



Forward House



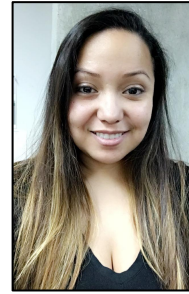
UW-Madison
UW-Milwaukee



Nic



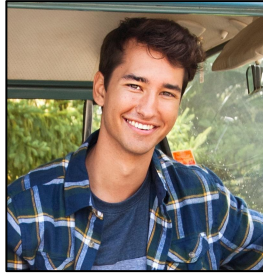
Dan



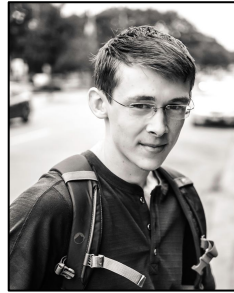
Laura



Jake



Rob



Jonnie



Nasim



Drew

Faculty Advisors

Professor Mark Keane | UW-Milwaukee

Dr. Michael Cheadle | UW-Madison

Professor Lesley Sager | UW-Madison



Industry Partners



Special Thanks to

Professionals


Professor Linda Keane | The School of the Art Institute of Chicago
Cozette Moffatt | Interior Designer

Students

Emily Cruz | UW-Madison
Marilyn Grace Cervantes | UW-Madison
Rebecca Cohn | UW-Madison



Design



Story
Architectural Design
Envelope Durability
Mechanical Systems
Energy Analysis
Financial Analysis



**Water
Conservation**



**Access to Public
Services**



Livability



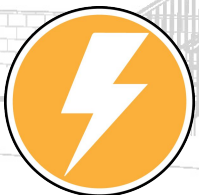
**Neighborhood
Applicability**



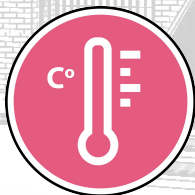
**Community
Building**



Affordability



**Energy
Efficiency**



**Thermal
Comfort**

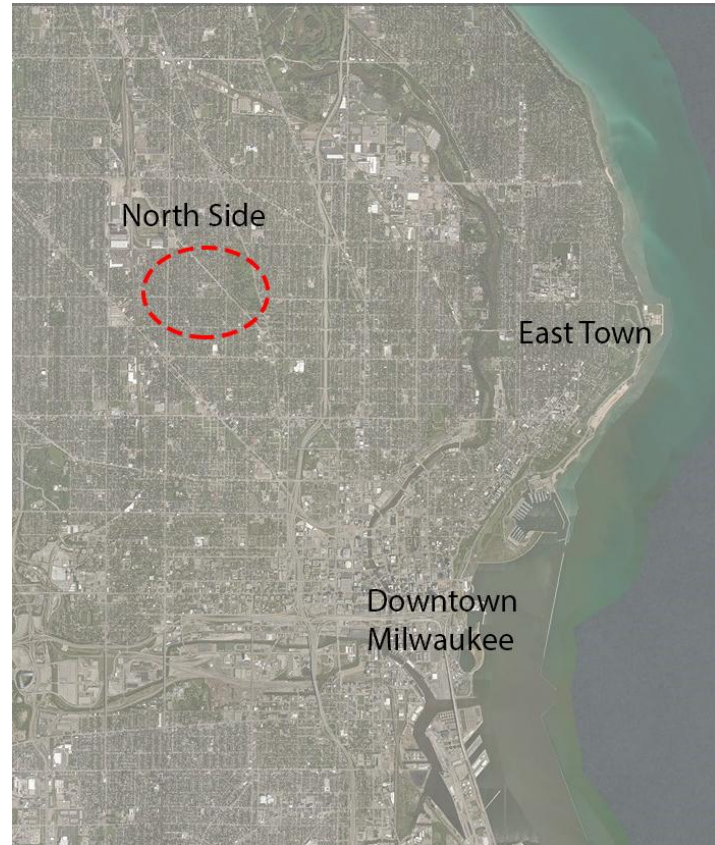


**Indoor Air
Quality**

Franklin Heights

Milwaukee, WI | “North Side”

- Vacancy epidemic
- Rich history of community building
- Strong tradition of early 20th century Milwaukee homebuilding



