



# D.O.E. RACE TO ZERO COMPETITION

PENN COLLEGE<sup>®</sup> - WILLIAMSPORT TEAM

# Team Qualifications

# Penn College Design Team



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CIVIL ENGINEERING, ARCHITECTURAL TECHNOLOGY  
AND BUILDING SCIENCE & SUSTAINABLE DESIGN



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ZACH ROBEY

BUILDING AUTOMATION TECHNOLOGY, HVAC  
REFRIGERATION & PLUMBING



MATTHEW VENT

RESIDENTIAL CONSTRUCTION TECHNOLOGY &  
MANAGEMENT, ARCHITECTURE TECHNOLOGY MINOR

# Design Goals

# Influential Programs

- Habitat for Humanity
  - Fit the neighborhood
  - Space and energy efficient
  - 2-3 bedrooms per unit
  - 1-1.5 baths
  - Slab on grade, no basement
  - Washer, dryer, dishwasher
  - Simple construction
  - Homeowners earn 30-80% of median Williamsport income
  - Unit cost \$100,000-\$120,000

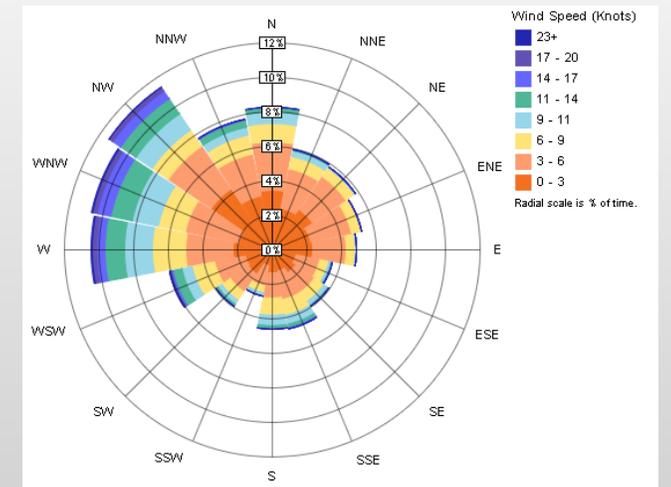
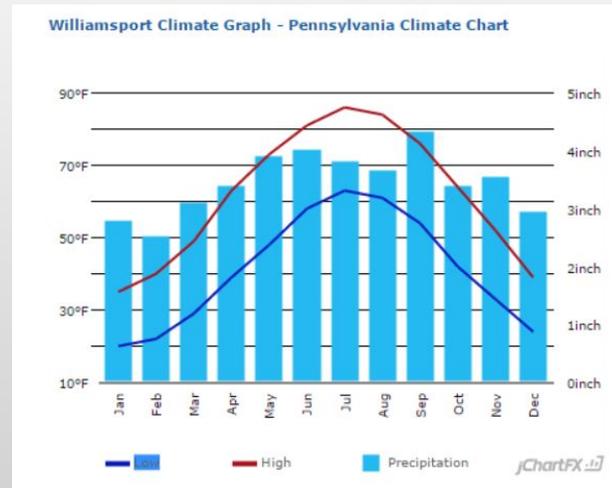
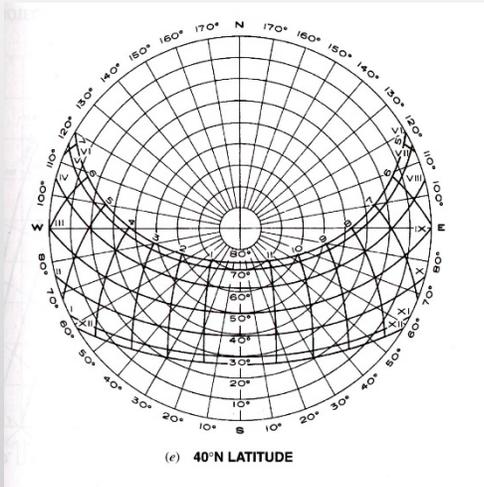
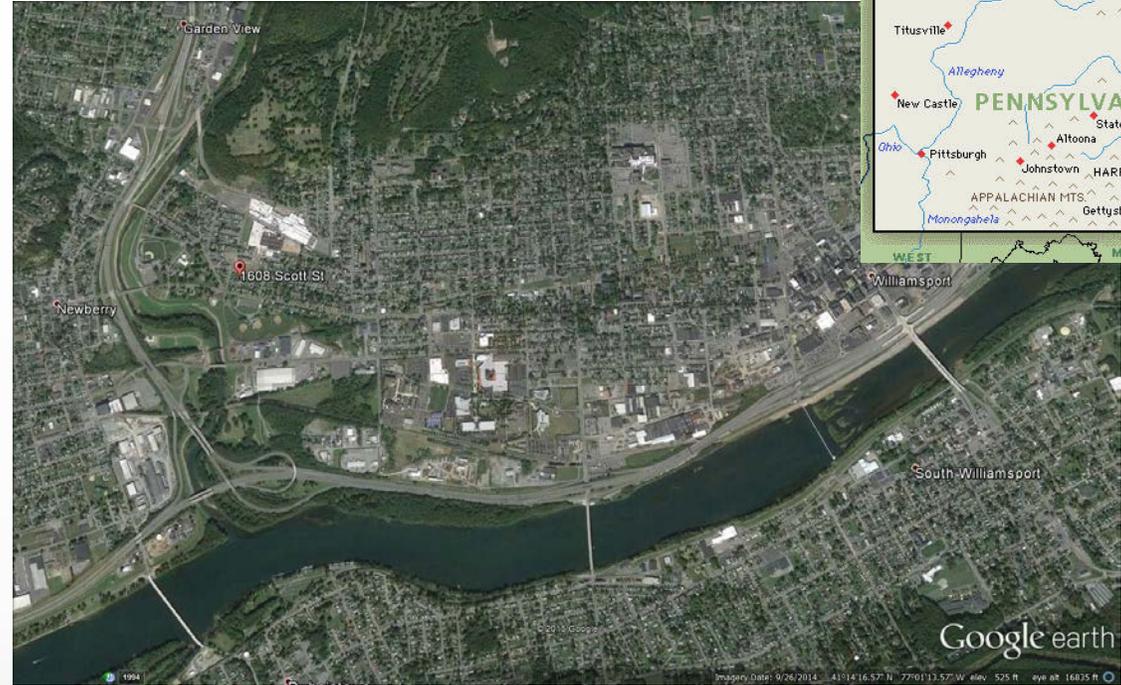


# Primary Goals

- Extreme affordability
  - Low utility bills
  - Quickly pay off mortgage
- PHIUS Certified
  - Super insulated
  - Super sealed
  - Renewable energy ready
- ADA design
  - House-wide accessibility

# Location

- Williamsport, Pennsylvania
  - Lycoming county
  - Little League World Series
  - Once the richest city in the world
- Population
  - 29,349
- Climate Zone
  - Zone 5 – Humid Continental
  - Mild summer, cold winter



# Neighborhood Context

- Brodart Neighborhood Improvement Project
  - Penn Marcellus Shale natural-gas impact fee
  - 3 Story, 40 Unit apartment complex
  - 2 Habitat for Humanity projects
  - Several other duplexes



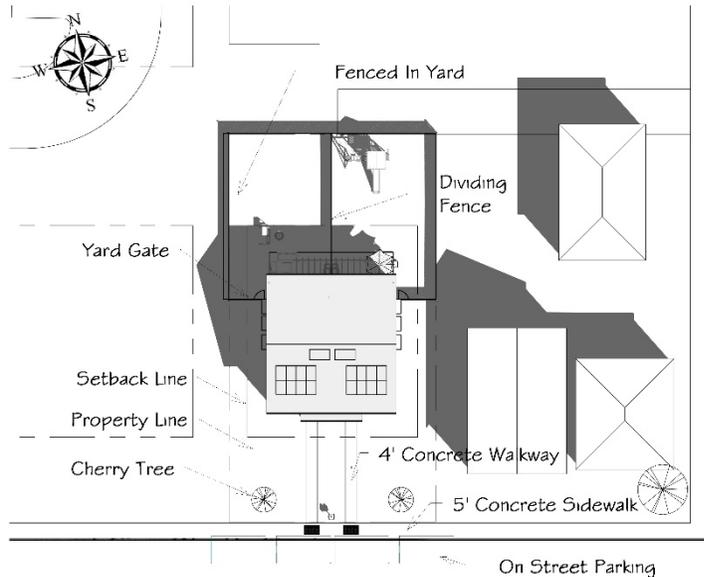
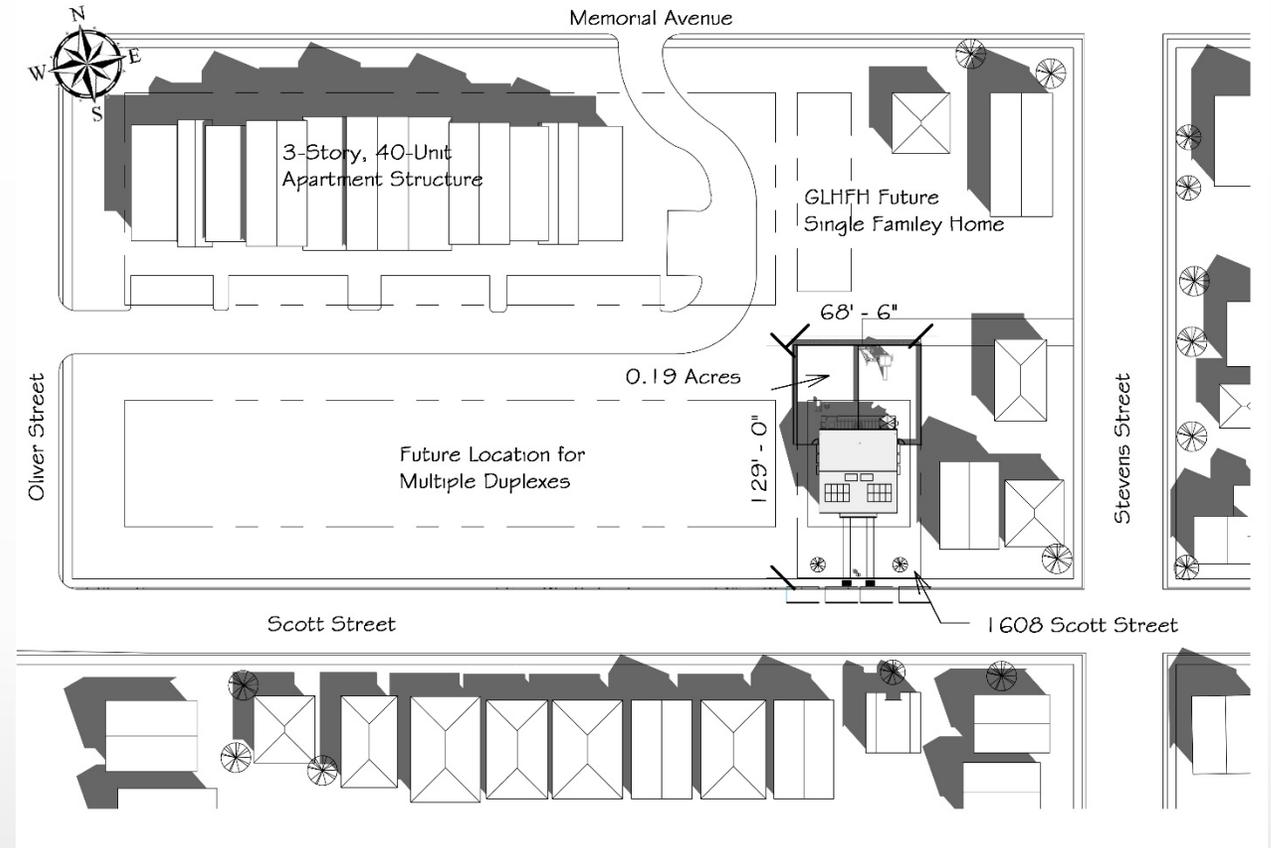
# Neighborhood Context

- Community
  - Density: 3,456/ sq mi
  - MFI: \$56,400
  - Mix of owned and rented homes
  - Stores and shops in walking distance
  - 2 blocks away from public park, Bowman field, and 3 public bus lines
  - Located near highway
- Home fit to site
  - Blends aesthetics of surrounding buildings
  - Colonial style with craftsman touch
  - 2 stories
  - Gable roof
  - Shed roof porch



# Site

- Brownfield
- 68'-6" x 129'-0"
- 0.19 acres
- Linkage to Outdoors
  - Front yard creates space from street
  - Small footprint allows for side yards
  - Large private backyard

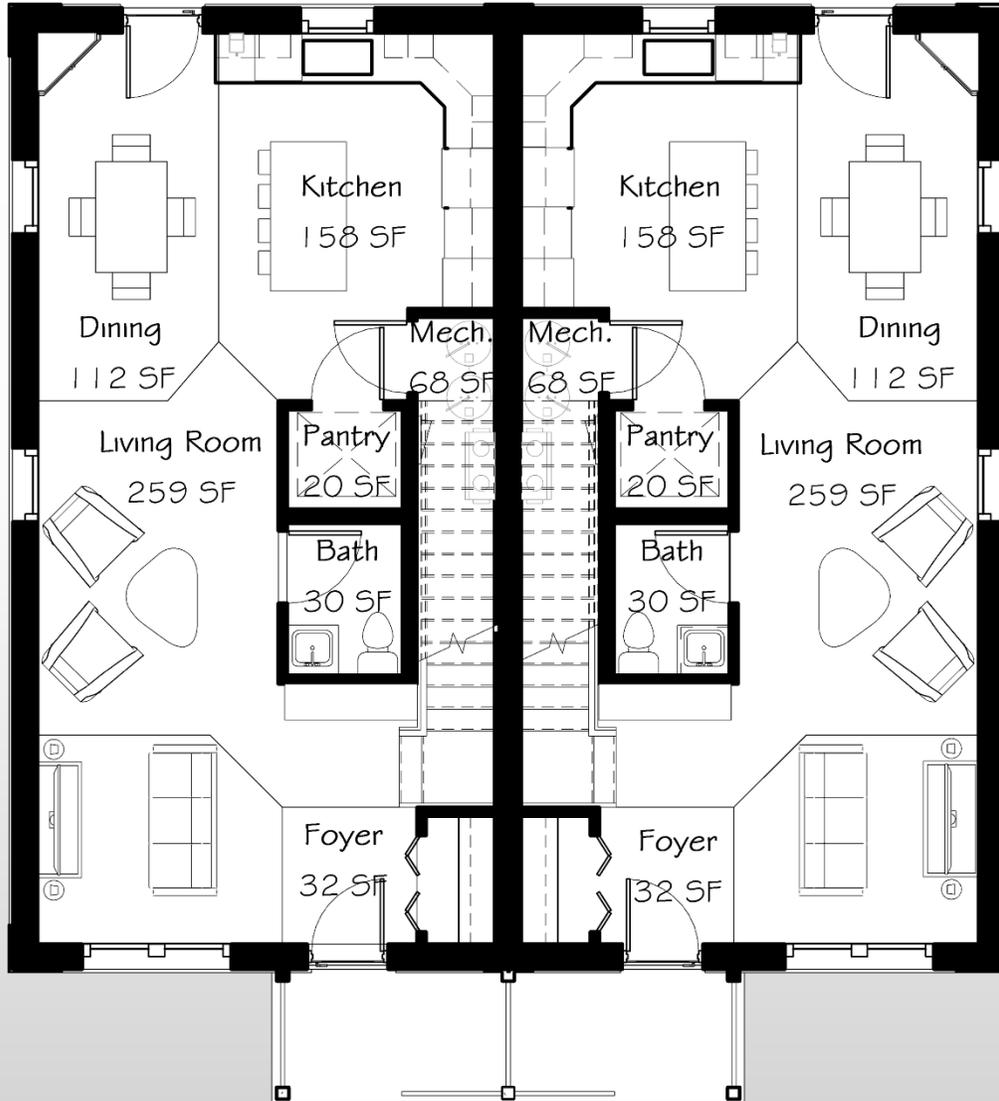


# Design

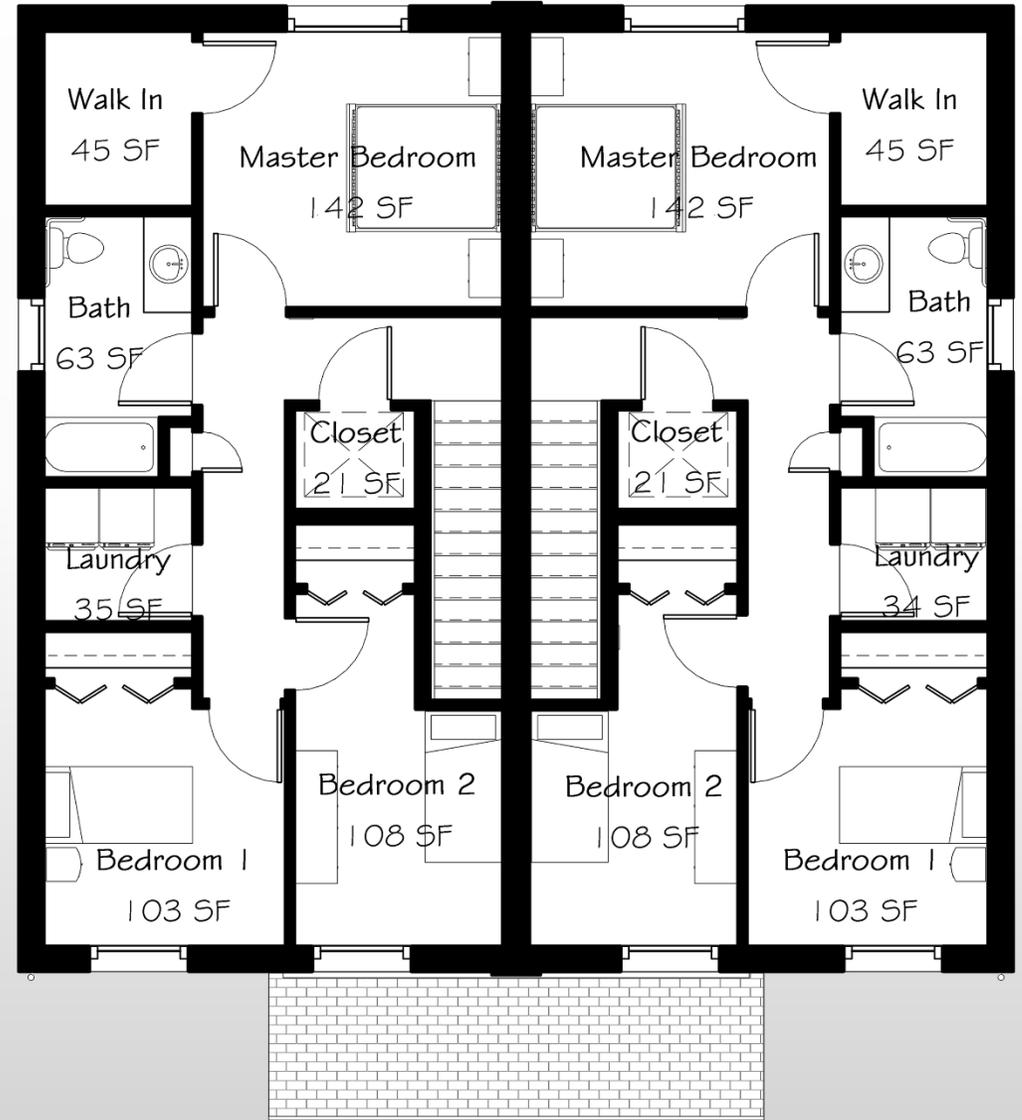
- House Type
  - Single family attached, duplex
- Square Footage
  - 1644 SF / unit
- Size
  - 2 Stories
  - 3 Bedrooms
  - 1.5 Bath
- Open Floor Plan
  - Flooding of natural daylight
  - Easy circulation of air
  - Open flow, communication, direct sightline
  - Increases apparent size and feel
  - Barrier free design
  - Minimal circulation
  - No wasted space



