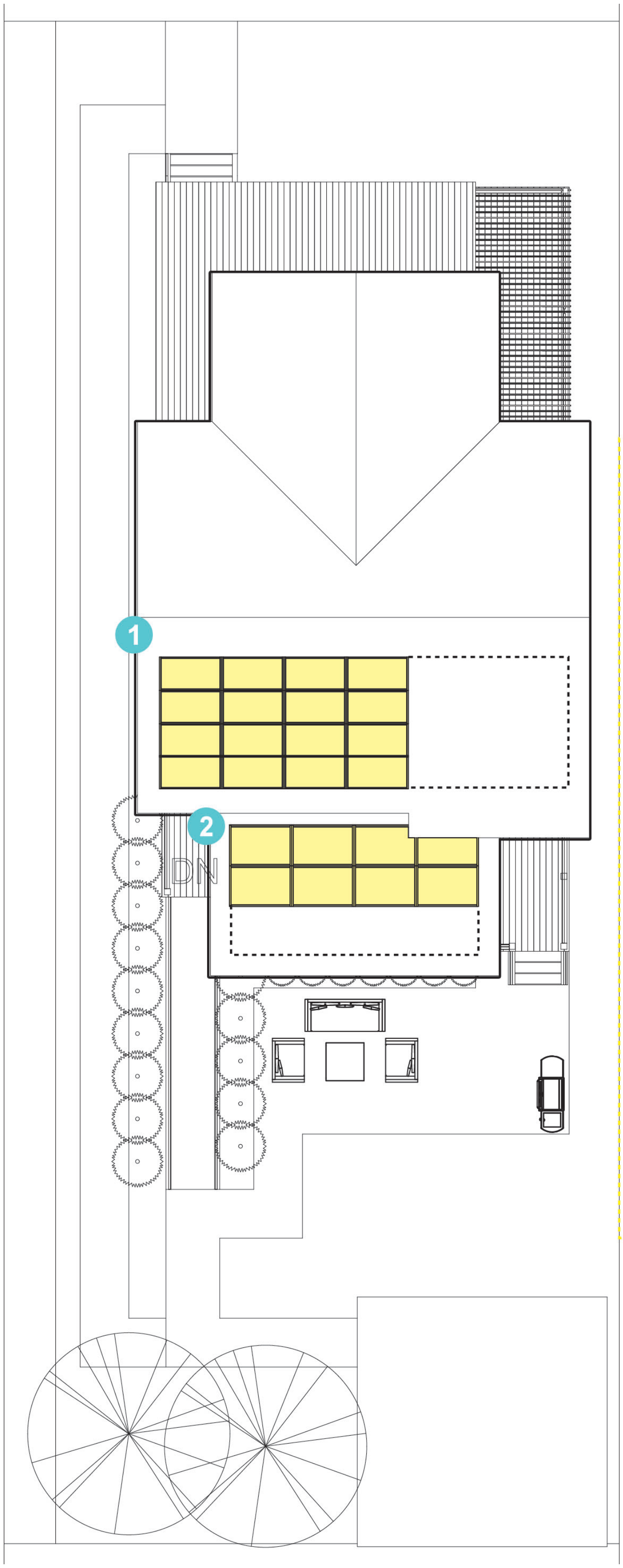
Samsung Wind-Free
4 Way Cassette
- heating capacity=
10,000 BTU/hr
- cooling capacity=
9,000 BTU/hr

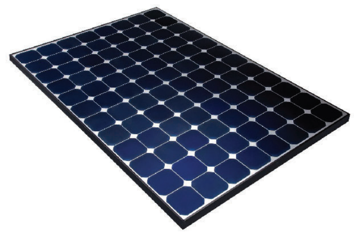
Samsung AR 5000
- heating capacity=
5,800 BTU/hr
- cooling capacity=
5,000 BTU/hr

We aim to design a home that is net-zero ready, we are including in the design certain elements and systems, such as stacked plumbing core, HVAC system, hot water heater and a PV array system, that allows for highly efficient systems that have low utility costs. For the solar collection of the home, we included in the design of the roof two different roof angles that allow for the photovoltaic array to collect the maximum amount of solar energy as possible, while still fitting into the context of the Emily Kimbrough Neighborhood Historic District requirements. Habitat aims to build homes with healthier interiors with good environmental and thermal comfort, the design plans for a VRF Heat Pump with integrated ERV for fresh air. This system includes individual cassettes in each room and a high wall mounted system in the sunroom that offers simultaneous heating and cooling with 100% energy recovery. In our design of the home, we grouped all of the fixtures that use water and placed them on a central plumbing core that allows for the reduction of plumbing piping in the home, reduces the amount of space needed for the piping of the system, and makes it easier for any future repairs in the system. For the hot water heater, we are using an electric tankless hot water heater. Due to the fact that we have all of the plumbing to be on a stacked, central plumbing core, there is minimal opportunity for a “cold water sandwich” to occur. When compared to a heat pump hot water heater, the purchase price of a electric tankless hot water heater is more economically feasible.