Story



Access to Public Services



Story



flickr.com | Bossco



HGTV.com



plazamidwoodliving.com



thebungalowcompany.com



pinterest.com | Clare Moodie



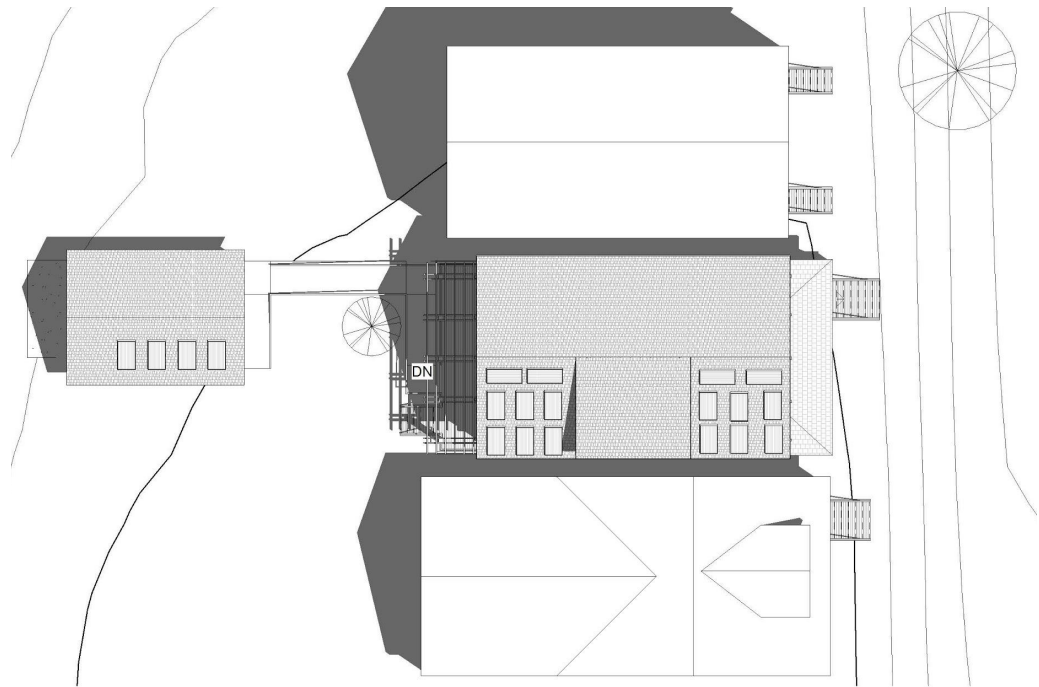
thebungalowcompany.com





Architectural Design

- Orientation creates challenges for passive solar strategies
- Solar panels and dormer must accommodate neighboring houses



Neighborhood Applicability



South Elevation

- Shed dormer maximizes solar gain



Neighborhood Applicability



North Elevation

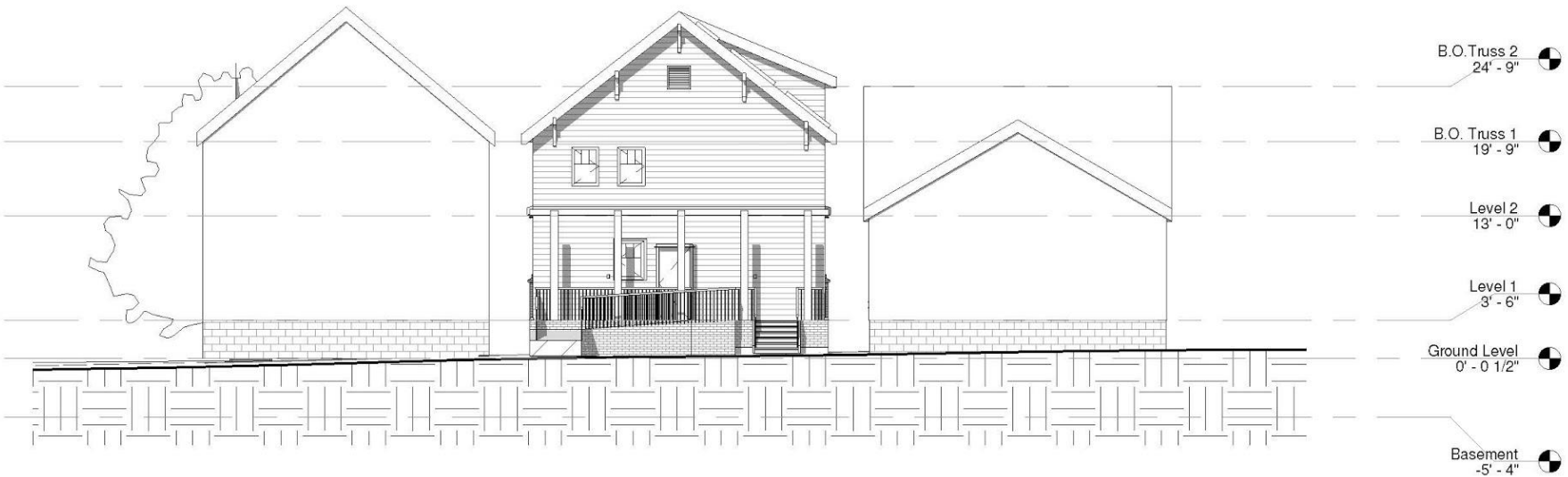
- Rear ramp makes home wheelchair accessible