# Design



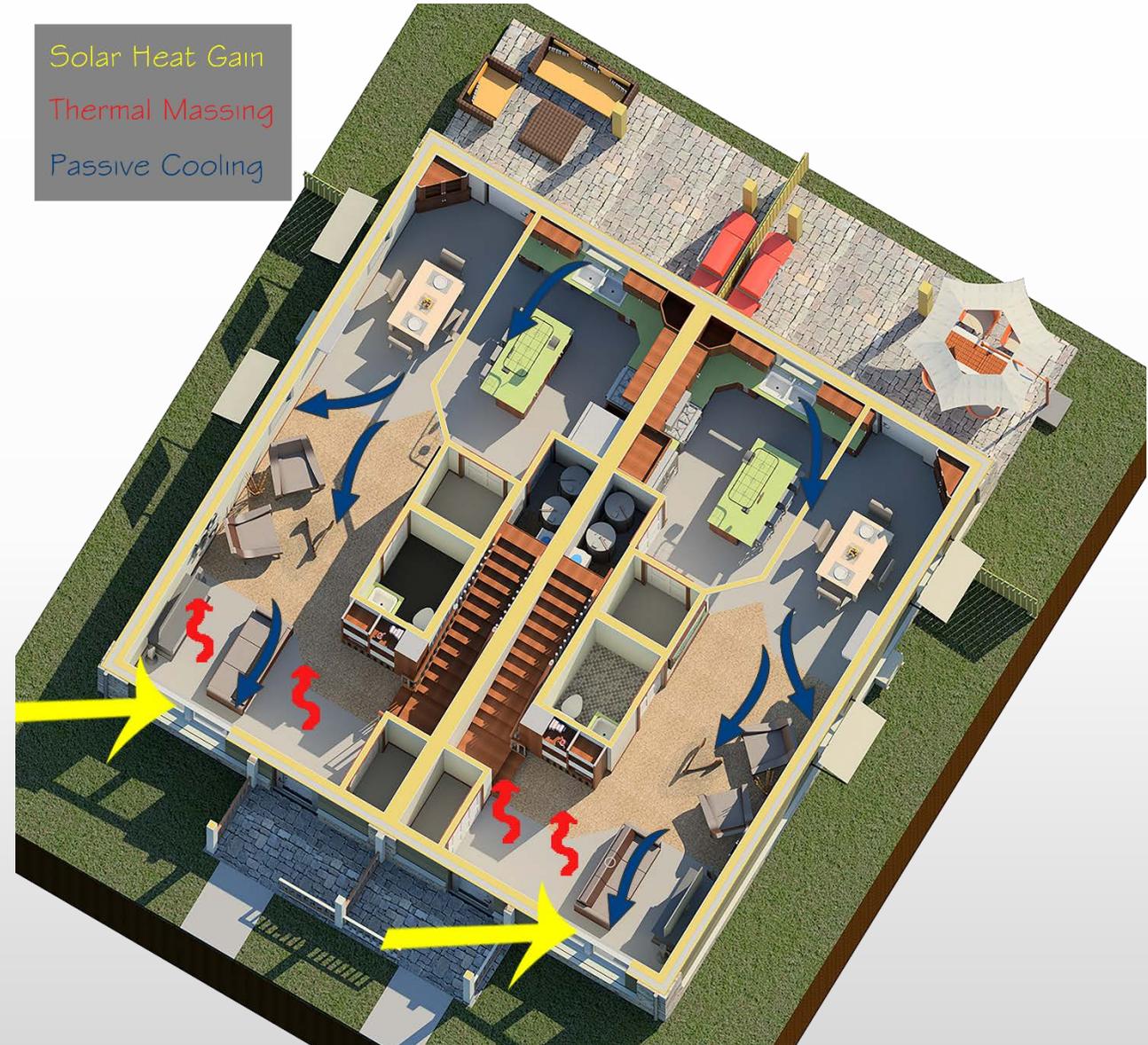
First Floor Plan



Second Floor Plan

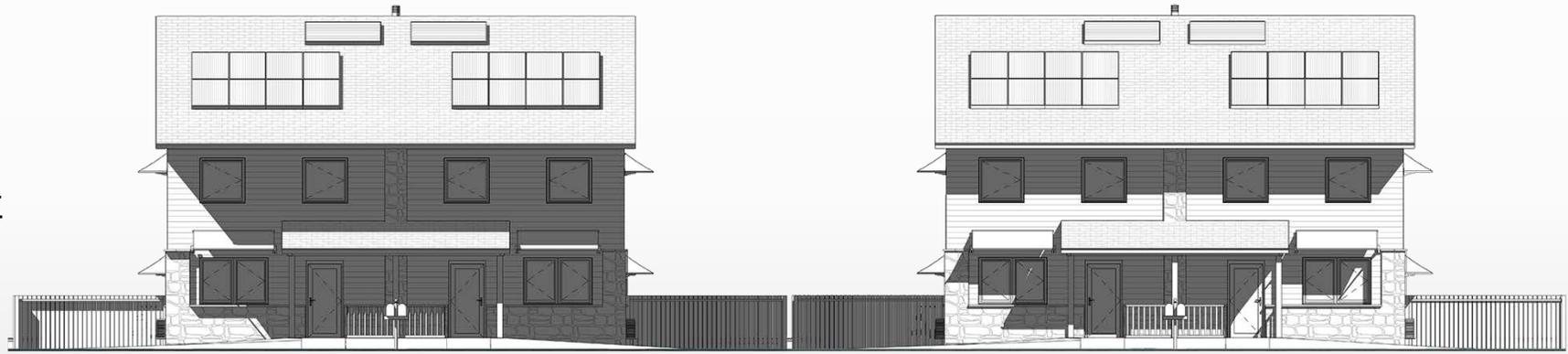
# Passive Strategies

- Solar Orientation
  - South 11° West
  - Within 15° of true South
  - Large living room windows
- Thermal Mass
  - Stamped concrete flooring in foyer
  - 4" concrete acts as heat sink
  - Absorbs heat gain from southern windows
  - Controls diurnal temperature range
  - Increases comfort throughout year
- Natural Ventilation
  - Operable windows at 3' sill height
  - Open inward swinging casement
  - Open inward like hopper



# Passive Strategies

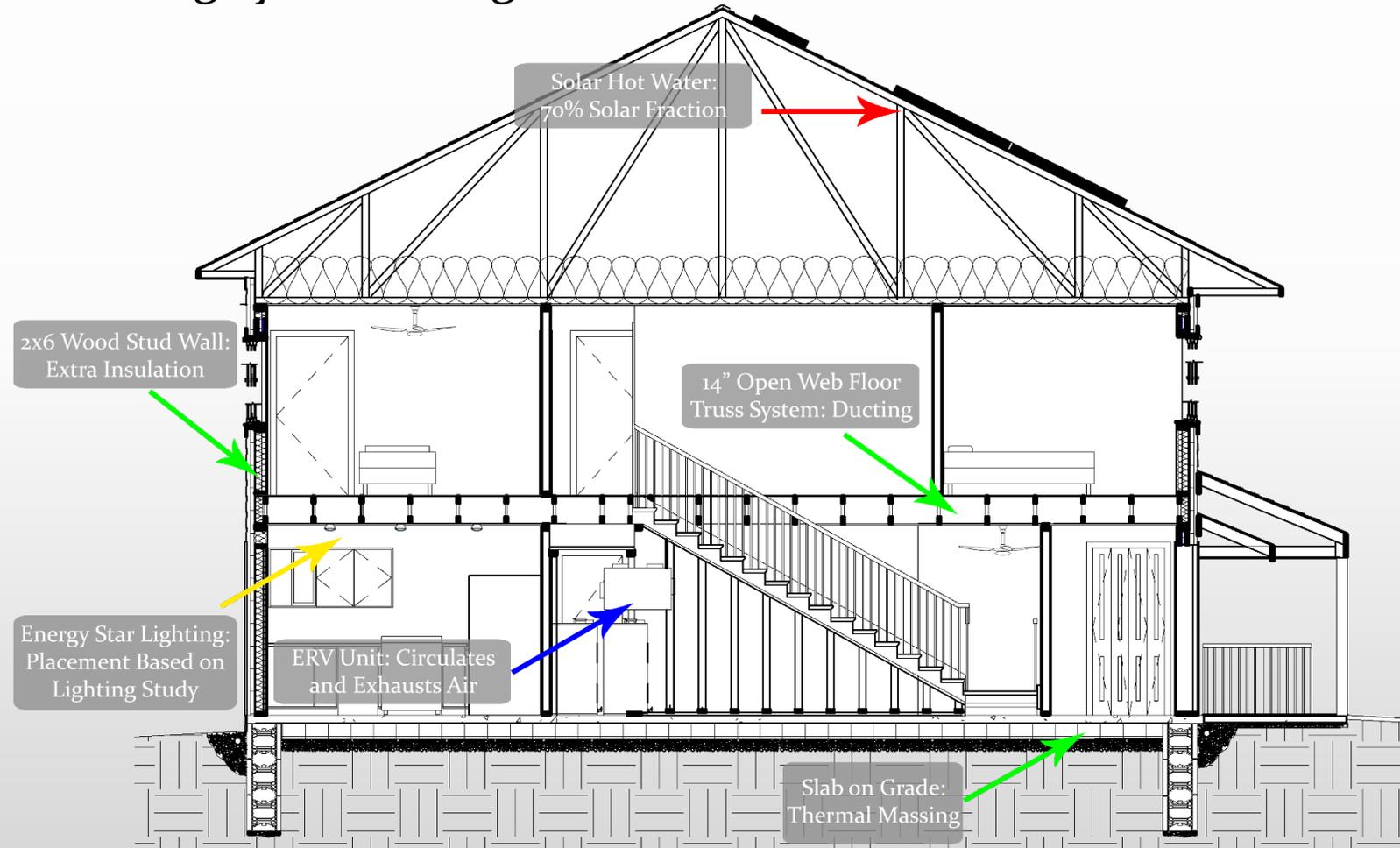
- Natural Shading
  - Weeping Cherry trees
  - Large maple south of site
- Solar Shading: South
  - Designed overhangs
  - Fixed awnings
- Solar Shading: East & West
  - Adjustable awnings
- Over-heated period
  - May – September
  - Fully shades
- Under-heated period
  - September – May
  - Allows direct solar heat gain



# Integration

- Structural System
  - Slab on grade
  - 2x6 wood stud wall
  - 14" open web floor truss system
- HVAC System
  - ERV used to circulate and exhaust
  - Mini split pumps w/ dehumidification
  - Supplies to common areas
  - Exhausts from bedrooms
- Plumbing System
  - Solar hot water system: 70% solar fraction
  - Condensed plumbing, efficient pipe length
- Lighting System
  - Fixtures placed based on daylighting study
  - 90% ENERGY STAR fixtures
  - LED bulbs

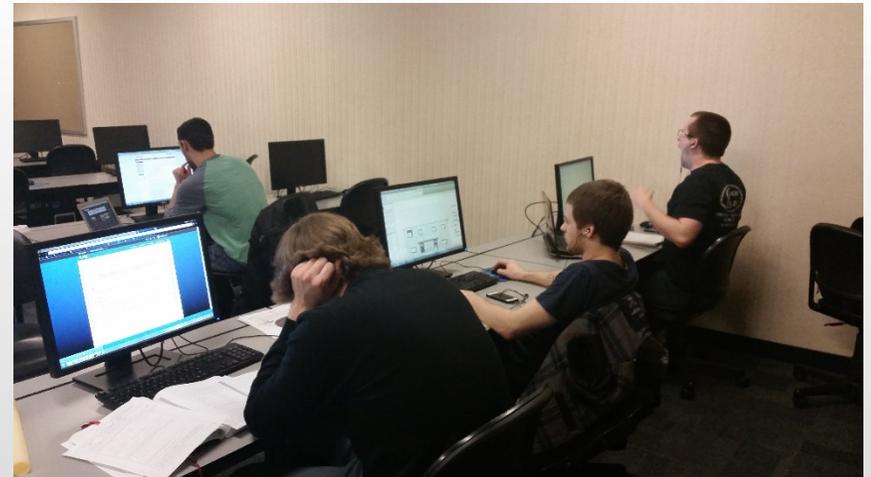
## Building Systems Integration



# Integration



- School Wide Meeting
  - Students from all majors
  - DOE competition
  - Passive house design
  - Habitat for Humanity
- Weekly Meetings
  - Discussed design goals
  - Collaborate between group members
- Designated Section Leaders
  - Based on academic major
  - Decisions based on all sections input
- “Group Me” Application
  - Continuous flow of information
  - Well informed design decisions
- Central Work File
  - Easily share and access project files and documentation



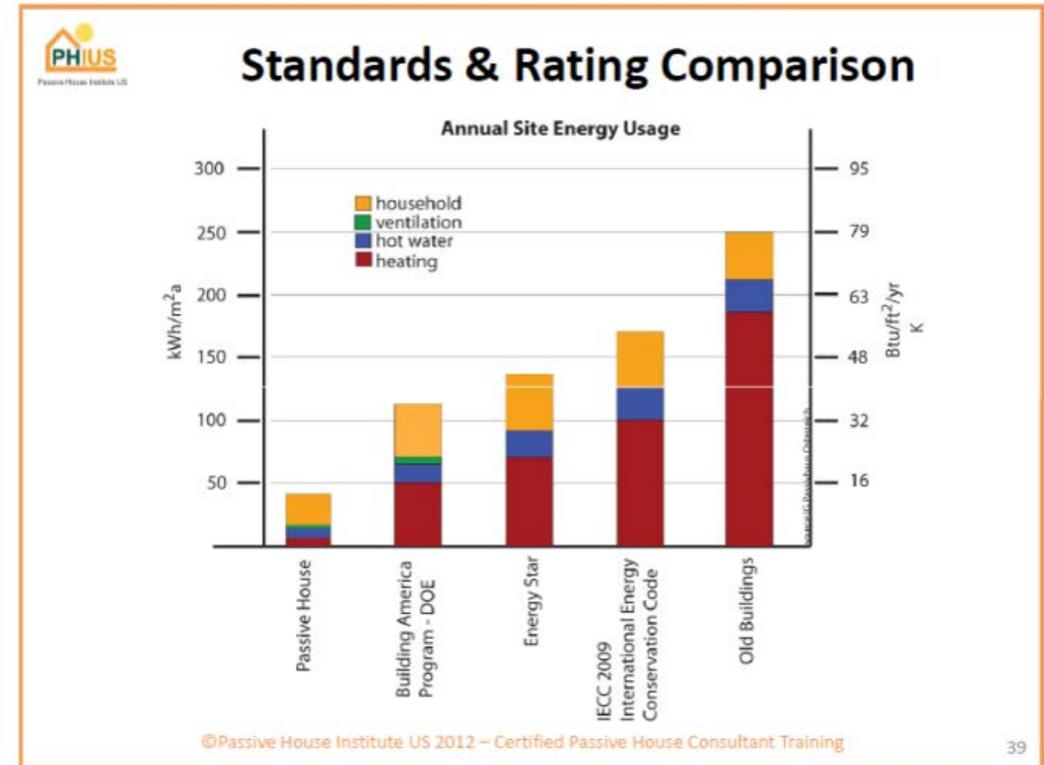
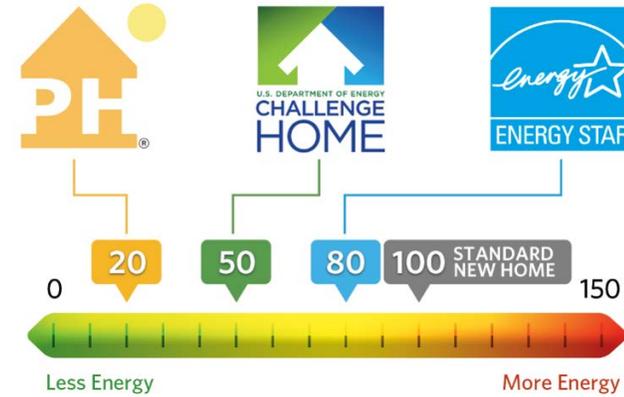
# Sustainability

- 1) Local & readily available materials, donated locally
- 2) Easy to use products for quick and simple construction
- 3) Low maintenance & high durability
- 4) High performance: cost ratio
- 5) Minimized finishes with off gassing potential



# Standards

- DOE Zero Energy Ready
  - HERS 50 or lower
  - Energy Star qualified homes Version 3
  - Energy Star fenestration requirements
  - 2012 IECC ceiling, wall, slab insulation
  - HVAC ducting within thermal boundary
  - Hot water delivery efficient design
  - Energy Star appliances
  - 80% Energy Star fixtures
  - EPA Indoor airPLUS certified
  - Renewable Energy Ready