Operations - Roofs

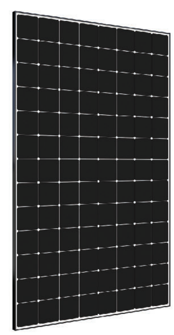
CONTEXT
CONSERVE
CONSTRUCT





SunPower
E-Series Residential Solar Panel
SPR-E20-327
- nominal power = 327W
- temperature = -40°F to 185°F
- 96 monocrystalline Maxeon Gen II Solar Cell

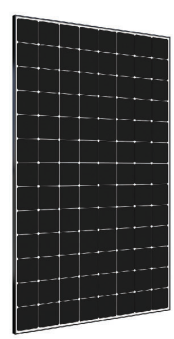
1 Main Roof PV Array



ACTUAL
- 16 panels
- 5 kW array
- 37° tilt towards South
- YIELD: 7,154 kWh/yr

POTENTIAL
- 30 panels
- 9.3 kW array
- 37° tilt towards South
- YIELD: 13,307 kWh/yr

2 Shed Roof PV Array



ACTUAL
- 8 panels
- 2.5 kW array
- 14° tilt towards South
- YIELD: 3,410 kWh/yr

POTENTIAL
- 12 panels
- 3.75 kW array
- 14° tilt towards South
- YIELD: 5,074 kWh/yr

FIG 23: Solar Placement

Financials and Affordability

CONTEXT
CONSERVE
CONSTRUCT

Habitat for Humanity Muncie begins the process of building a home by accepting applications from families who need a new home. These families must meet three criteria in order to be considered for a new home:

Homeowner Selection Criteria

o You need adequate housing

o Current housing is inadequate or too expensive

o Unable to obtain a conventional mortgage

o You have the ability to pay the Habitat mortgage

o Steady income within the guidelines below

o No unpaid liens or judgements

o You are willing to partner with Habitat

o Fulfill all partnership requirements for Habitat homeownership, such as:

o Complete sweat equity

o Participate in homeowner education classes

o Contribute down payment

o Live where Habitat is working

o Income guidelines:

Family Size	Minimum Income	Maximum Income
1	$12,850	$25,620
2	$14,650	$29,280
3	$16,500	$32,940
4	$18,300	$36,600
5	$19,800	$39,540
6	$21,250	$42,480
7	$22,700	$45,420
8	$24,200	$48,360

TABLE 1

In discussion with our community partner, they always have a family selected before beginning the construction process. Their main demographics that go through the application include single people with no children, young families with children, and people over the age of sixty. These families typically stay in their homes for 15 years or longer and are given a 20 year low interest mortgage. Because Habitat for Humanity Muncie builds homes for this demographic, it is also important to consider that a typical family of four makes an annual income in the range of $17,000-$32,000 a year.

One of the exciting opportunities that comes with Habitat for Humanity Muncie as our community partner is their partnerships with local, national and even international companies who donate supplies and materials to the project to keep costs low. Some of the partnerships that Habitat for Humanity Muncie has includes:

o Valspar (covers interior and exterior paints)

o Dow Chemical (rigid board, spray foam)

o Fiberglass blow-in insulation from Richmond, IN

o IKEA (provide cabinets)

o Square D (electrical panels and breakers)

o Appliances

o Property (is given through tax sale or lobby the city for the land)

In terms of costs that Habitat for Humanity Muncie pay for or cover through monetary donations that come in through fundraising include the following materials and labor costs for installation:

o Foundations and footings

o MEP

o HVAC

o Drywall

o Siding & flooring installation

o Crane rental

o Installation of the roofing and shingles

Financials and Affordability

CONTEXT
CONSERVE
CONSTRUCT

The labor that goes into the construction process falls into two areas: contracted out labor that covers the areas in the above list, or the sweat equity that comes from Habitat for Humanity Muncie, volunteers and the family that the house is being built for. While the use of sweat equity is an opportunity to lower costs of construction, the typical demographic that volunteers for Habitat for Humanity Muncie falls into the age group of 55-60. Because of this age demographic, it is important to consider using modular and prefabrication systems that are easy to install. For example, prefabricating the second story floor and wall systems allow for the sweat equity labor force to construct the second floor at grade level. This allows for Greater Muncie Habitat for Humanity to not be liable for any of the volunteers to be on the second story of the home, and also utilize the contractors and the crane that will be hired out to help lift and attach the prefabricated systems to the second story.