Neighborhood Applicability



Livability



West Elevation

- Trellis provides space for social interaction and privacy



Neighborhood Applicability



Community Building



East Elevation

- Takes cues from neighboring homes
- Designed to fit seamlessly within the urban fabric

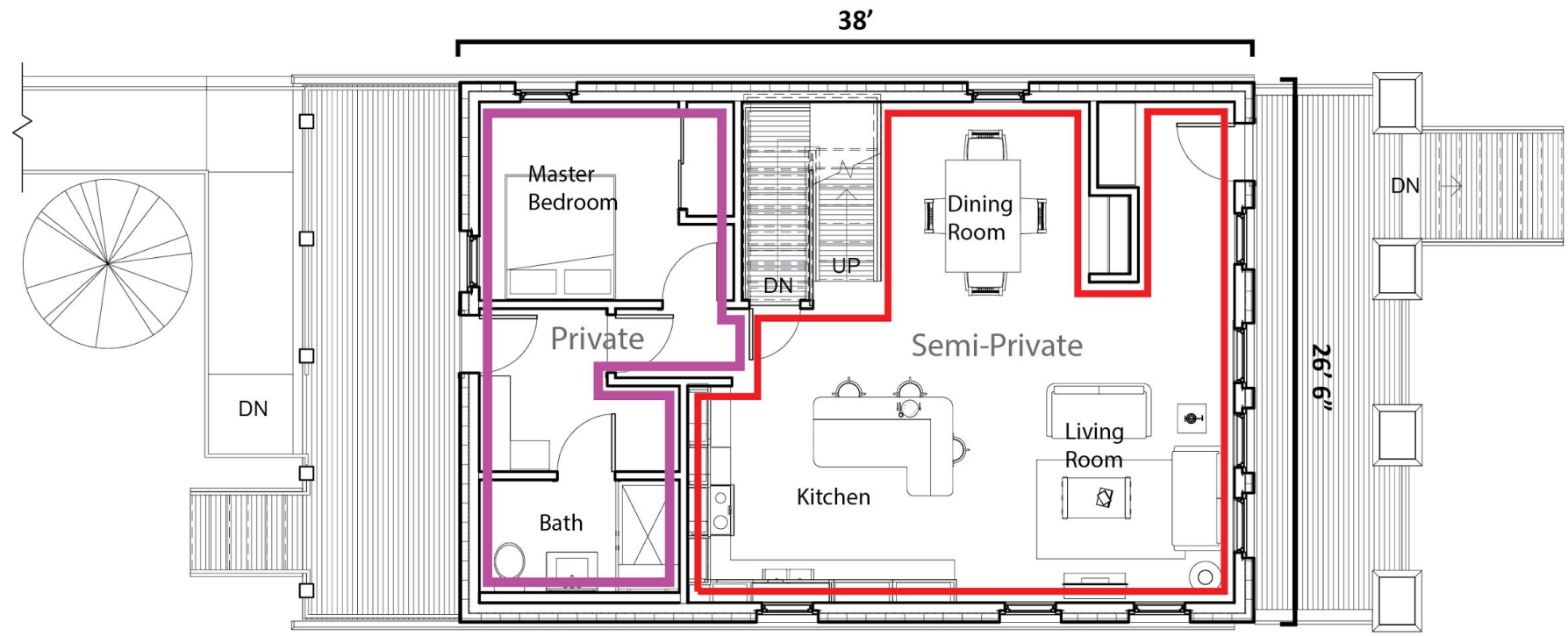


Neighborhood Applicability