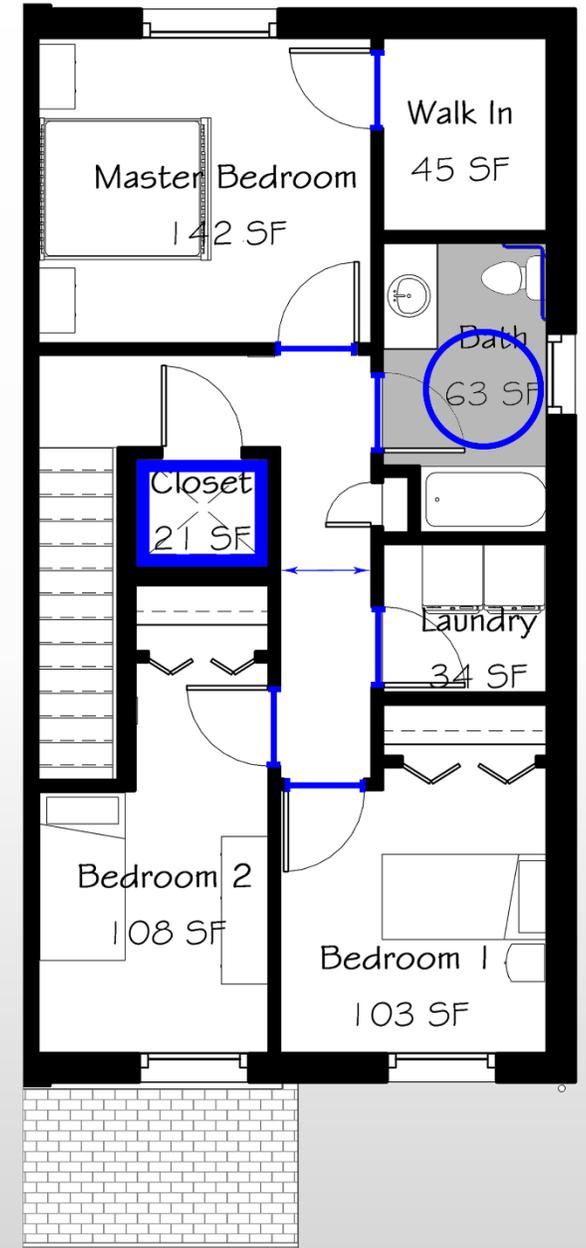
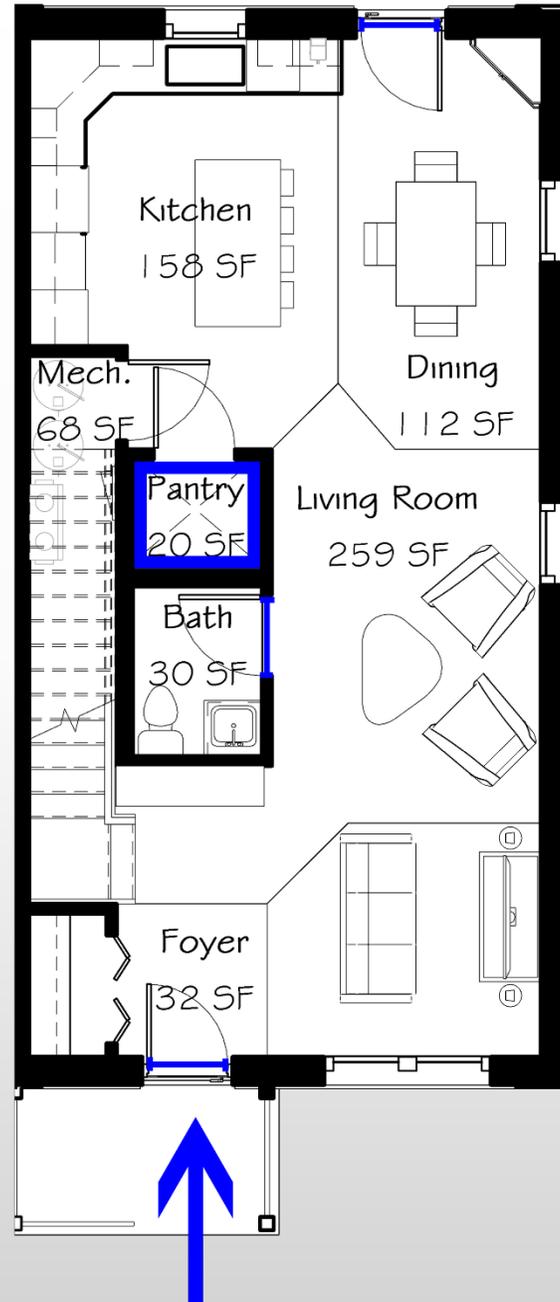
# PHIUS Standards

- Required
  - 4.75 kBTU/sf/yr heating
  - 0.6 ACH @ 50 Pascal's
  - 38 kBTU/sf/yr energy
- Actual
  - 4.70 kBTU/sf/yr heating
  - 0.6 ACH @ 50 Pascal's
  - 21.27 kBTU/sf/yr energy



# Standards

- Accessible Design
  - Accessible building entrance
  - Open floor plan with 3' hallways
  - Pantry can be retrofitted for elevator
  - 32" clearance at all doors
  - Accessible bathroom with nonslip floors and grab bars
  - Light switches at 36" above floor
  - Electrical outlets at 18"-24" above floor



# Incentives and Rebates

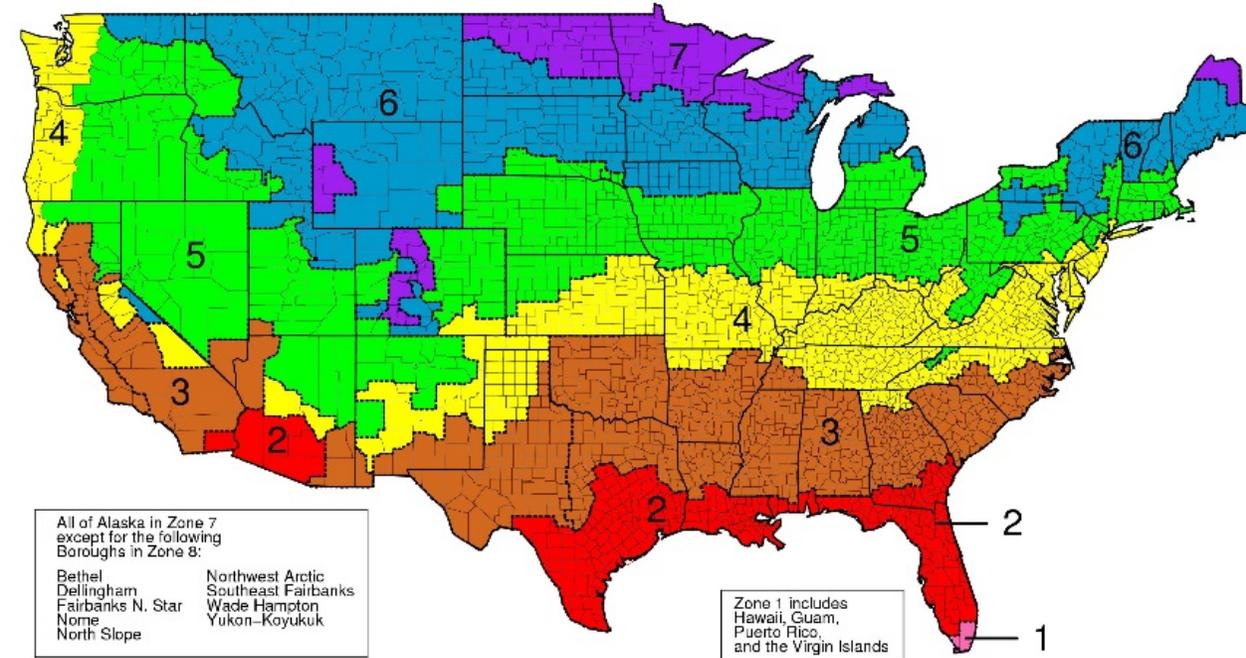
- Residential Renewable Energy Tax Credit
  - 30% personal tax credit
  - The High Performance Building Program
  - Underwrites the cost of high performance building
- Lowes Community Partners Grant
  - Grant ranging from \$2,000 to \$100,000
  - Generally \$5,000 to \$25,000
  - Tax exempt nonprofit organizations and public agencies in communities



# Envelope Durability

# Climate Zone

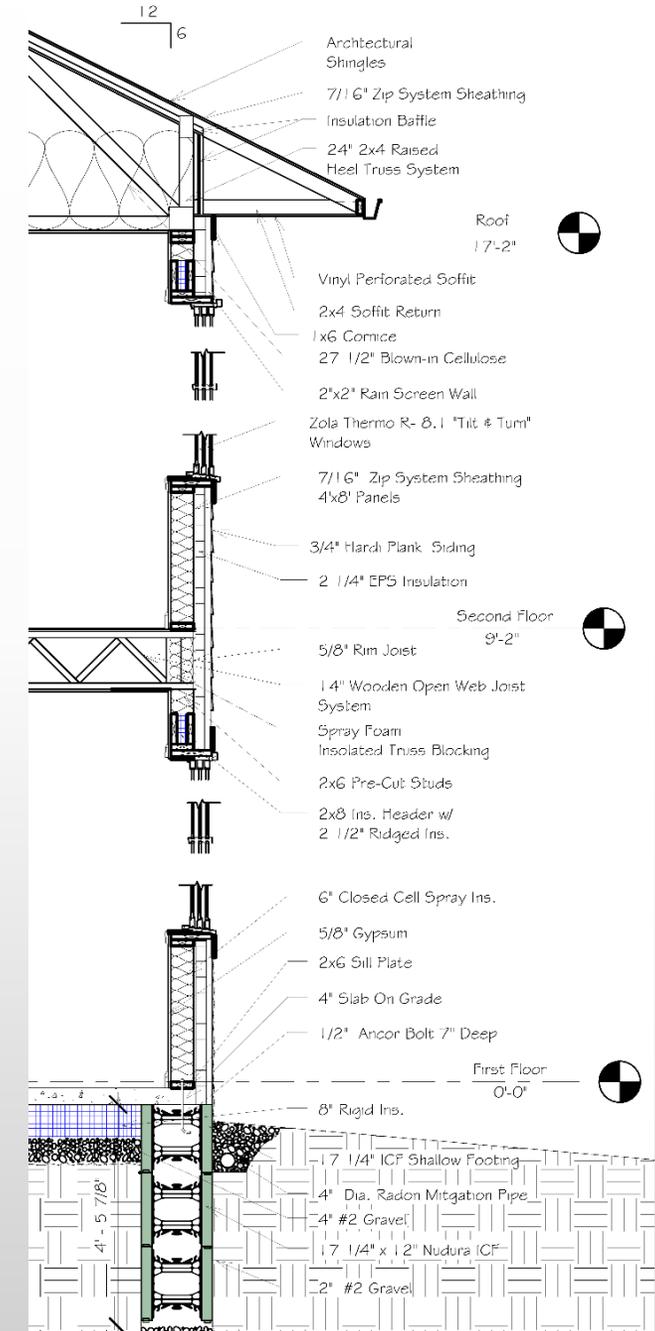
- Considerations
  - Geological location
  - Local Code
  - Climate Zone
  - Moisture and Condensation
  - Constructing a Continuous Building Envelope
  - Meeting PHIUS and Energy Star Requirements
  - Overall Durability
- Climate Zone 5 Requirements
  - Thermal Bridging
  - Interior and Exterior Systems
  - Ventilations
  - Air Tightness
  - Required minimum Infiltration Rates



Climate Zone	Infiltration Rate, ACH50	≤ 50% Infiltration Rate, ACH50
1,2	6	≤ 3
3,4	5	≤ 2.5
5-7	4	≤ 2
8	3	≤ 1.5

# Building Envelope

- Designed for several maximum requirements
  - Air tightness
    - Continuous Envelope
  - Insulation
  - Moisture Protection
  - Constructed with Economy in mind
  - Durability
  - Shallow ICF Footing
    - Below frost line
    - Above potentially contaminated soil



# Windows

- Zola Tilt and Turn Windows
  - R-Value 8
  - Triple Glazed
  - Tilts 3 Different ways
  - Allowed for less wall insulation

**zola** European Windows

## THERMOPLUS

**SPECIFICATIONS**

Zola ThermoPlus Clad is the natural choice for Passive Houses and Net-Zero Homes. With R-11 glass standard in an industry-leading 18mm spacer thickness. ThermoPlus can be offered in extremely large sizes. Patented German Purent Insulation creates a thermally broken frame, and the recessed aluminum cladding allows for overinsulation.

**ZOLA™ ThermoPlus Clad**



# Energy Star Rating & PHIUS Requirements

- Building Envelope Development
  - Insulation thickness
  - Window types and placement
  - Raised Heal Truss Height
  - Built beyond code standard
- Case 10 - Original case to estimate overall R values required. R-54 ceiling, walls, slab.
- Case11 – R-54 ceiling, walls, slab. Case 10 + larger windows on the south
- Case 12 – R-54 ceiling, walls, slab. Case 11 + larger windows on the south
- Case 13 – Same as case 12, with R-values adjusted to R-40 slab, R-45 walls, R-75 ceiling

Acceptable R-value combinations			
slab	14" wall	12" wall	ceiling
32	50	48	75
32	48	46	84
40	48	45	75
40	46	44	84
48	44	42	84
48	42	40	92

## PASSIVHOUSE ENERGY PASS

2

### BUILDING INFORMATION

#### General information

Type: Residential  
 Year of construction:  
 Dwelling units: 2  
 Number of occupants: 7.1 (Verification)

#### Boundary conditions

Climate: WILLIAMSPORT REGIONAL AP PA  
 Internal heat gains: 0.7 Btu/hr ft<sup>2</sup>  
 Interior temperature: 68 °F  
 Overheat temperature: 77 °F

#### Building geometry

Enclosed volume: 35925 ft<sup>3</sup>  
 Total area envelope: 6815.8 ft<sup>2</sup>  
 AV ratio: 0.2 1/ft  
 Treated floor area: 2669 ft<sup>2</sup>

### PASSIVEHOUSE REQUIREMENTS

Certificate criteria: European

#### Heating demand

Specific: 4.7 kBtu/ft<sup>2</sup>yr  
 total: 12599.7 kBtu/yr  
 peak (month): 1.4 kBtu/ft<sup>2</sup>



#### Cooling demand

Specific: 0.6 kBtu/ft<sup>2</sup>yr  
 total: 1547.8 kBtu/yr  
 peak (month) - sensible: 0 kBtu/ft<sup>2</sup>  
 latent: 0 kBtu/ft<sup>2</sup>yr



#### Heating load

Specific: 3.1 Btu/hr ft<sup>2</sup>  
 total: 8177.9 Btu/hr



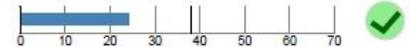
#### Cooling load

Specific: 0.9 Btu/hr ft<sup>2</sup>  
 total: 2487.6 Btu/hr



#### Primary energy

Specific: 24.1 kBtu/ft<sup>2</sup>yr  
 total: 64412.2 kBtu/yr



#### Air tightness ACH50

0.6 1/hr



# Indoor Air Quality Evaluation

# Moisture Control

- Humidity control in super-tight structures is critical
- Conventional AC systems cool air too quickly in low-load buildings
- Rapid cooling satisfies sensible heat demands LONG before humidity is removed from air
- Decoupled dehumidification is the most energy efficient approach
- Solution: mini-splits with dehumidification
- We accomplish <0.5 ACH with appropriate sealing and air barriers
- These barriers, & screens at openings ensure pest control
- Filtration of all outdoor air is ensured through positive building pressure, and high levels of mechanical filtration

# HVAC Systems

- Mini-split Heat Pump
- DX-200 Ultimate Air ERV
  - 2 ERV's providing 24/7 fresh air ventilation
  - exhausts from the bedrooms, and supplies to the upstairs/downstairs common areas
  - CO2 sensor to supplement regular occupancy expectations with limit-based additional ventilation
  - 1 waste ERV exhausts the less desirable rooms (bathroom, kitchen, laundry) 24/7 to prevent moisture, smells, and pollutant build up
- The ERVs have standard pretreatment heaters (Mfg. specific), however these can be replaced or supplemented with glycol water coils to utilize the DHW energy supplied by the solar panels (balance being between Solar Thermal/ Solar Electric) making them scalable in energy economies



# Space Conditioning

# System Design

- Mini-Split Heat Pump (air-source) will run to maintain
  - Central Control
    - Heads are programmed for desired conditions
    - Optional central control center can control both heads simultaneously
  - Downstairs Heating (Programmed @ head)
    - 68° F Sensible Temperature
    - 40-50% Humidity
  - Upstairs Cooling (Programmed @ head)
    - 72° F Sensible temperature
    - 40-50% Humidity
    - Night set-back to facilitate nighttime economization via ERV
- ERV
  - Upstairs bathroom (Occupancy + 10min) EXH 20 CFM
  - Downstairs bathroom (Occupancy + 10min) EXH 20 CFM
  - Kitchen (Exhaust Hood use) EXH 100 CFM
  - Kitchen (Programmable CO2 sensor @ 800 PPM) (Occupancy based ventilation modulation per ASHRAE 90.1)
- Occupant Comfort
  - Latent design: 40-50% RH
  - Sensible design: 68/72° F Heat/Cool

# The Cold Bedroom

- Touted as the easiest tight-house problem to solve..... But is it?
- Bedrooms are outdoor air supply points
- Tempering is effective, then again not infallible
- Behavior is **KEY** to these homes working as “intended

# Building Science

- Our methodology is to explore
  - Exhausting from bedrooms
- vs
- Supplying fresh air to bedrooms
- Though ventilation air is not provided in high enough quantities to move air, not providing (possibly very poorly) tempered air to bedrooms with doors closed is a known issues with current Passive Houses



Evidence of “The cold bedroom”