We have formulated an estimated budget for the project, the main goal of this cost analysis is to create value for Greater Muncie Habitat for Humanity on why they should develop a two-story net-zero ready home in a neighborhood such as the Emily Kimbrough Neighborhood Historic District. When looking at a typical budget that Habitat for Humanity Muncie spends on a single-story home, the developmental cost ranges anywhere from $130,000-$140,000. The financial analysis we received from our Construction Management department has the estimated cost of $219,801.70. After going through this financial analysis and comparing costs of materials and labor to what materials Habitat for Humanity Muncie receives through donations and the volunteer labor force, we found that the estimated budget for this home is $170,081.66. This value does not include the photovoltaic solar array, which would be done at a later date.

Unit Cost Estimate

Typical Construction

Category	Category Type	Cost
A	sitework	$ 23,254.54
B	foundation	$ 23,273.94
C	framing	$ 54,807.37
D	openings	$ 13,385.13
E	finishes	$ 8,433.07
F	appliances	$ 8,880.00
G	Air, ventilation & HVAC	$ 12,912.20
H	plumbing	$ 14,448.60
I	electrical	$ 12,574.00
J	solar array	$ 20,100.00
K	landscaping	$ 2,732.85
L	connections & other	$ 25,000.00
	total cost	$ 219,801.70

TABLE 2

Habitat Home

Category	Category Type	Cost
A	sitework	$ 23,254.54
B	foundation	$ 23,273.94
C	framing	$ 40,364.12
D	openings	$ 11,626.01
E	finishes	$ 2,807.60
F	appliances	$ -
G	Air, ventilation & HVAC	$ 15,000.00
H	plumbing	$ 14,448.60
I	electrical	$ 11,574.00
J	solar array	$ -
K	landscaping	$ 2,732.85
L	connections & other	$ 25,000.00
	total cost	$ 170,081.66

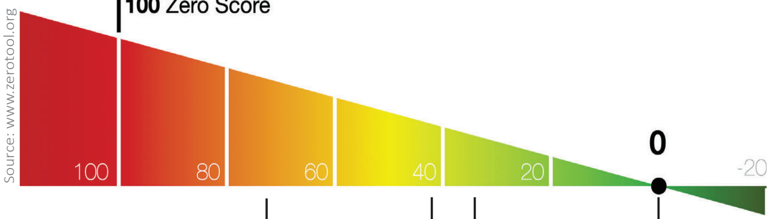
TABLE 3

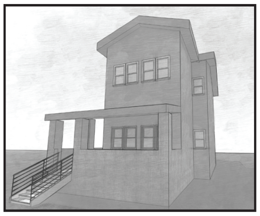
Energy Performance

CONTEXT
CONSERVE
CONSTRUCT

BASELINE
39 EUI
100 Zero Score
TARGET
39 EUI
100 Zero Score

Charted Calculations forom BEopt: FIG 24



BENCHMARK	REVISON I	REVISON 2	SOLAR
			

	BENCHMARK	REVISON I	REVISON 2	SOLAR
EUI:	31.7 Kbtu/sf./yr	17.7 Kbtu/sf./yr	14.3 Kbtu/sf./yr	0 Kbtu/sf./yr
SOURCE ENERGY		55.9 kBtu/sf./yr	49.4 kBtu/sf./yr	1.2 kBtu/sf./yr
ANNUAL HEATING CONSUMPTION	13.5 kBtu/sf./yr	5.3 kBtu/sf./yr	3.8 kBtu/sf./yr	5.4 kBtu/sf./yr
ANNUAL COOLING CONSUMPTION	8.1 Kbtu/sf./yr	.45 kBtu/sf./yr	.40 kBtu/sf./yr	.4 kBtu/sf./yr
PEAK HEATING LOAD:	24.3 kBtu/hr	22 kBtu/hr	20.1 kBtu/hr	4.7 kBtu/hr
PEAK COOLING LOAD:	25.3 kBtu/hr	24 kBtu/hr	24 kBtu/hr	1.3 kBtu/hr