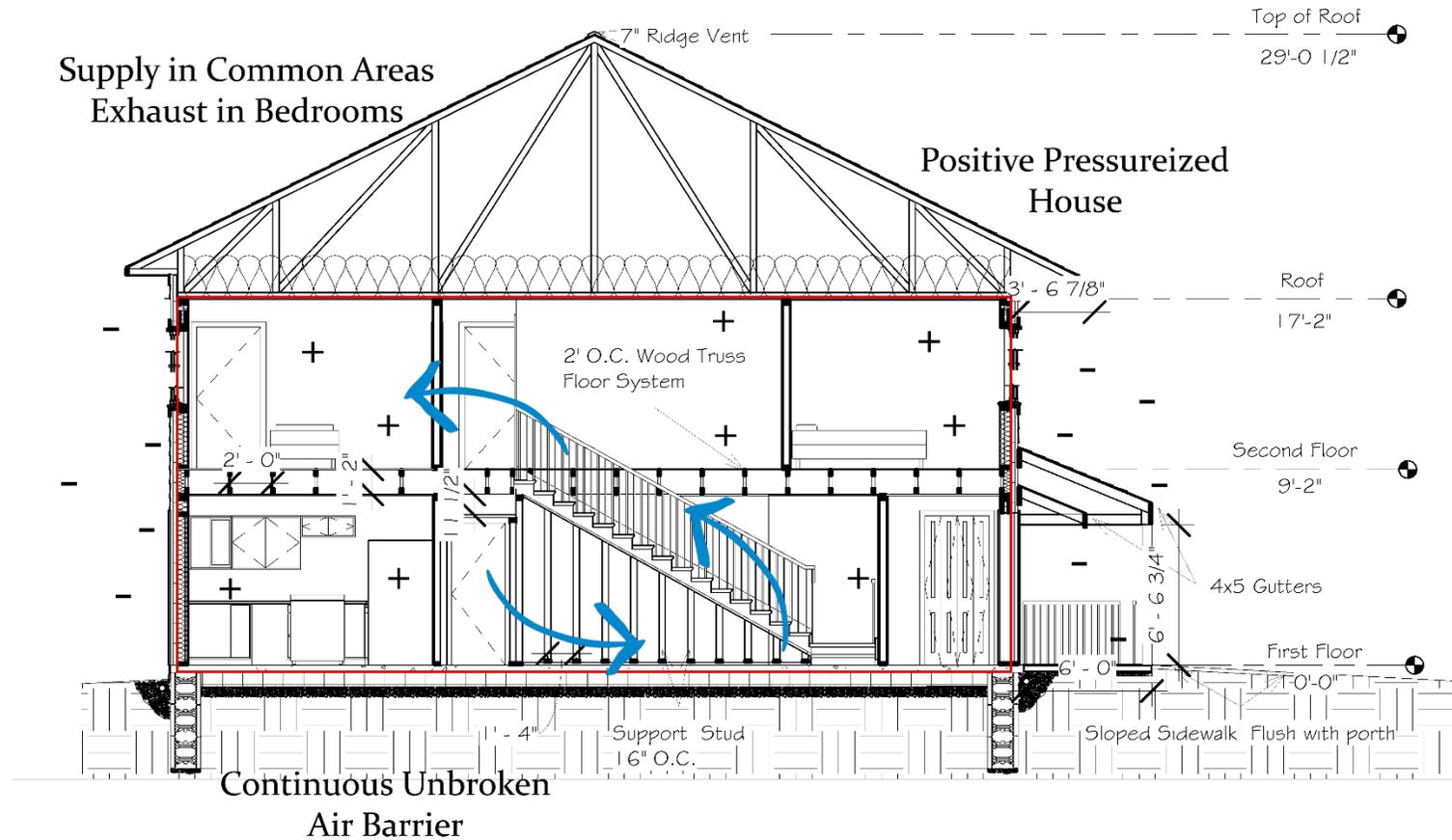
R. Carter Scott’s  
*Net-Zero-Energy House*  
Townsend, Massachusetts

South Mountain Company’s  
*Elakim’s Way project*  
Martha’s Vineyard

RDI’s  
*Wisdom Way project*  
Greenfield, Massachusetts

# Positivity

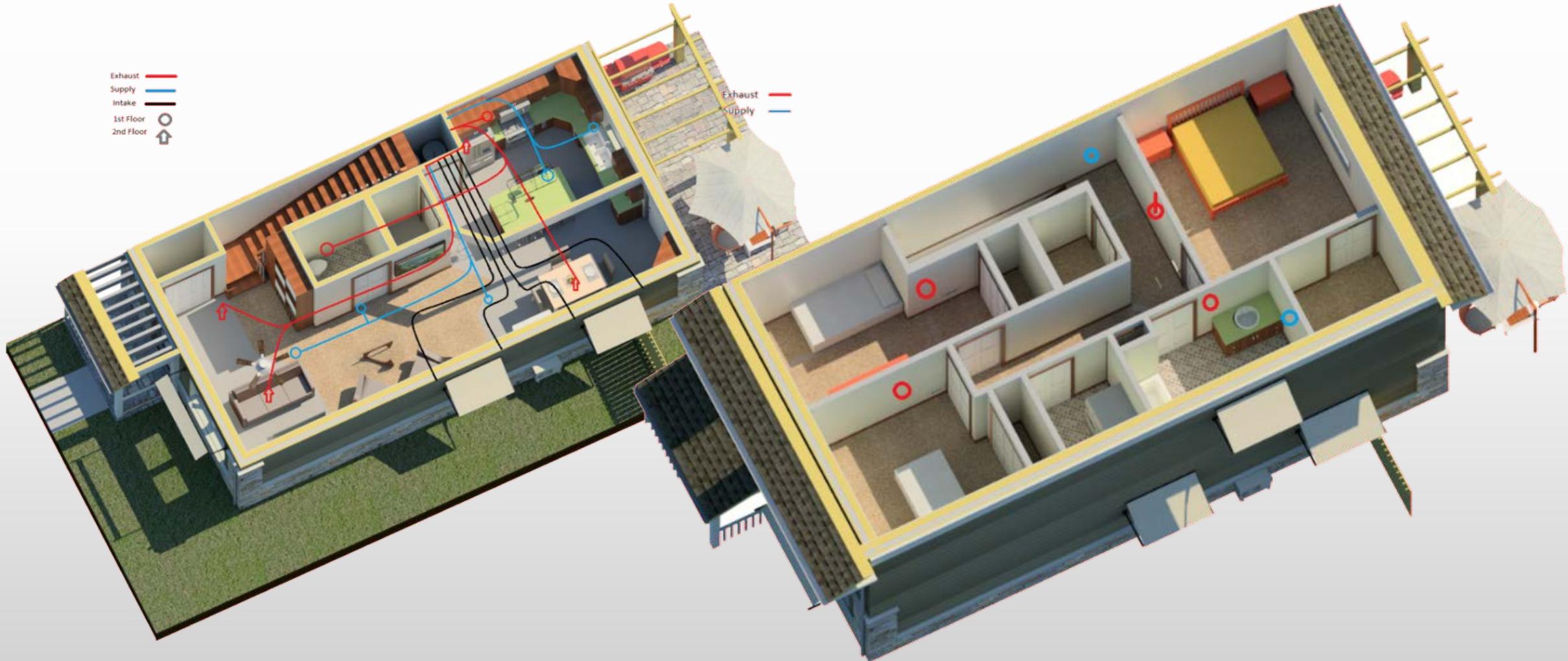
- The house is kept at a net-positive pressure versus the outdoors
- Positive indoor
  - Pressure eliminates infiltration completely
  - Ensures that all air entering the building has been conditioned for maximum comfort and health



# The HVAC

- Space conditioning requirements are satisfied by a dual indoor unit mini-split heat pump
- We placed a head on each level to offset the natural stratification of air in the building
- The upstairs unit does the bulk of dehumidifying and cooling (Hot, humid air rising to the top of the building)
- The downstairs unit does the bulk of the heating (with cold air falling to the first floor)
- Total System Size: 18,000BTUH
  - Accounts for over twice the building maximum load
  - Uses Variable refrigerant volume to make this more acceptable
- Wall cassettes
  - Affordable (avg. \$300/unit)
  - Effective (multi speed, variable refrigerant volume, load matching capable)
  - Each head is independently capable of conditioning the whole house (9 kBTUH/head),

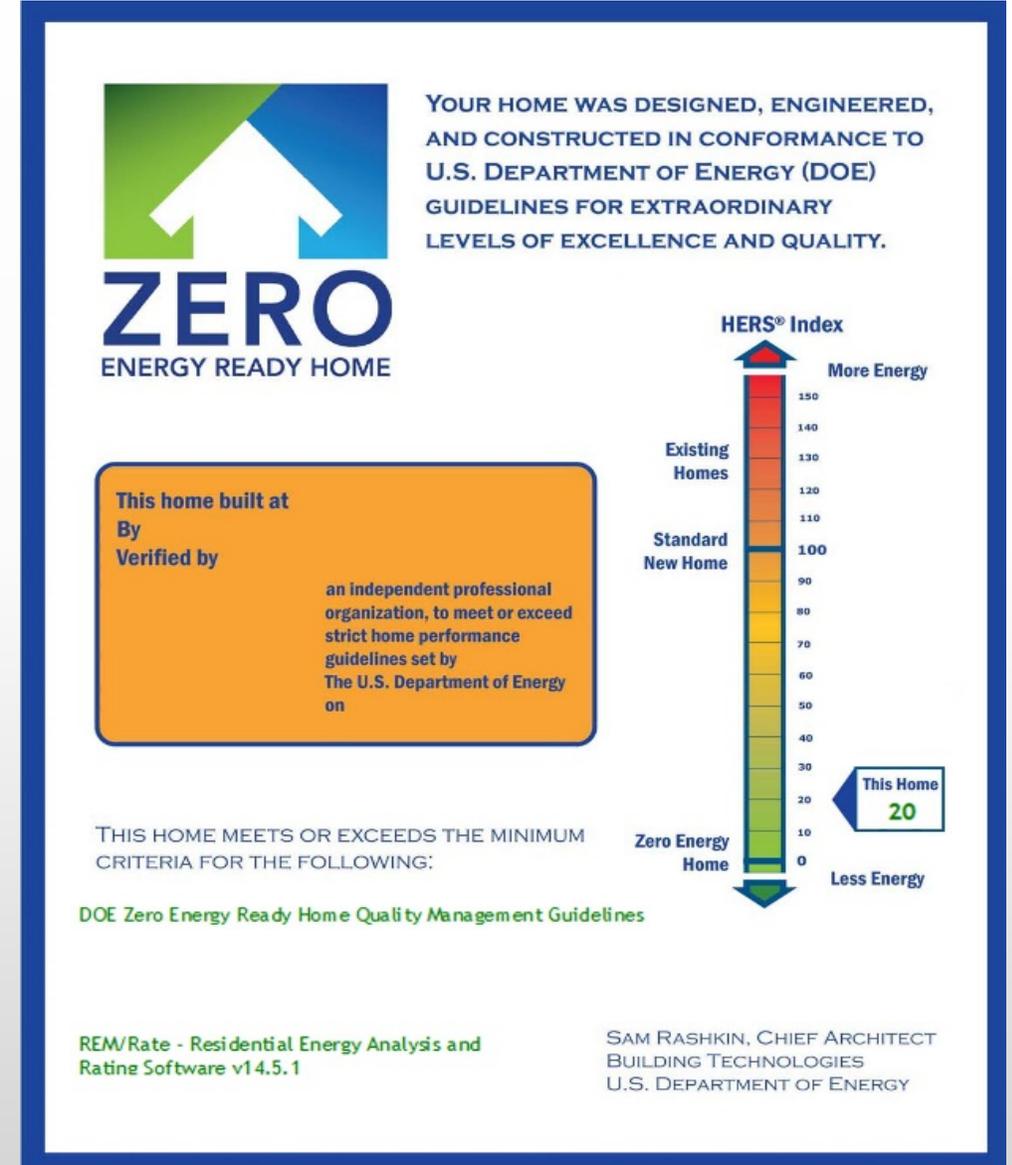
# HVAC Plans



# Energy Analysis

# Challenges / Constraints

- Building Occupancy
- Plot Size
- Budget
  - 20-60% Less than Current Williamsport MFI
- Maximize Usable Space
- Maximum Heating and Cooling Load
  - 162.76 kWh per Year
- Maximum Energy Consumption
  - 564.60 kWh per Year



# HERS Baseline Rating – 33

## Home Energy Rating Certificate



**Projected Rating: Based on Plans - Field Confirmation Required.**

### General Information

Conditioned Area	1654 sq. ft.	House Type	Duplex, single unit
Conditioned Volume	13232 cubic ft.	Foundation	Slab
Bedrooms	3		

### Mechanical Systems Features

Water Heating:	Conventional, Electric, 0.95 EF, 80.0 Gal.
Air-source heat pump:	Electric, Htg: 9.0 HSPF. Clg: 19.5 SEER.
Duct Leakage to Outside	NA
Ventilation System	Balanced: ERV, 47 cfm, 47.6 watts.
Programmable Thermostat	Heat=Yes; Cool=Yes

### Building Shell Features

Ceiling Flat	R-75.0	Slab	R-40.0 Edge, R-40.0 Under
Sealed Attic	NA	Exposed Floor	NA
Vaulted Ceiling	NA	Window Type	U-Value: 0.130, SHGC: 0.550
Above Grade Walls	R-46.0	Infiltration Rate	Htg: 0.60 Clg: 0.60 ACH50
Foundation Walls	NA	Method	Blower door test

### Lights and Appliance Features

Percent Interior Lighting	100.00	Range/Oven Fuel	Electric
Percent Garage Lighting	0.00	Clothes Dryer Fuel	Electric
Refrigerator (kWh/yr)	584.00	Clothes Dryer EF	3.01
Dishwasher Energy Factor	0.46	Ceiling Fan (cfm/Watt)	0.00

REM/Rate - Residential Energy Analysis and Rating Software v14.5.1

This information does not constitute any warranty of energy cost or savings. © 1985-2014 Architectural Energy Corporation, Boulder, Colorado. The Home Energy Rating Standard Disclosure for this home is available from the rating provider.

Registry ID		Rating Number	
Certified Energy Rater		Rating Date	
Rating Ordered For	Habitat for Humanity		

Estimated Annual Energy Cost			
Use	MMBtu	Cost	Percent
Heating	1.4	\$34	6%
Cooling	1.4	\$32	5%
Hot Water	3.1	\$72	12%
Lights/Appliances	17.2	\$404	67%
Photovoltaics	-0.0	\$-0	-0%
Service Charges		\$60	10%
<b>Total</b>	<b>23.1</b>	<b>\$602</b>	<b>100%</b>

Criteria	
This home meets or exceeds the minimum criteria for the following:	

# HERS w/ PV Rating – 20

## Home Energy Rating Certificate



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Registry ID		Rating Number	
Certified Energy Rater		Rating Date	
Rating Ordered For	Habitat for Humanity		

Estimated Annual Energy Cost			
Use	MMBtu	Cost	Percent
Heating	1.4	\$34	9%
Cooling	1.4	\$32	8%
Hot Water	3.1	\$72	19%
Lights/Appliances	17.2	\$404	106%
Photovoltaics	-9.4	\$-221	-58%
Service Charges		\$60	16%
<b>Total</b>	<b>13.7</b>	<b>\$381</b>	<b>100%</b>

Criteria	
This home meets or exceeds the minimum criteria for the following:	

TITLE	
Company	
Address	
City, State, Zip	
Phone #	
Fax #	

# Renewables Details

## Description

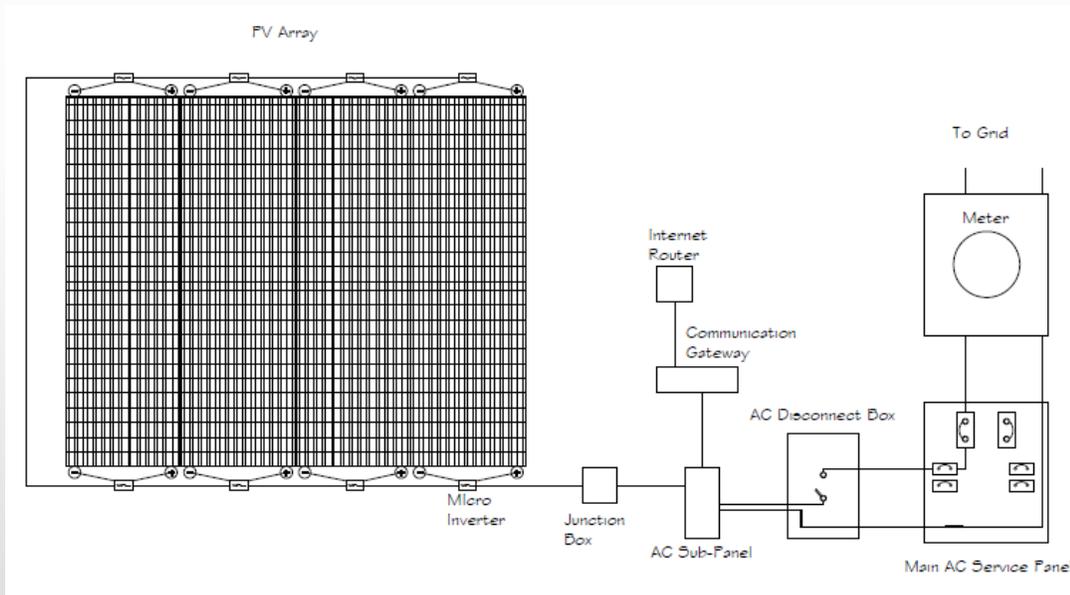
- Closed Loop DWH system
  - 24.91 SqFt
    - 70.2% Solar Fraction
- Photovoltaics
  - 2,080 Watts
    - 2252 kWh per year
- Meets RERH Standards
- 4" capped chase to attic
- 1" conduits for DC wire run.
- Micro Inverters on solar Panels

## Components

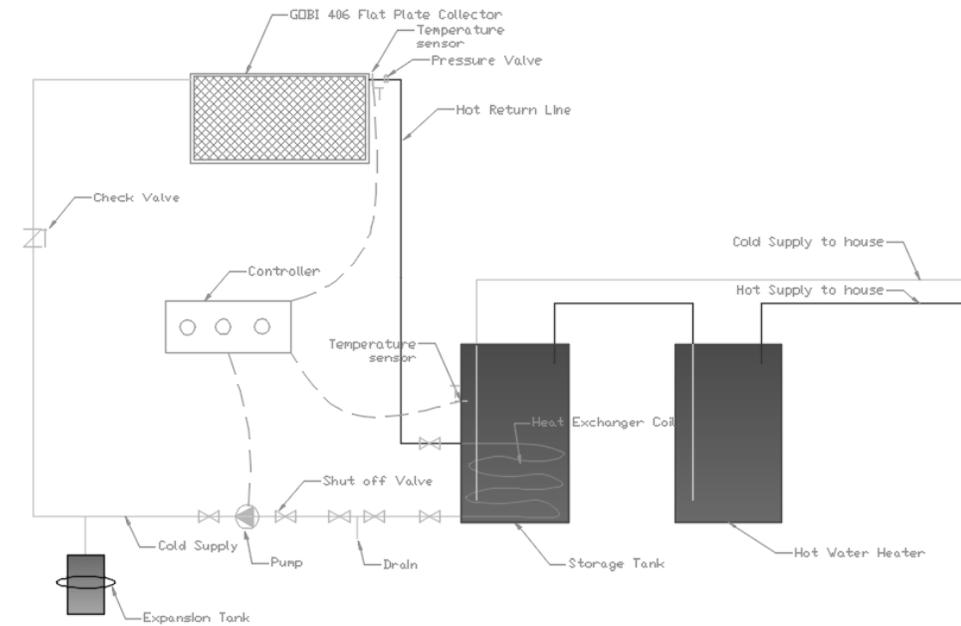
- Solar Thermal
  - Heliotype Gobi 406
  - Blue Sputter
  - Bio Glycol
  - 80 Gallon Hot Water Heater
- Photovoltaics
  - Astronergy 260 Watt Poly Crystalline
  - Enphase Micro Inverter