BUILDINGS VALUES

		BENCHMARK	REVISON I	REVISON 2	SOLAR
R-VALUE:	WALLS	R-25	R-31	R-31	R-25
	ROOF/ATTIC	R-49	R-49	R-49	R-49
	FLOOR	R-10	R-10	R-20	R-10
WINDOWS:	U-VALUE	.29	.27	.27	.27
	SHGC	.4	.4	.4	.4
AIR LEAKAGE:		1 ACH@50PA	.1 ACH@50PA	.1 ACH@50PA	1ACH@50PA
HVAC:	HEATING	94 AFUE 32 K	94 AFUE 32 K	AIR SOURCE HP	94 AFUE 32 K
	COOLING	13 SEER 1.5 TON	13 SEER 1.5 TON	SEER 22, HSPF 10 VAR. SP	13 SEER 1.5 TON
LIGHTING:		100% LED	100% LED	100% LED	100% LED
SOLAR:		N/A	N/A	N/A	8.5 Kw
HOT WATER:		GAS (50 GAL)	GAS (50 GAL)	HPWH ELECTRIC (50 GAL)	GAS (50 GAL)

Energy Performance

Over the course of this project our design has reached an efficiency point that is almost 50% reduction and is lower than the 2030 Challenge benchmark. This gives our building an EUI of 14.3 kBtu/sf/yr and a HERS of 36, however, this is without the added PV. Once the PV is added the home reaches it's Net Zero Standing with HERS 0. In the process of designing this home the energy modeling was taken from many tools. We began with REMrate and have been using this to look at our HERS rating. Next, there was the use of BEopt, which was helpful with its many charts, especially the saddle charts showing a more 3-D representation of our home's loads. The process of energy analysis also looked at Climate Consultant, HEED, SAFAIRA and PVWatts for added measurements.However, even with all of these tools we found it difficult most times to truly gain a proper energy analysis of our home. Mainly this was due to our complexity of our systems. For instance the our chart shows that we are reach zero once PV is added, however, our spreadsheet calculation tells us that the home is creating more energy than it needs with the solar. This discrepancy is something we can only assume is due to some small amount of error between our design, our inputs and the programs we are using to analyse.

The home is equipped with, first, a split ducted and non-ducted system. Ducted on the first floor, because both systems needed to work with the system unit downstairs, and because it was also very minimal ductwork. The system upstairs is ductless, minus a small portion that connects to the other half of the system. We wanted to lessen the amount of ducts in the home to account for leakage. The portion that connects is for the system in our sunroom, and helps to move the heat energy collected there to where it will be better utilized in the home for heating or cooling. The sunroom, from our calculations in HEED the room reaches almost 111 degrees Fahrenheit at its maximum, and only gets as low as 42 degrees if the building is floating.

The needs of the home have been recorded best at having its hourly heating consumption of 22 kBTUs per hour and a cooling consumption of 24 kBTUs per hour. We also found that there will only be about 6.5 hours per year that the cooling loads are not met. For heating, it was found that there would be 78.2 hours per year that the loads could not be met, and we feel that these hours will be cut drastically with the use of the sunroom.

Overall, our calculations of usage for the home gave us a yearly site usage of electricity of 11,451 kWh per year. The home will of course be using Energy Star appliances, all LED lights, and a instantaneous hot water to ensure our efficiencies. It is with these systems in place that our home will be most effective not only functionally but for the future user.

Our scores are of course without the use of PV on the home, taken into consideration, because we want this to be a feature added later on, as a element that the homeowner can use as a way to increase the value of their home and expand upon their energy savings. From our calculations we have found, however, that our home would be putting more energy back into the grid than it was using, so we downsized our solar to fit the needs of the home. We have used the assumption that with the energy savings of the home the owner will be able to add the solar needed to make the investment worth while.