# Renewable Diagrams

## Photovoltaics



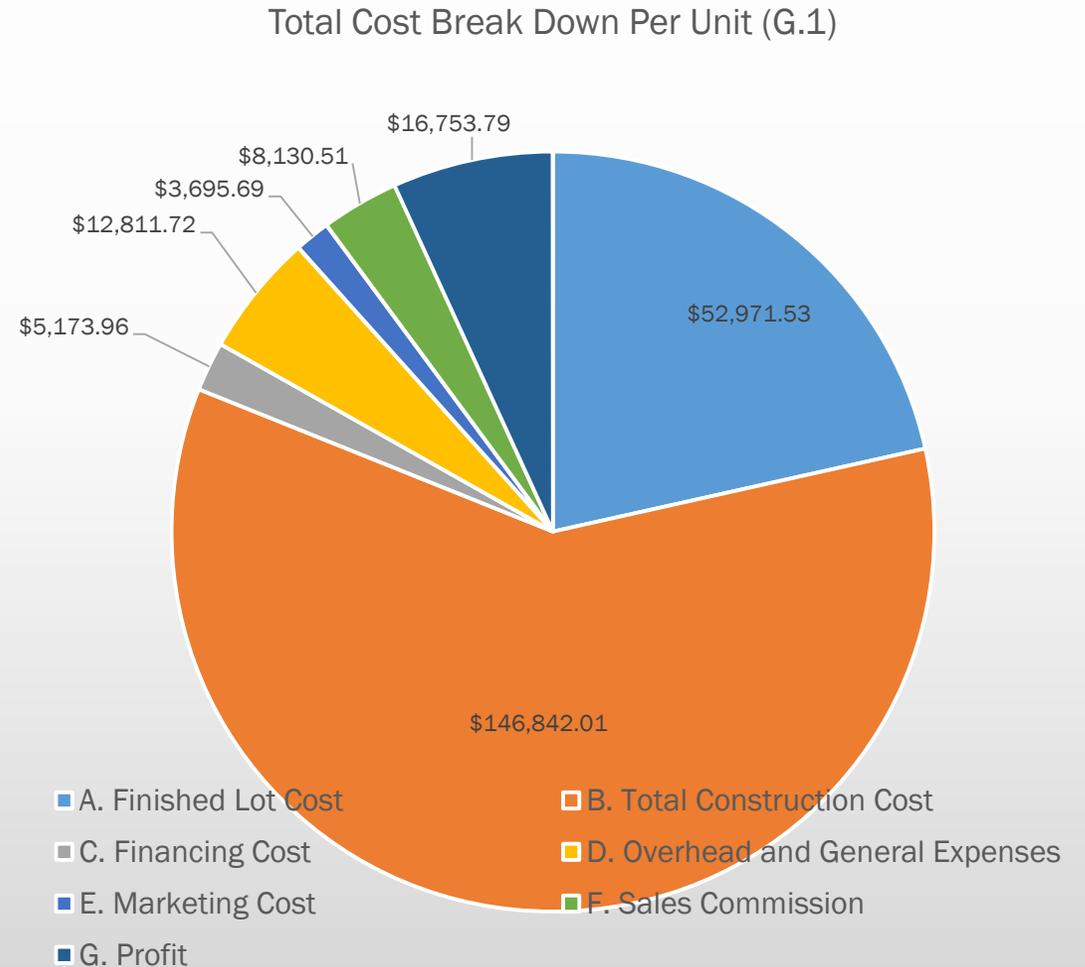
## Solar Thermal



# Financial Analysis

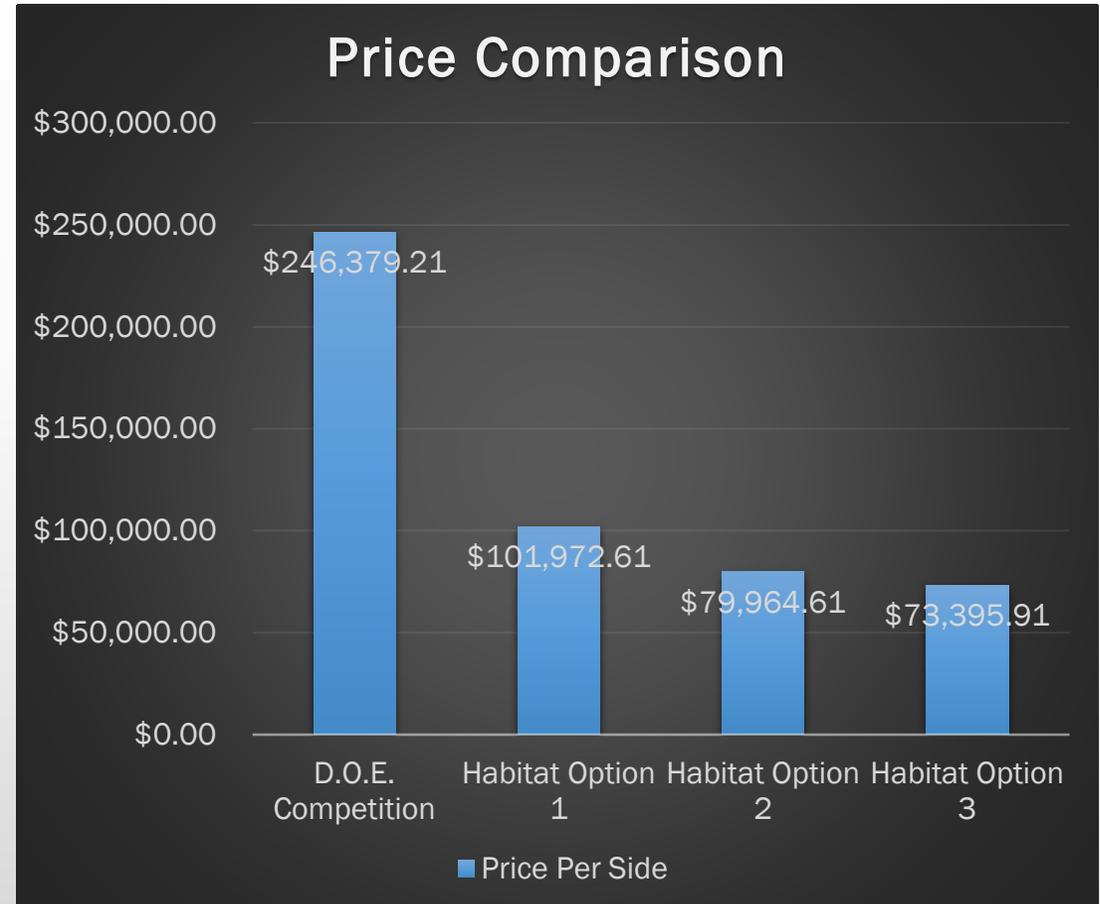
# Financial Analysis of Cost & Affordability

- “Speculative design” approach
  - regional median family income
- Habitat for Humanity
  - 20%-50% lower median family income
  - Lower materials costs
  - Significant labor reductions



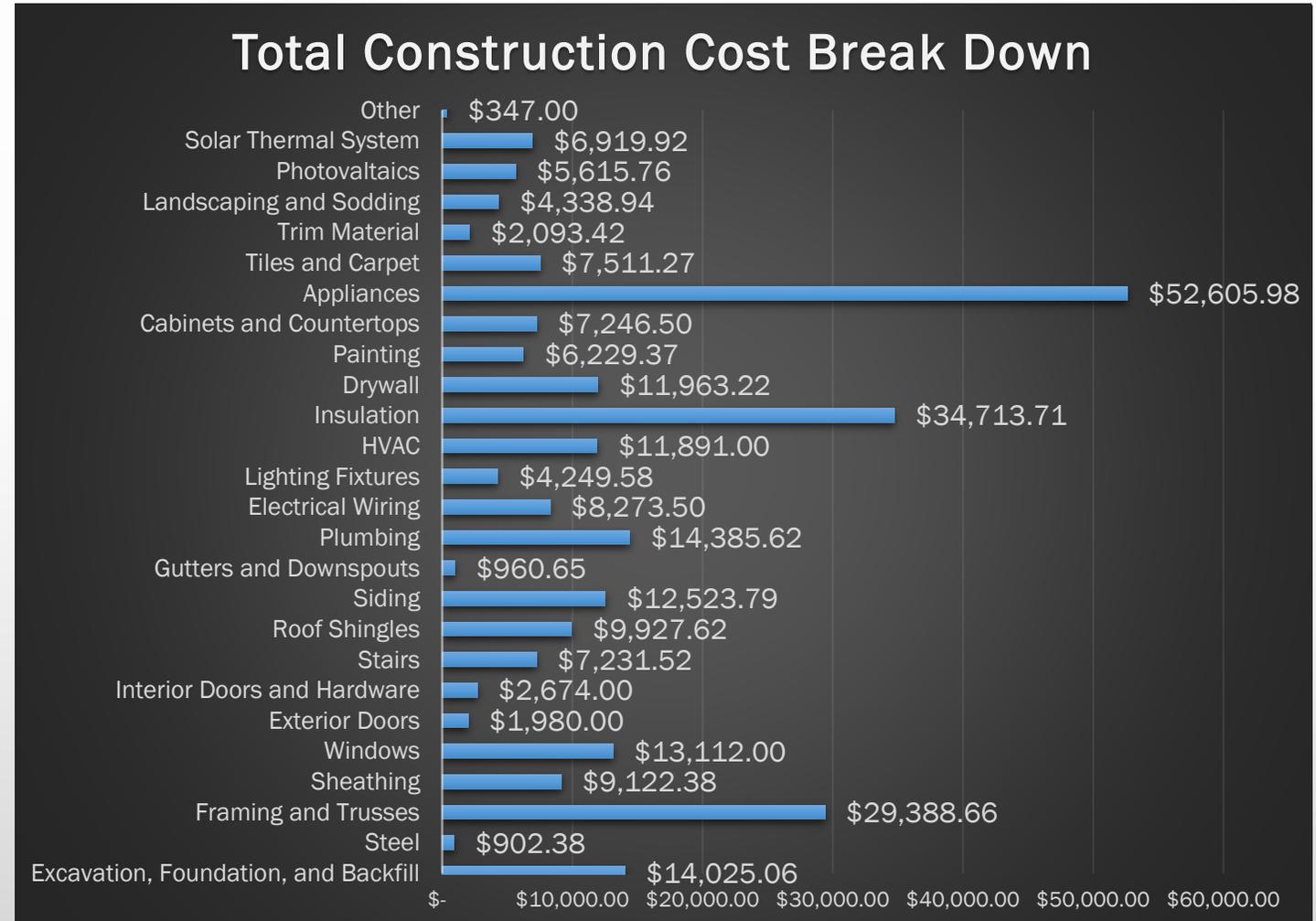
# Cost Breakdown Options

- D.O.E. Competition Total Per Side
  - \$246,379.21
- Habitat For Humanity Option 1: Renewables and ADA Accessible Per Side
  - \$101,972.61
- Habitat For Humanity Option 2: Renewables and ADA Ready Per Side
  - \$79,964.61
- Habitat For Humanity Option 3: Base Model Per Side
  - \$73,395.91



# D.O.E. Competition Total Per Side

- \$246,379.21
- Affordability MFI Requirement
  - \$43,703.25 per year
  - 22.5% less than Williamsport MFI
- \$981.96 Monthly Payment



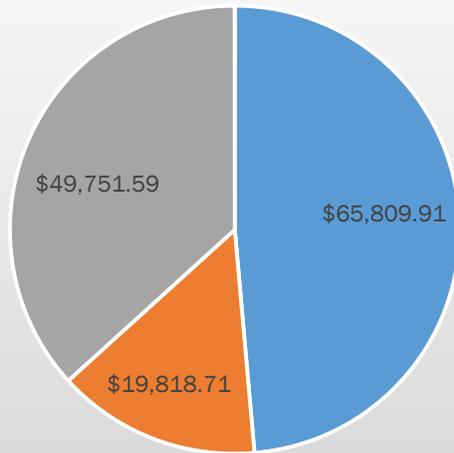
# Habitat For Humanity Deductions

- All Labor costs except: HVAC, Insulation, and Excavation costs & installation
- Material costs were reduced by 15% due to Lowes's Restore Program
- Lot cost was reduced to \$1.00 via the Brodart Neighborhood Improvement Plan
- Financing costs are eliminated due to Habitat For Humanity using their in house payment options for selected clients
- Marketing and Sales costs are eliminated by having no need for real estate agent market and sell the home
- Profit is eliminated because Habitat For Humanity is a Non-Profit organization

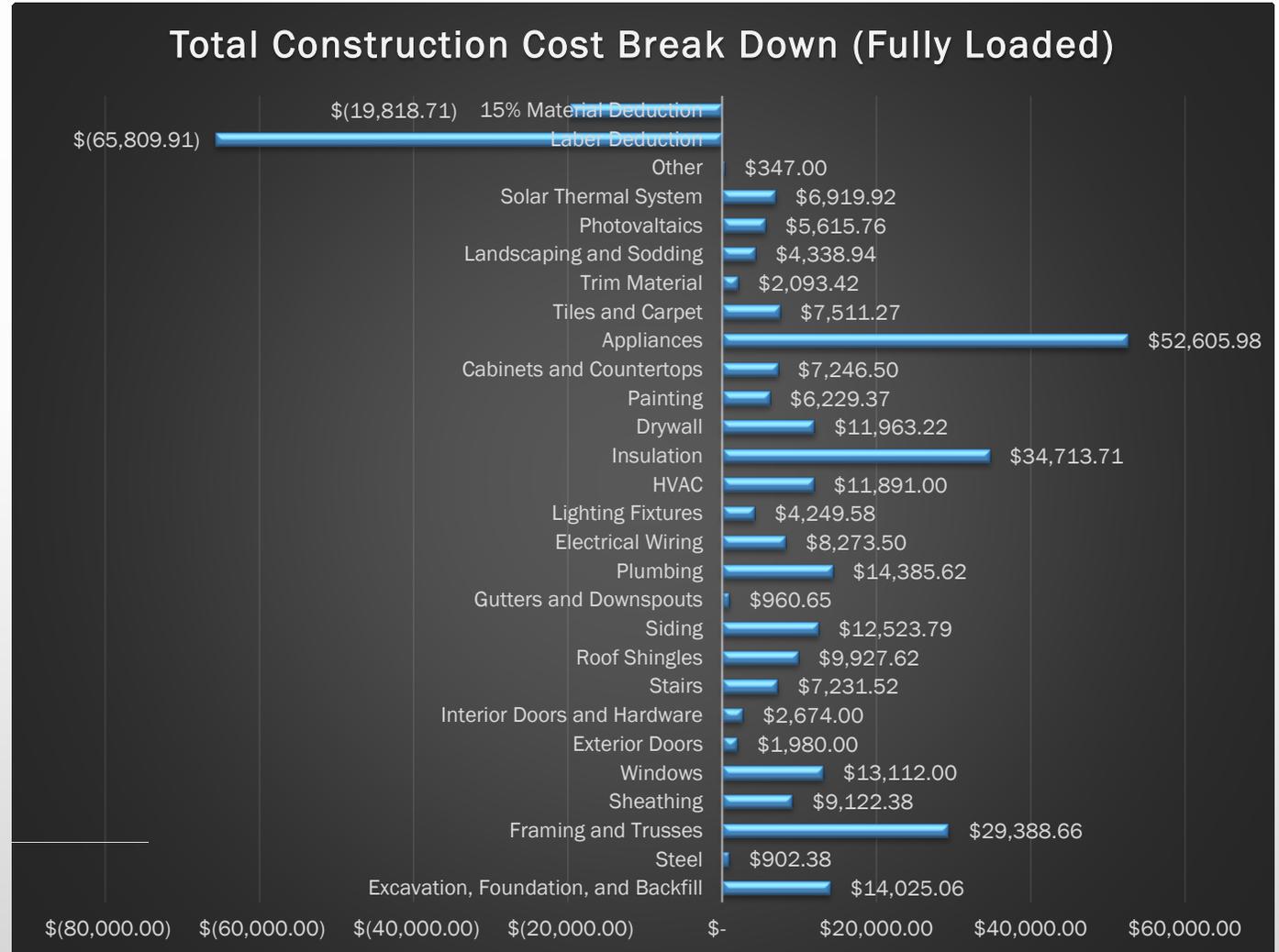
# Option 1: Renewables and ADA Accessible Per Side

- \$101,972.61
- Affordability MFI Requirement
  - \$25,746.83 per year
  - 54.3% less than Williamsport MFI
- \$413.34 Monthly Payment

Savings

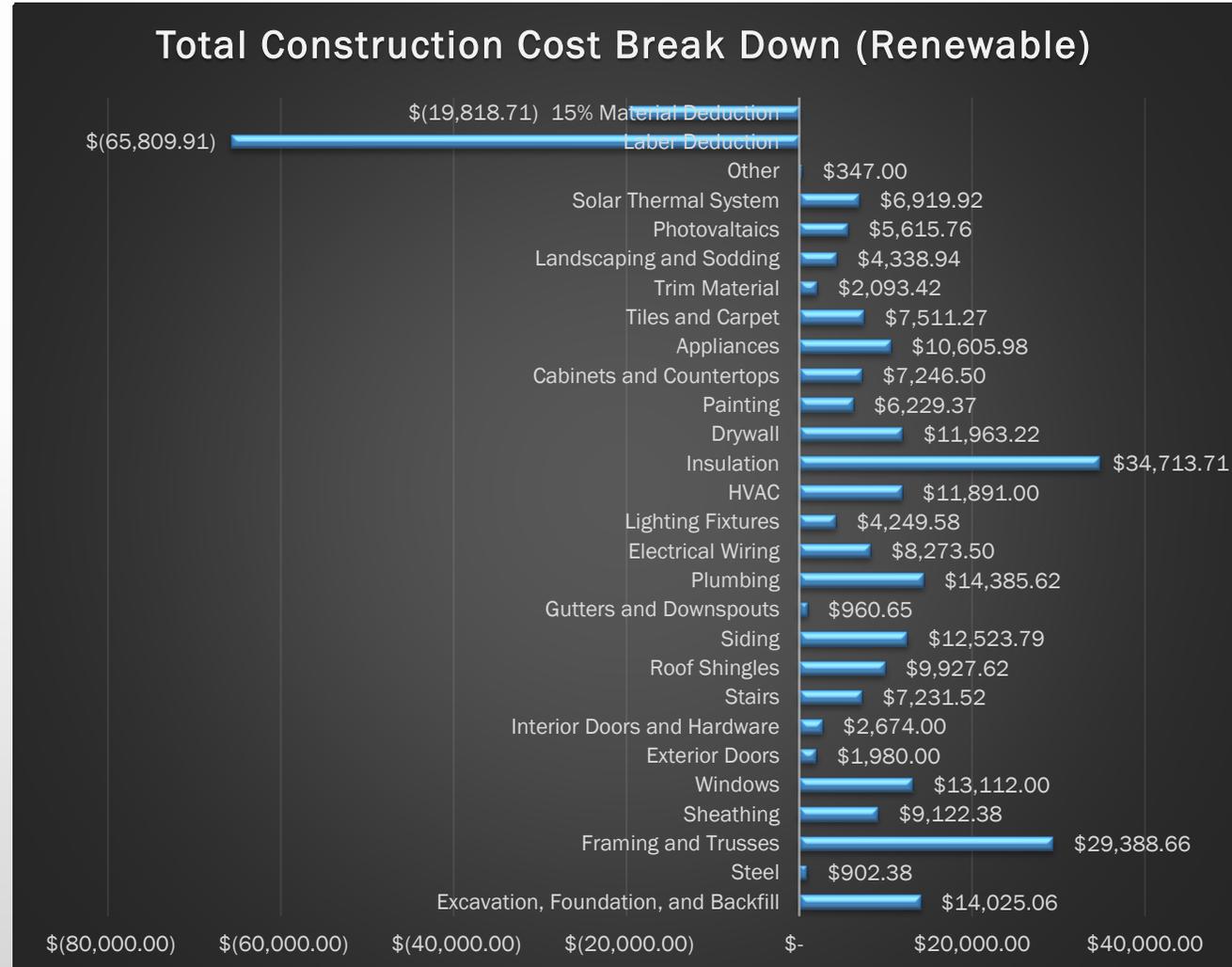


■ Labor Costs Savings 
 ■ Materials Deductions 
 ■ Non-Construction Costs Savings