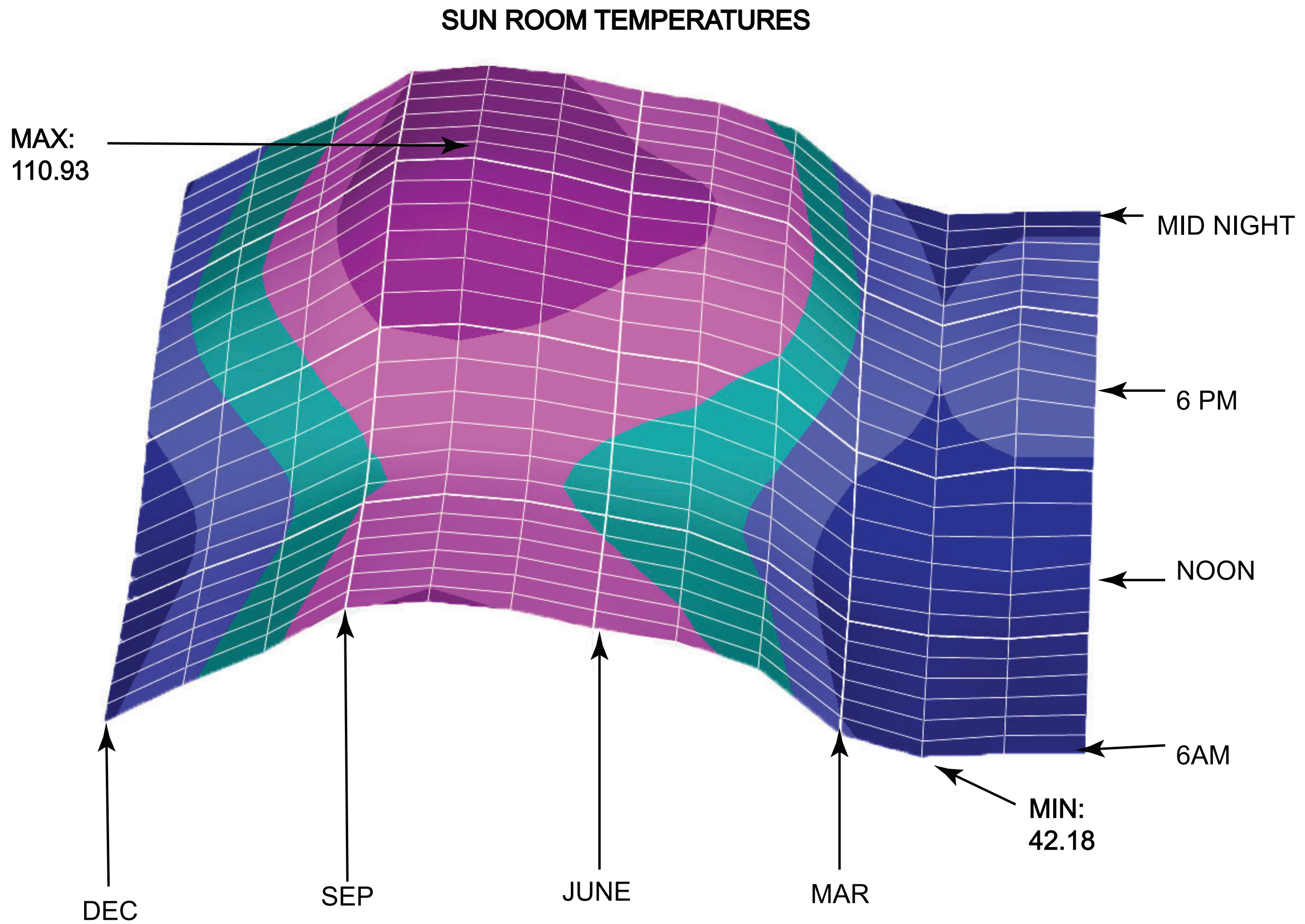


FIG 25: BEopt Saddle Diagram of Sun Room Temperatures

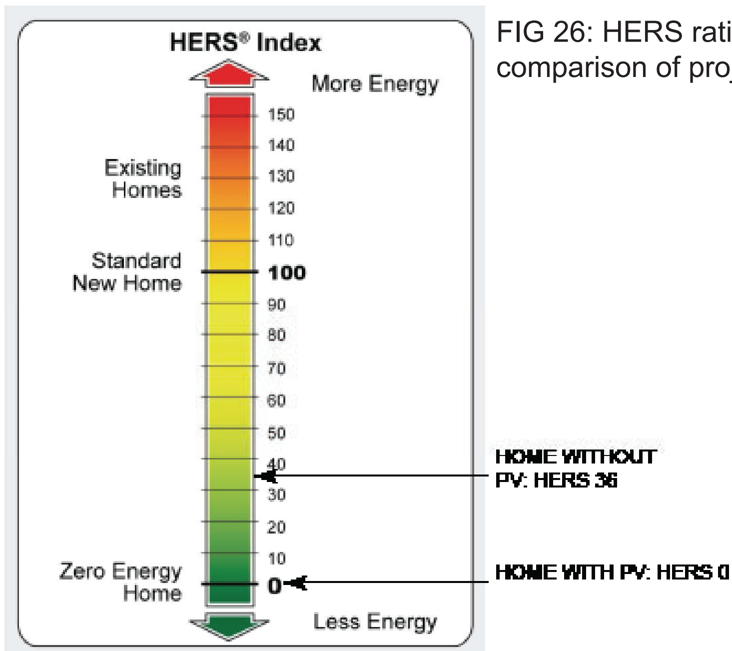


FIG 26: HERS rating chart comparison of project.

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