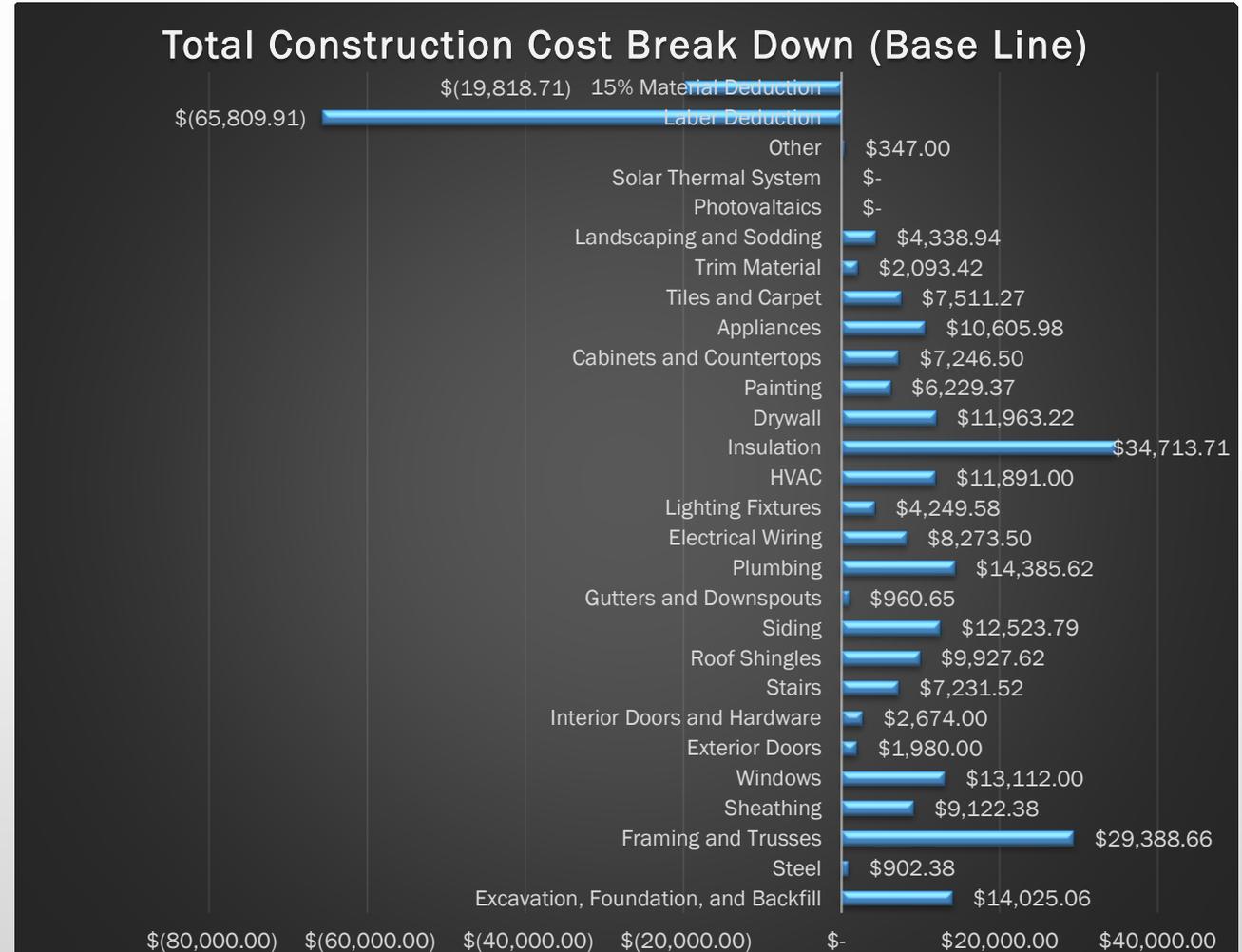
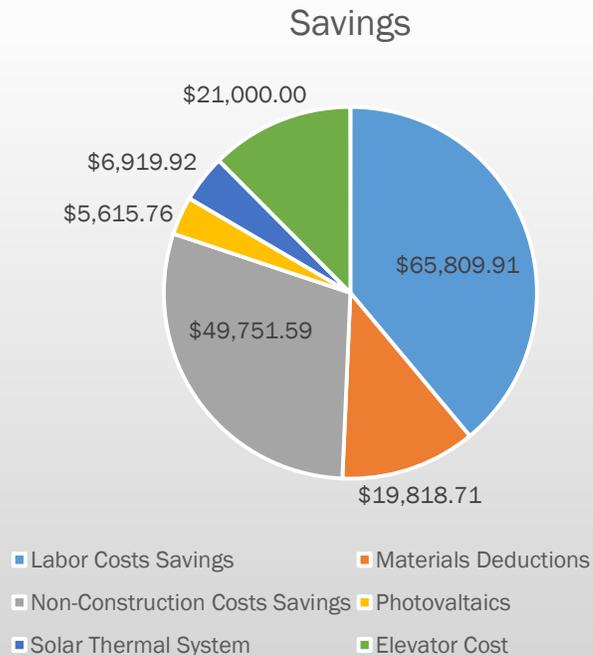
# Option 2: Renewables and ADA Ready Per Side

- \$79,964.61
- Affordability MFI Requirement
  - \$22,929.99 per year
  - 59.3% less than Williamsport MFI
- \$324.14 Monthly Payment



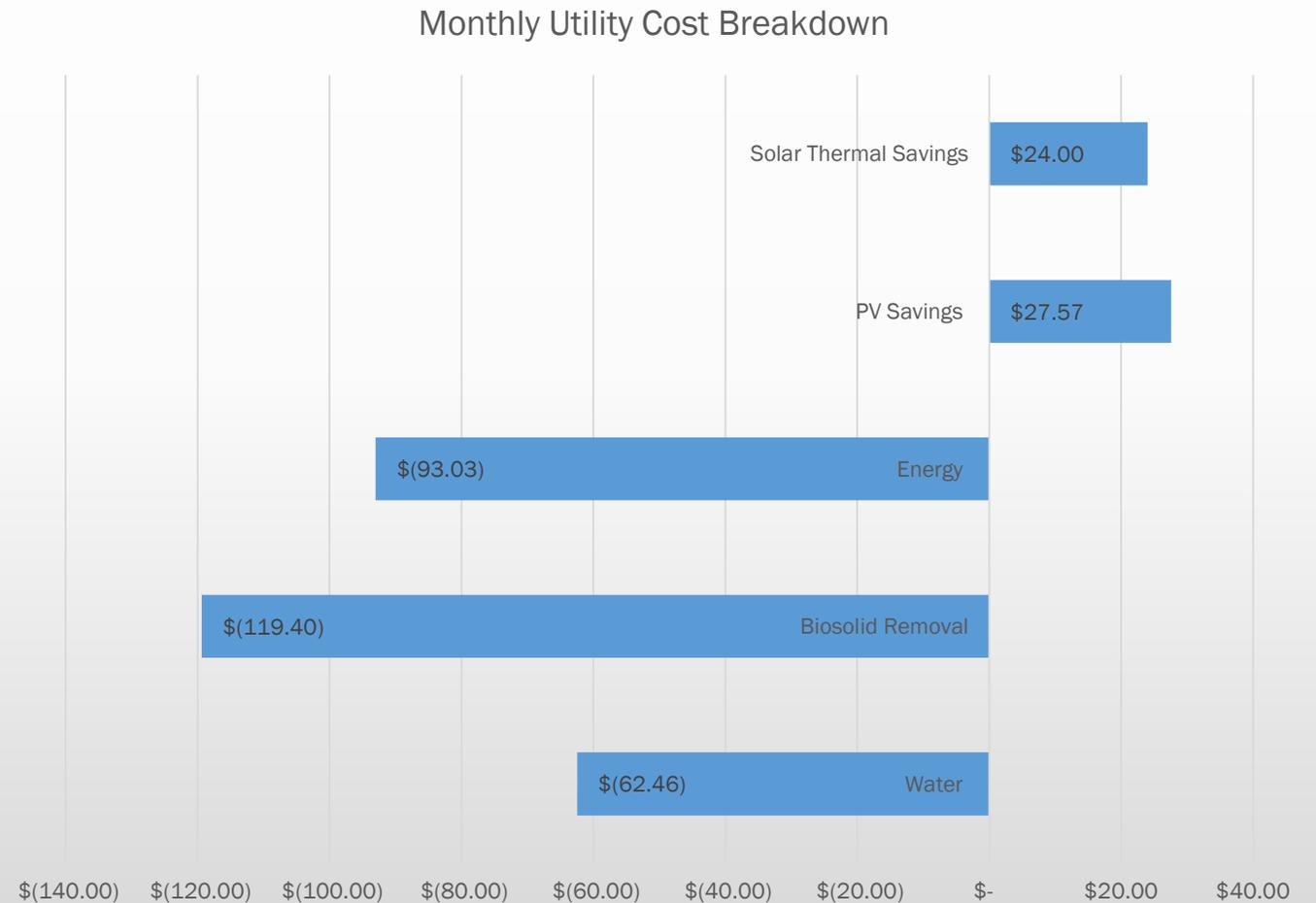
# Option 3: Base Model Per Side

- \$73,395.91
- Affordability MFI Requirement
  - \$22,089.04 per year
  - 60.8% less than Williamsport MFI
- \$297.51 Monthly Payment



# Renewable Savings per Home

- Photovoltaic Energy Savings
  - Federal Energy Tax Credit: 30%
    - \$1203.38
  - Savings per year
    - \$288.03
  - Payback period with Incentives
    - 9.7 years
- Solar Thermal Energy Savings
  - Saves \$330.87 per year
  - Payback period
    - 14.6 years
- Total Utility cost per Month
  - \$223.32

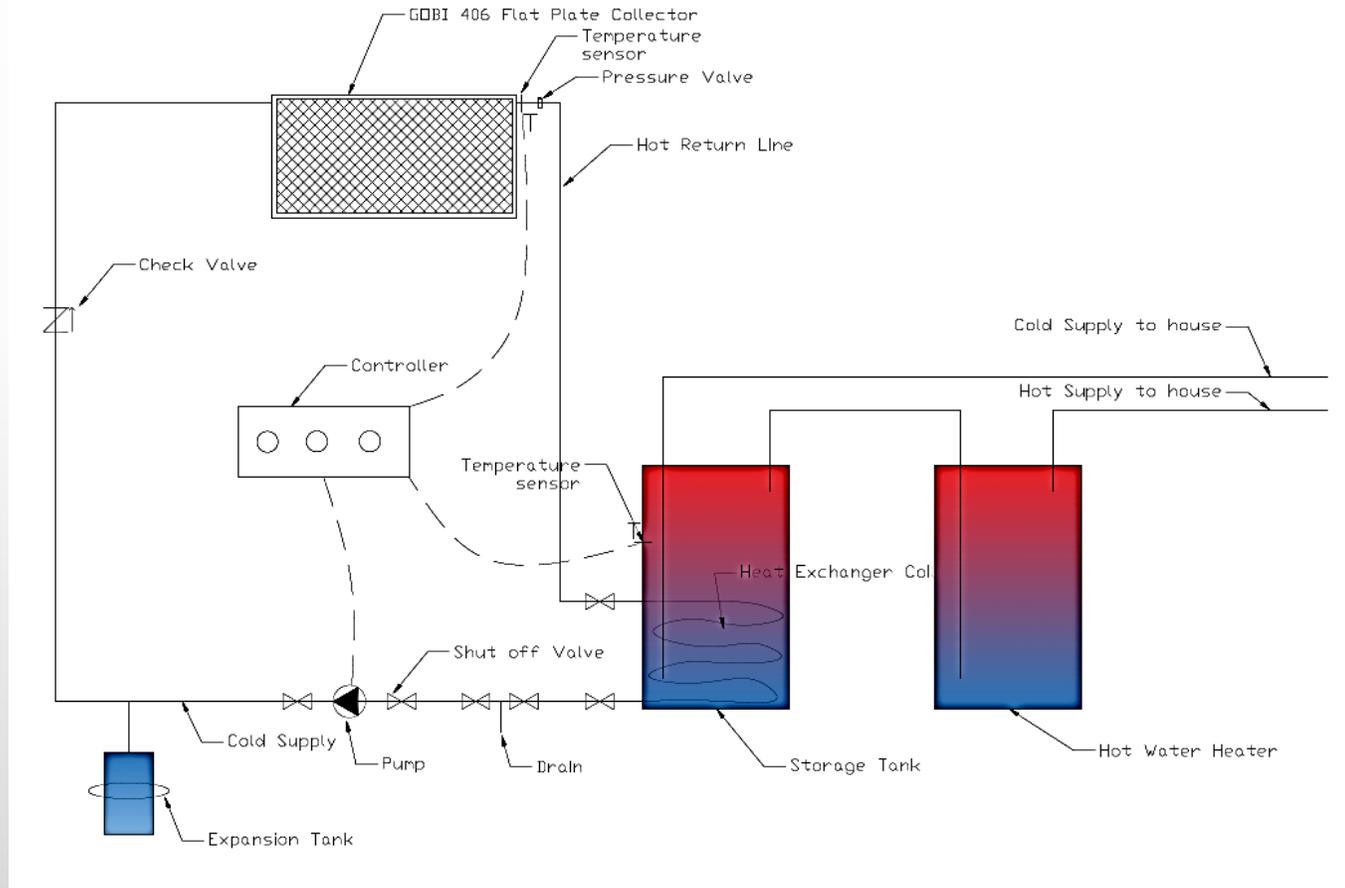


# Electrical Loads & DHW

# Domestic Hot Water

## Closed Loop Solar Hot Water

- Flat Plate Collector  
(Located on southern face of gable roof)
- Solar Storage Tank
- Pump/Fill Station



# Plumbing Layout

## Separate Meter Locations

- Convenience for occupants

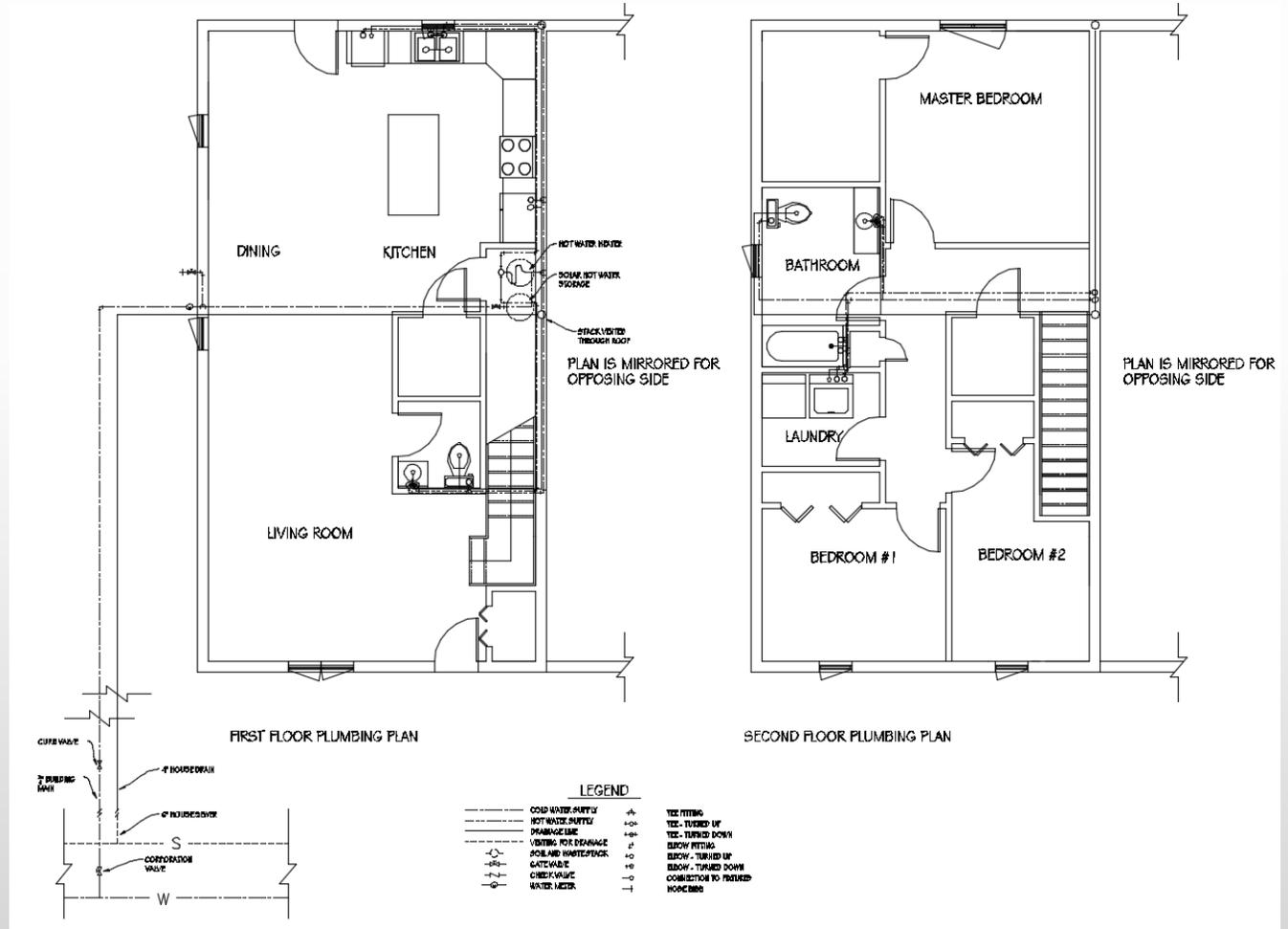
## Centralized Plumbing Chase Wall

- Fewer wall penetrations
- Follows overall house design
- Saves on plumbing materials

## EPA Water Sense Compliance

- No more than 0.5 Gal in system from Hot Water Heater to Hot Fixture

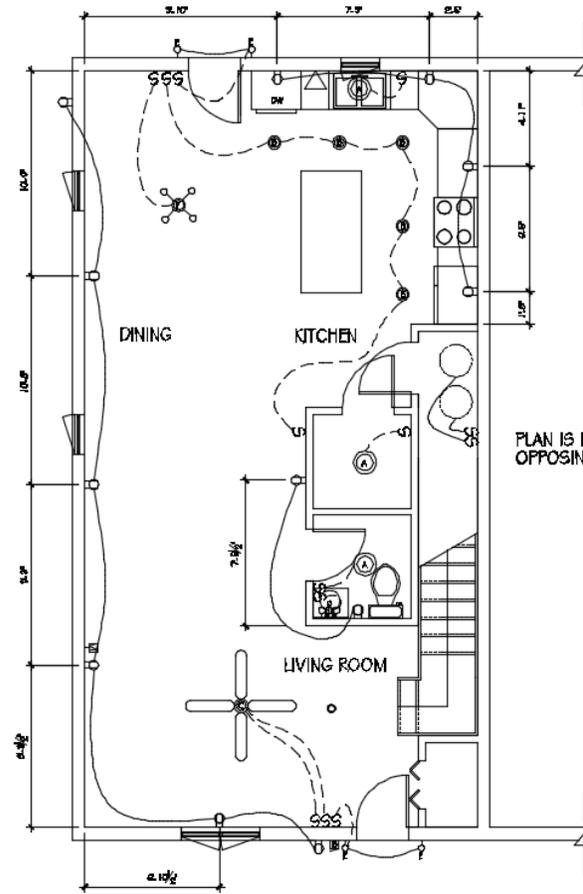
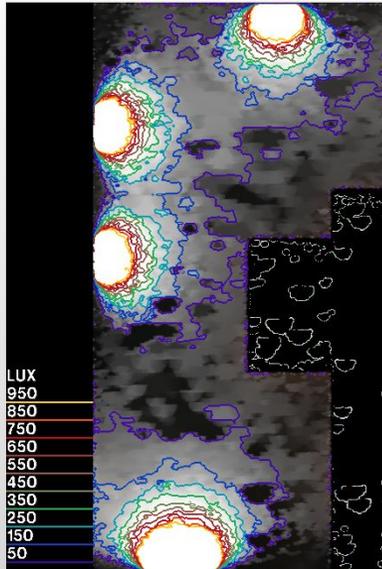
EPA 3.3 Water Sense					
No More than 0.5 Gal from Hot Water Supply					
Fixture	Feet	In	Diameter (In)	Area (In)	Volume (Gal)
Kitchen Sink	23	6	0.5	0.196	0.240
Half bath Sink	23	1	0.5	0.196	0.235
Full Bath Sink	29	0	0.5	0.196	0.296
Full Bath Tub	29	3	0.5	0.196	0.298
Washer	32	0	0.5	0.196	0.326
Diswasher	27	8	0.5	0.196	0.282



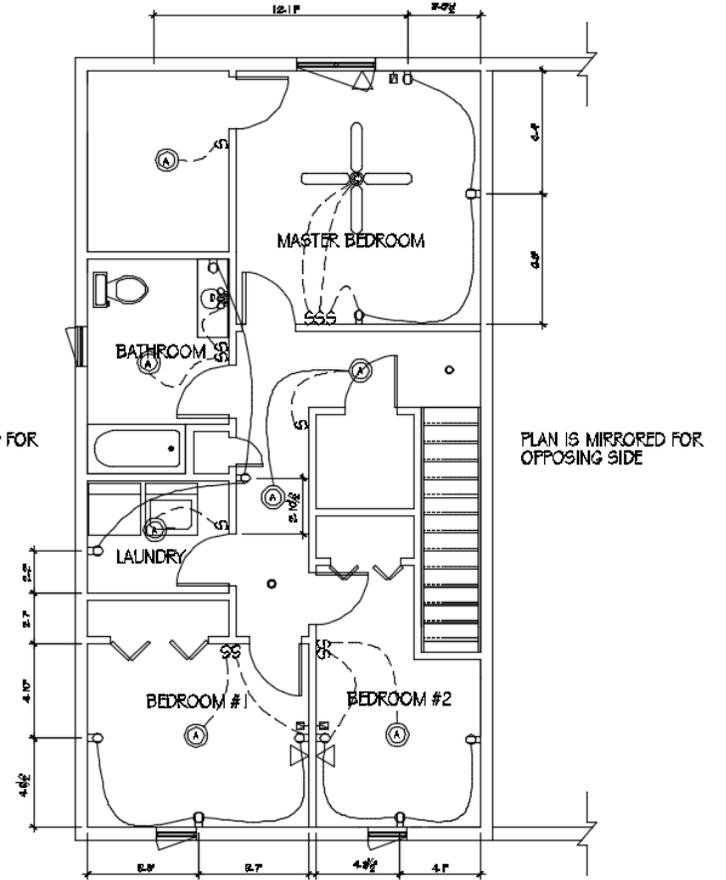
# Electrical Layout

## Task Lighting

- Deep corners where daylight does not reach
- Night time use



FIRST FLOOR ELECTRICAL PLAN



SECOND FLOOR ELECTRICAL PLAN



ELECTRICAL FIXTURE SCHEDULE		
LET.	TYPE	REMARKS
A	CEILING LIGHT FIXTURE	CEILING MOUNTED / LED
B	RECESSED CAN LIGHT FIXTURE	CEILING MOUNTED / LED
C	CEILING FAN W/ LIGHT FIXTURE	3 SPEED FAN / LED
D	BATHROOM WALL LIGHT FIXTURE	3 LIGHT / LED
E	EXTERIOR WALL LIGHT FIXTURE	WALL MOUNTED / LED
F	CHAIR PLUG	4 LIGHT / LED

# Appliances

## Energy Star Appliances

- Refrigerator, Dishwasher, Hot Water Heater, Clothes Washer

## Highly Efficient Hot Water Heater

- Overall cost turnaround within two years by energy savings

## Vent-Less Dryer

- Reduce building envelope penetrations

## Microwave With Vent

- Maintain Minimal ERV airflow

## Home Energy Monitoring System

- Inform the owners to their homes environmental impact
- Recognize areas of high energy loads

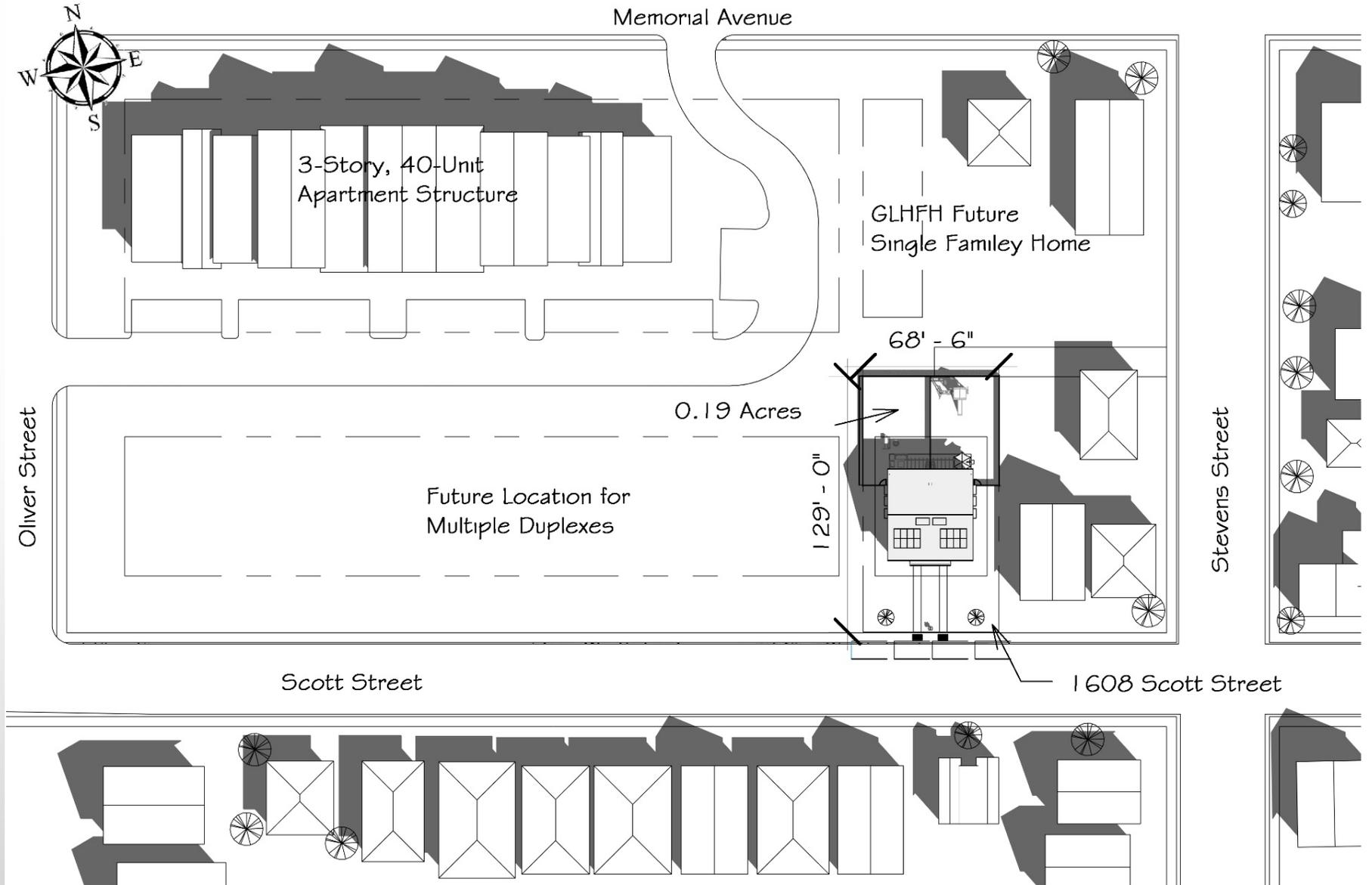
## Lighting Fixtures

- 90% ENERGY STAR Certified
- LED Bulbs

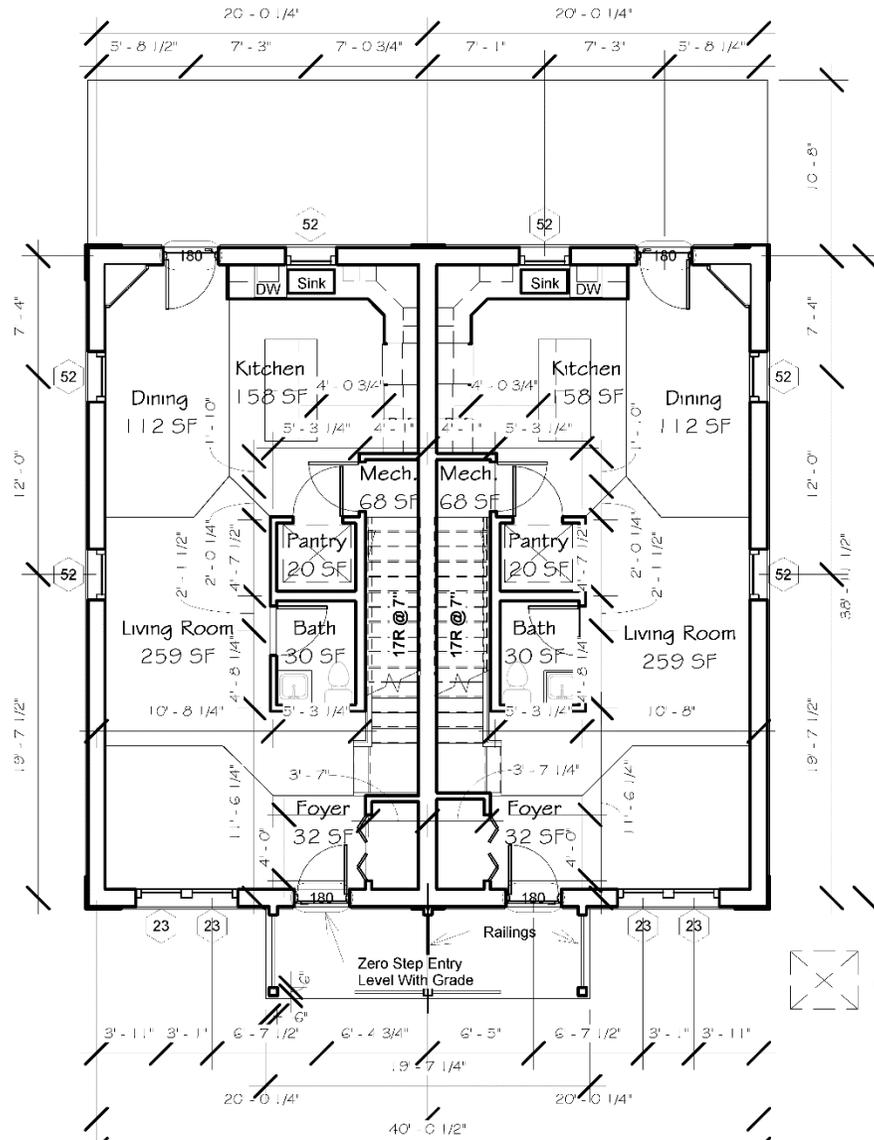


# Construction Documents

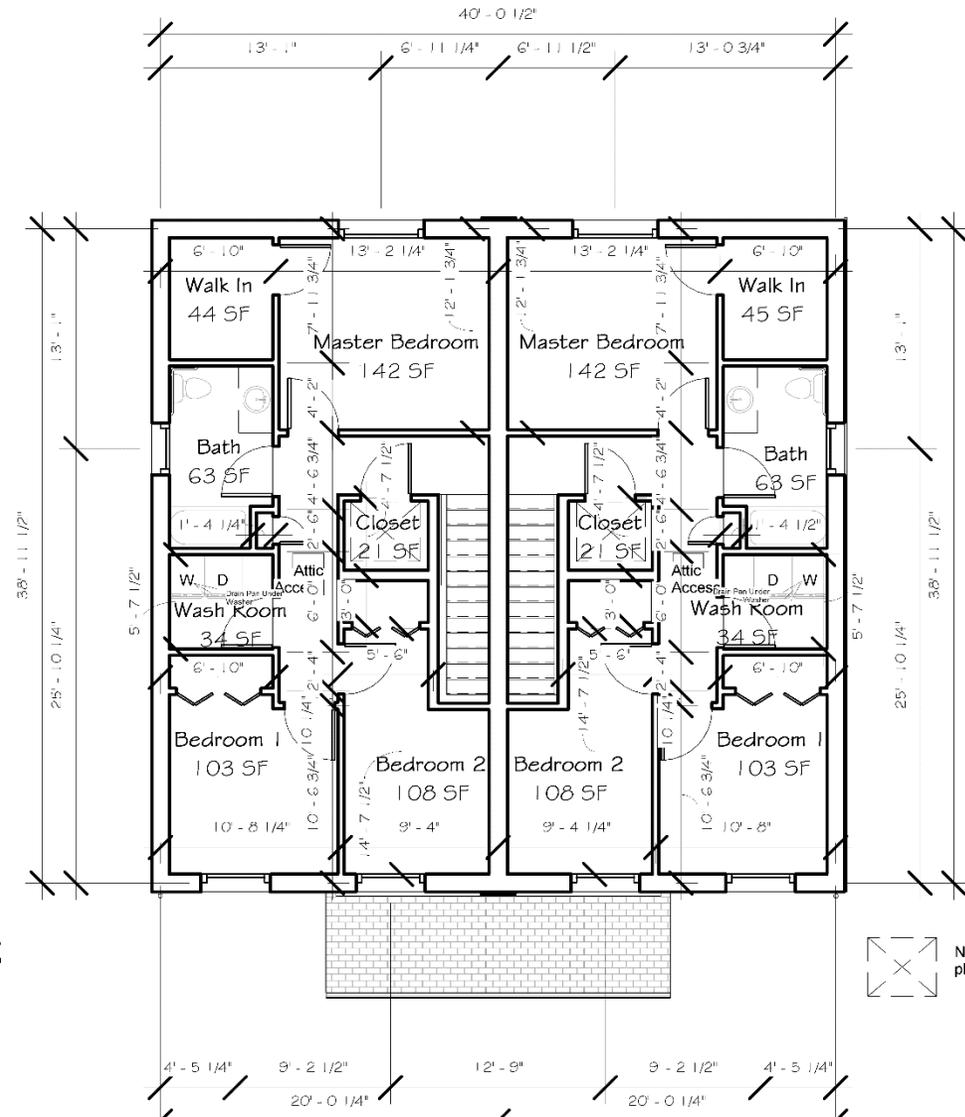
# Site Plan



# Floor Plans



First Floor Plan

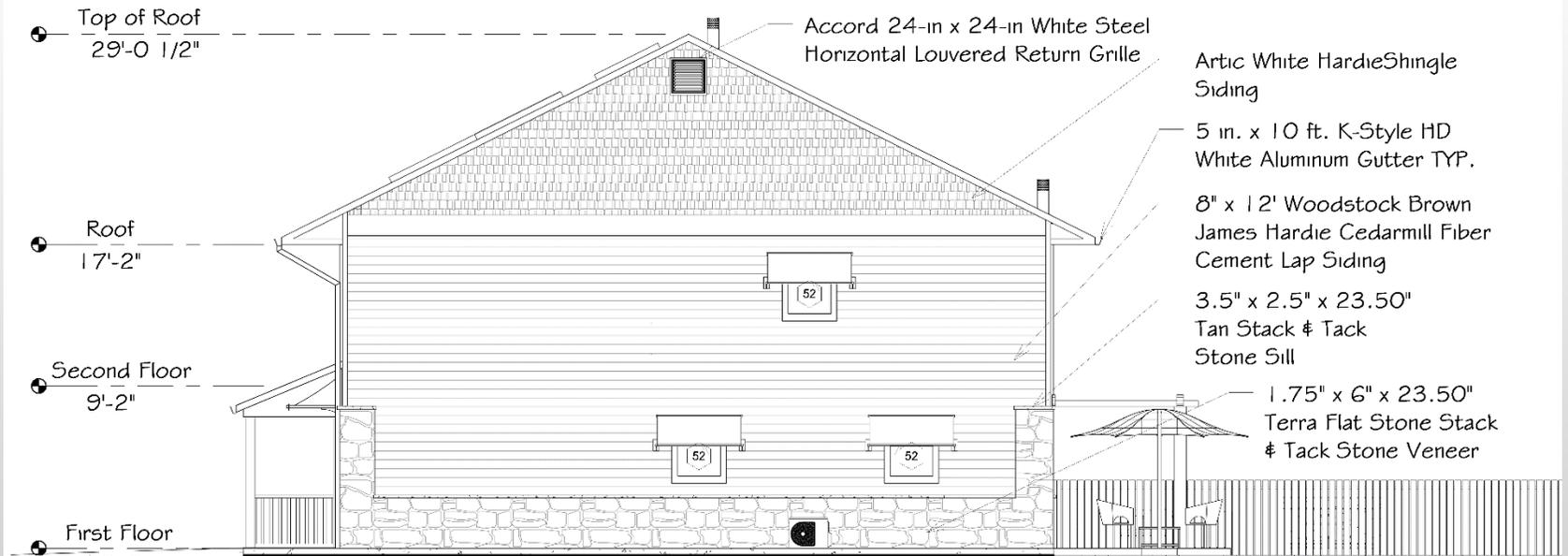


Second Floor Plan

# Elevations

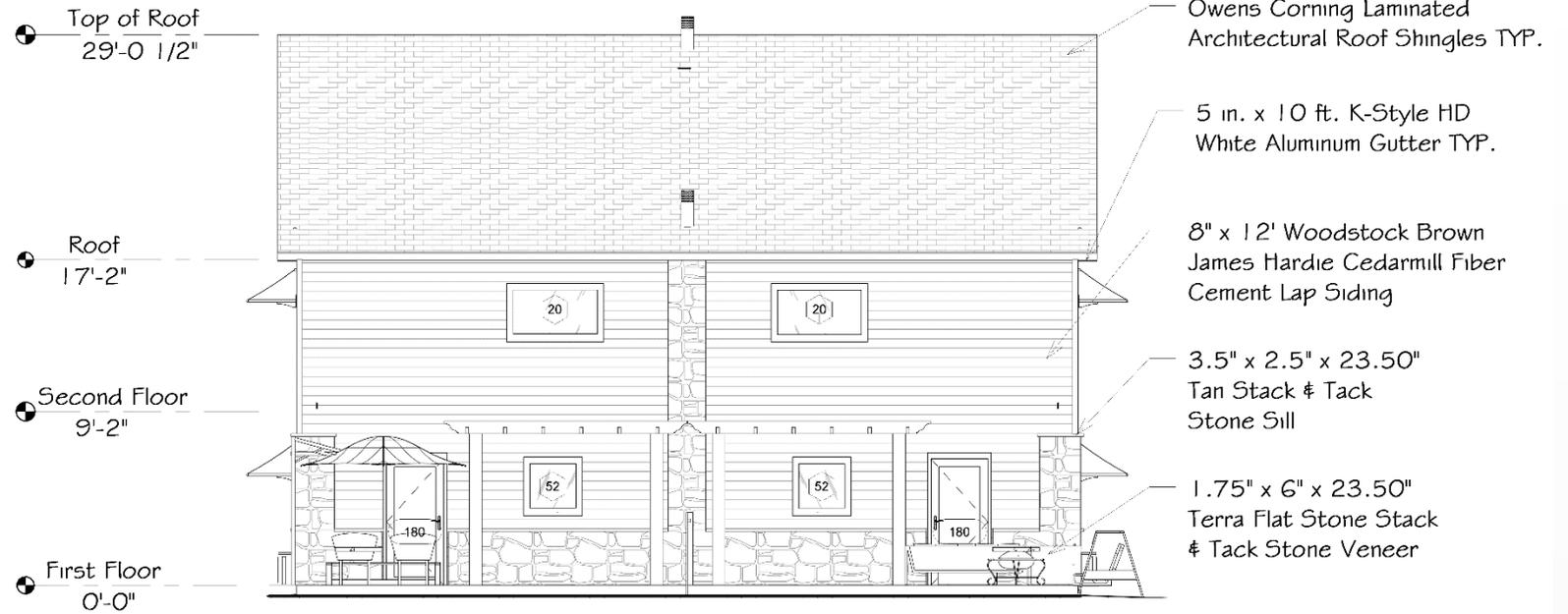


South Elevation

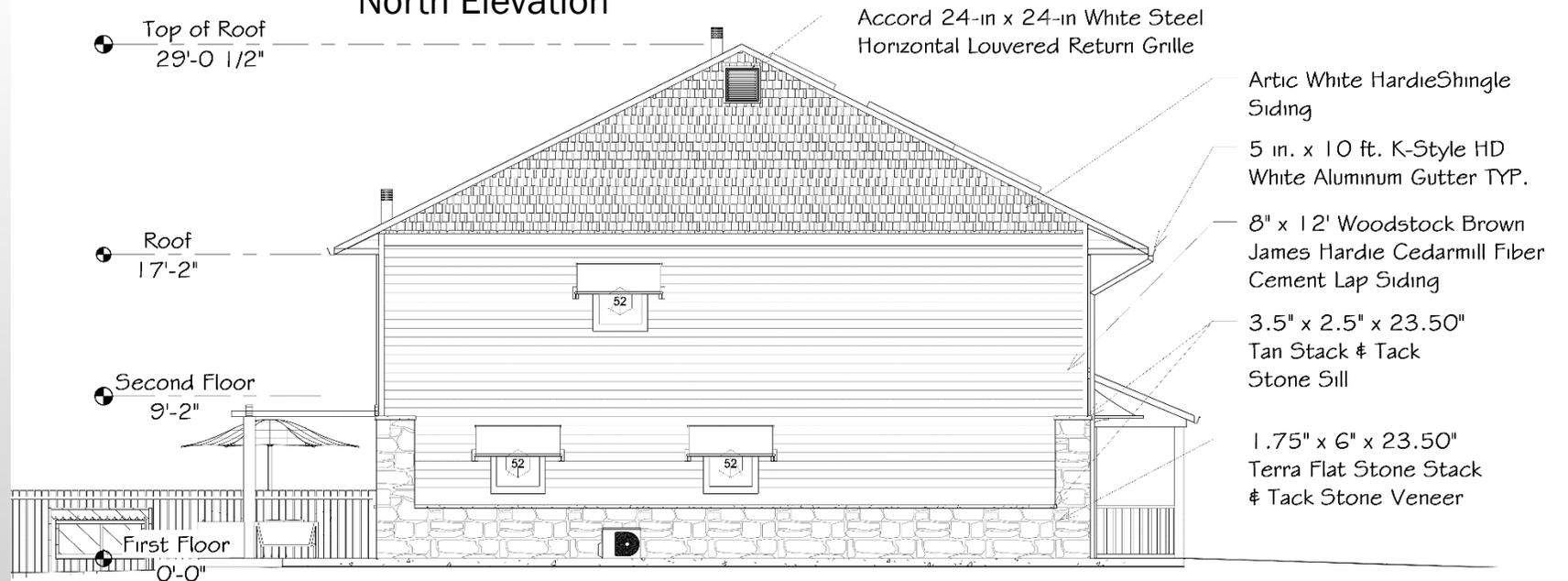


East Elevation

# Elevations

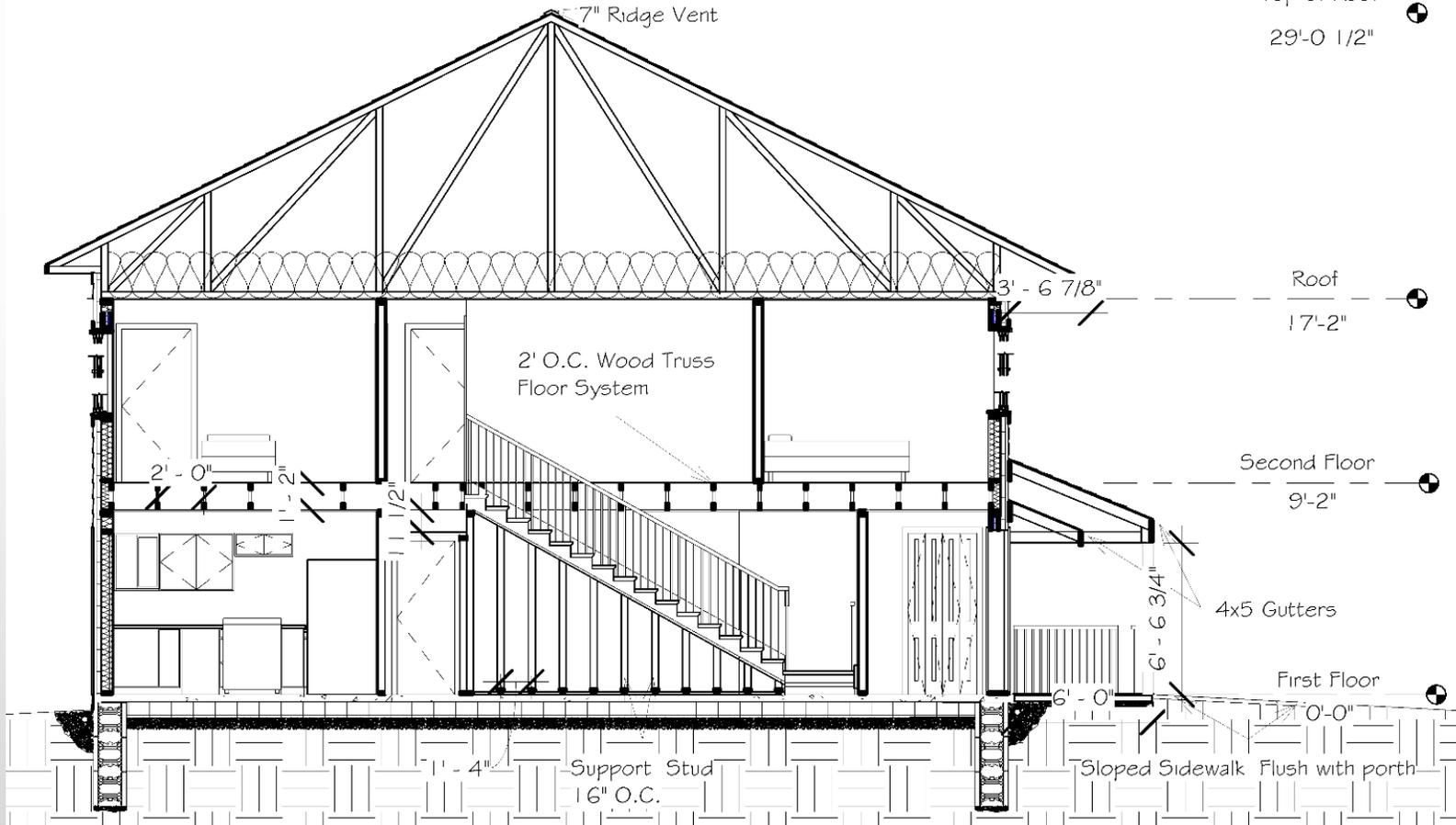


North Elevation

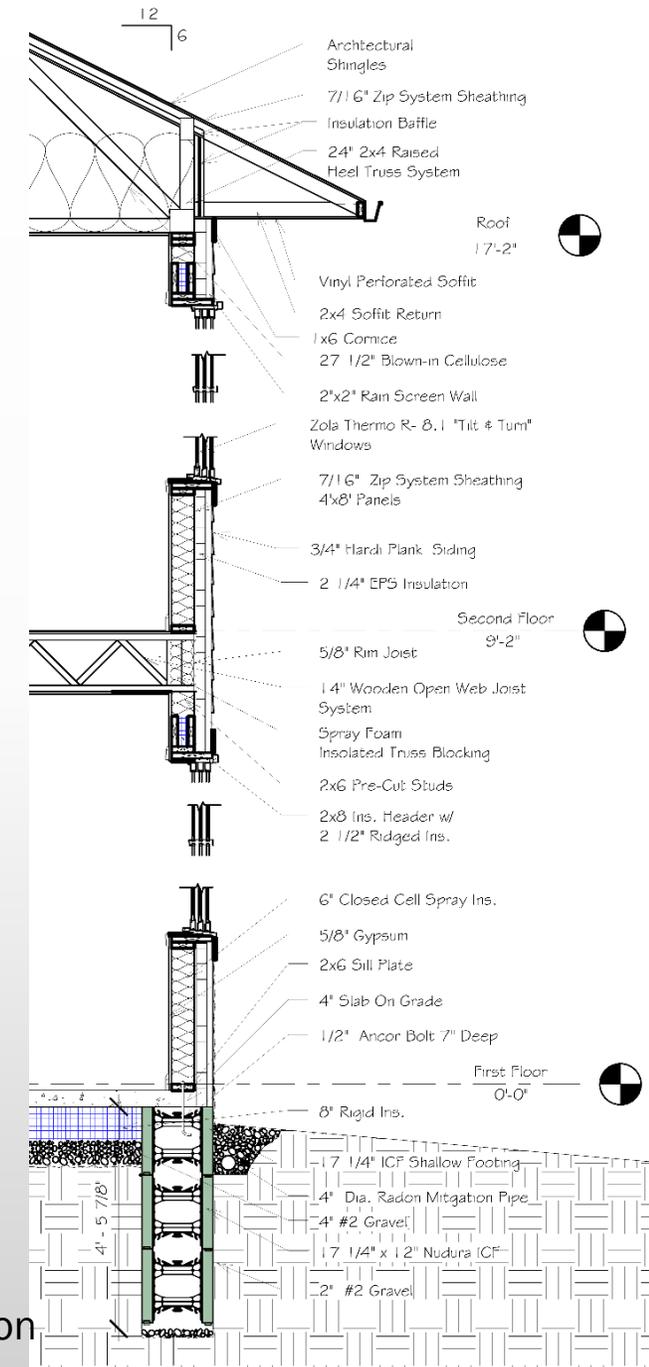


West Elevation

# Sections



Transverse Building Section



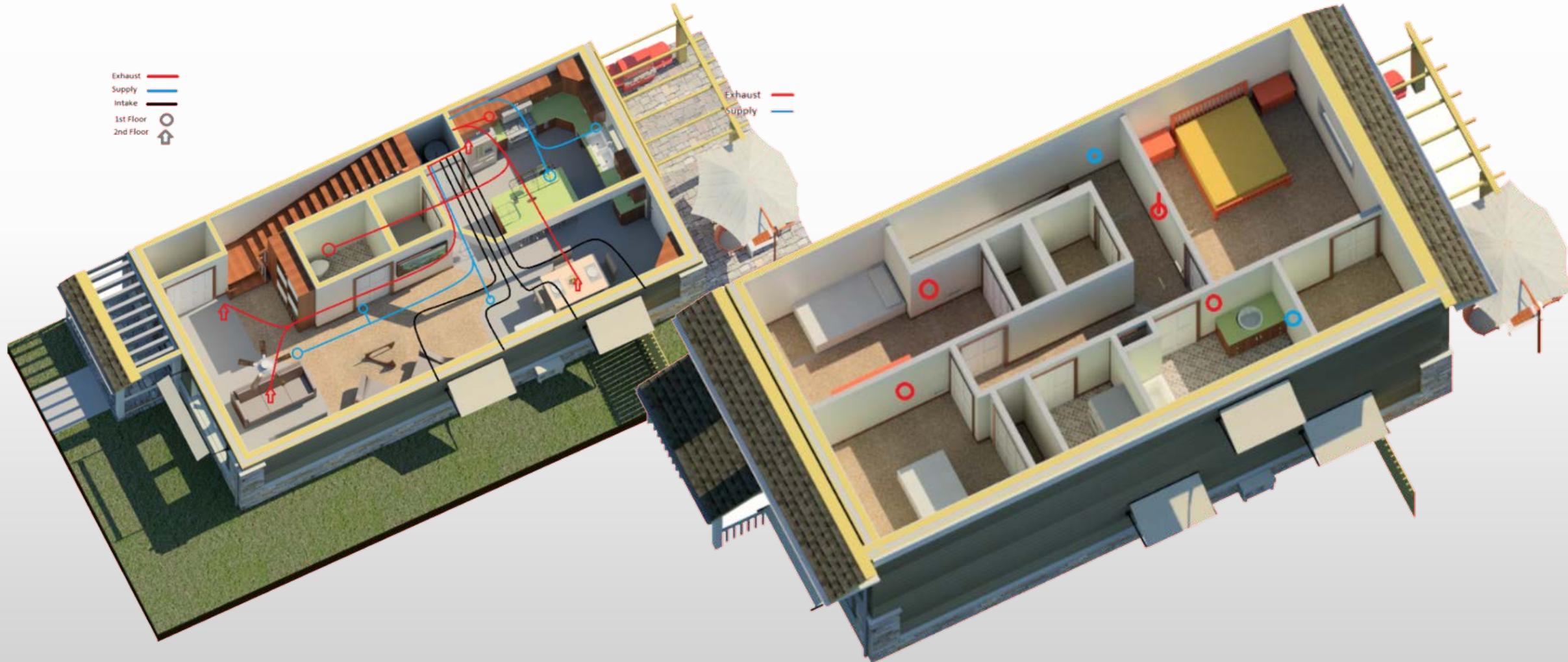
Wall Section







# Mechanical Plan



# Industry Partners

# Industry Partners

- Tina McDowell – *Executive Director, Greater Lycoming Habitat for Humanity, Williamsport PA*
  - Tina came on campus and presented to students what Habitat was looking for and what the neighborhood residents wanted. She provided documents for site. Students had continuing dialog of questions and direction. Students also visited her office to present ideas. She will also be essential after this competition in getting our building constructed in Williamsport.
- Carlene Keyte - *Assistant Vice President-Mortgage Lending, Woodlands Bank, Williamsport PA*
- Kristi Eberhart - *Mortgage Banker, Woodlands Bank, Williamsport PA*
  - Carlene and Kristi assisted by developing a spreadsheet relating to the financing/construction costs for the competition. The design team met with Carlene to review and revise financing numbers. They were essential in the formatting of our financial information.
- Jim Phelps - *Certified Passive House Consultant, Quality Assurance Manager, Performance Systems Development, Liberty PA*
- Mary Graham - *Certified Passive House Consultant, Energy Consultant, Tip to Toe Energy, Trumansburg, NY*
  - Jim came on campus twice to lecture on PHIUS and train students on how to use RemRate. Jim and Mary acted as energy consultants on the project, running WUFI reports on designs and recommending improvements to the design based on building models which were provided by the design team. There was constant dialog between the design team and both Mary and Jim, whether it came via phone or email. Mary and Jim were essential in the completion of the project.
- Keevin Larson - *President of K.C. Larson, Inc, mechanical, electrical and renewable energy contractors, Williamsport PA*
- Jamie Sherman – *Office Manager and Renewable Energy, K.C. Larson, Inc., Williamsport PA*
  - Keevin and Jamie met with students and reviewed mechanical system design, gave advice on the solar thermal design based on their experiences (recommended closed loop system without a heat dump vs. a drain-back system), and reviewed PV design. Provided information on preferred supplier and where to look for costing.