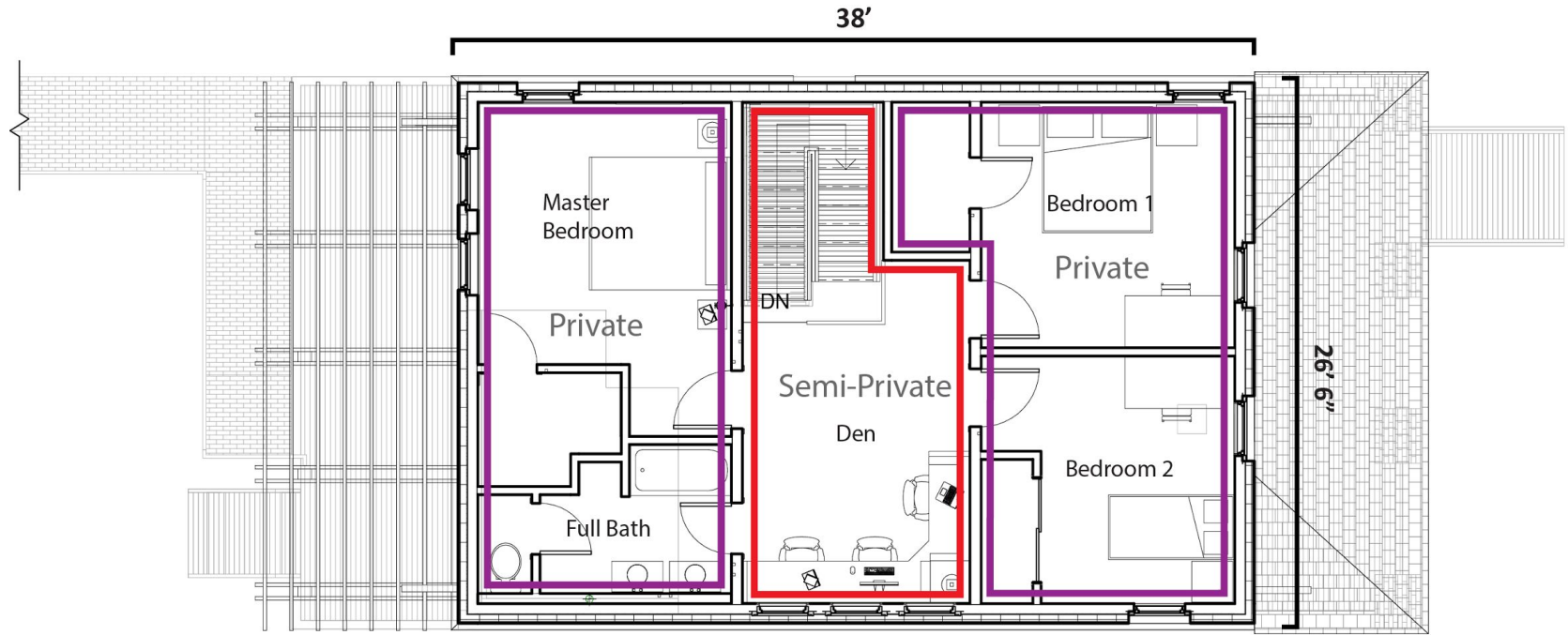
Community Building

Architectural Design



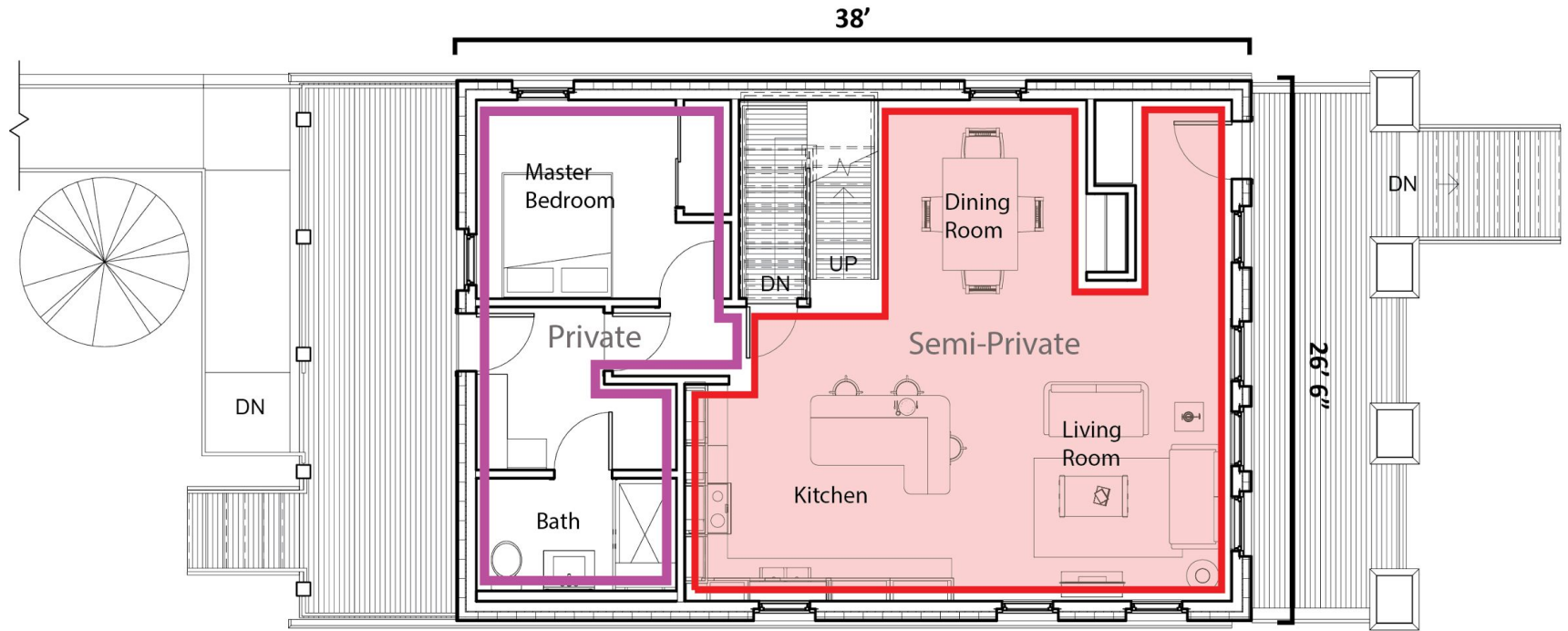
Livability

Architectural Design



Livability

Architectural Design



Livability

Kitchen Design:

- Centralized kitchen bar
- Craftsman features
- Local, sustainable materials



Livability

Downstairs Living Space:

- Open floor plan
- Adaptable

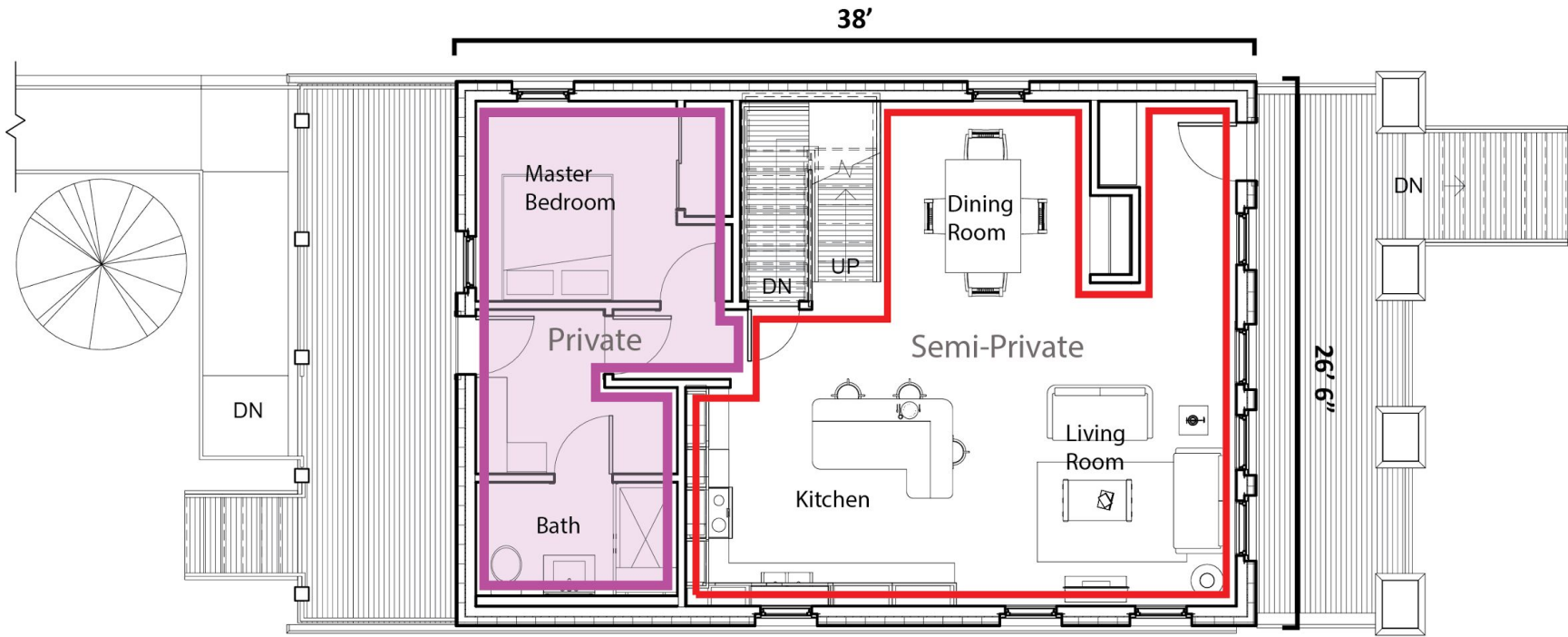


Livability



Affordability

Architectural Design



Livability

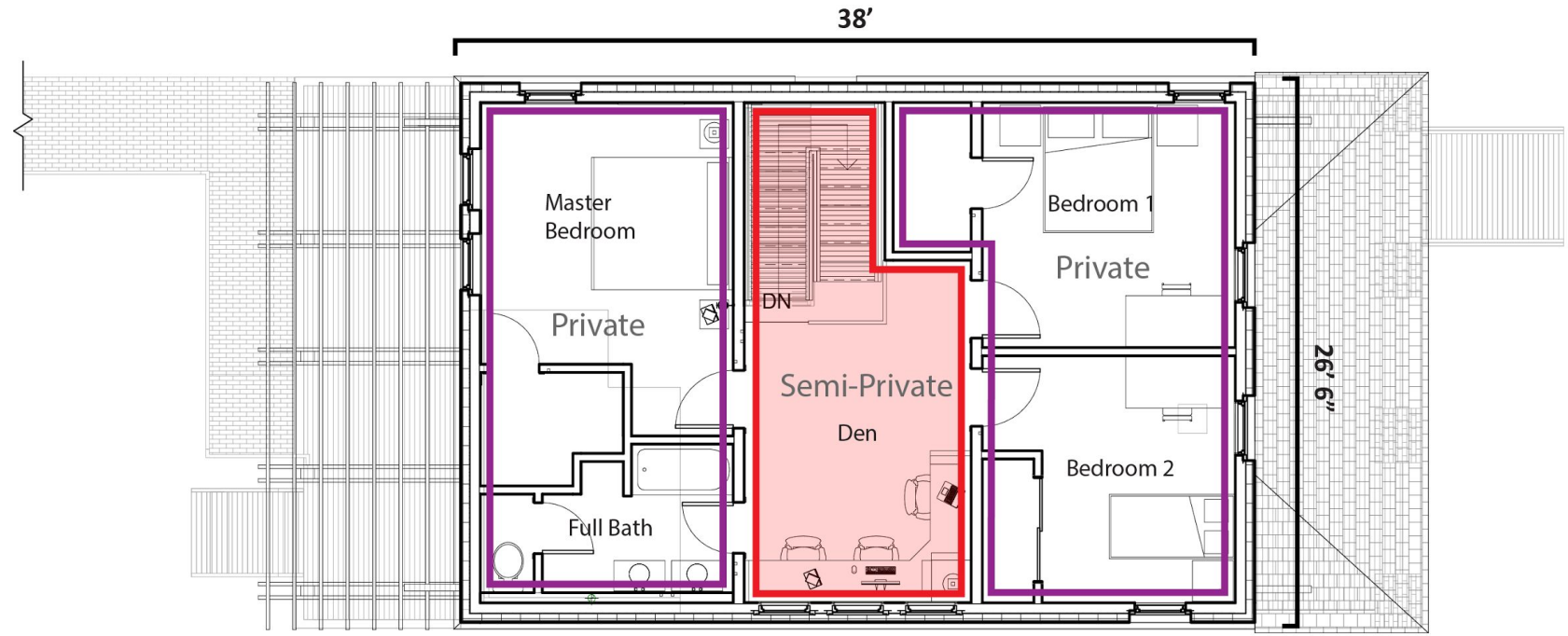
Bathroom Design:

- Wheelchair Accessible
- Curbless shower with drop down bench
- Local, sustainable materials



Livability

Architectural Design



Livability

Upstairs Den:

- Quiet second story space
- Large south facing windows bring in natural light and ventilation
- Multi-functional

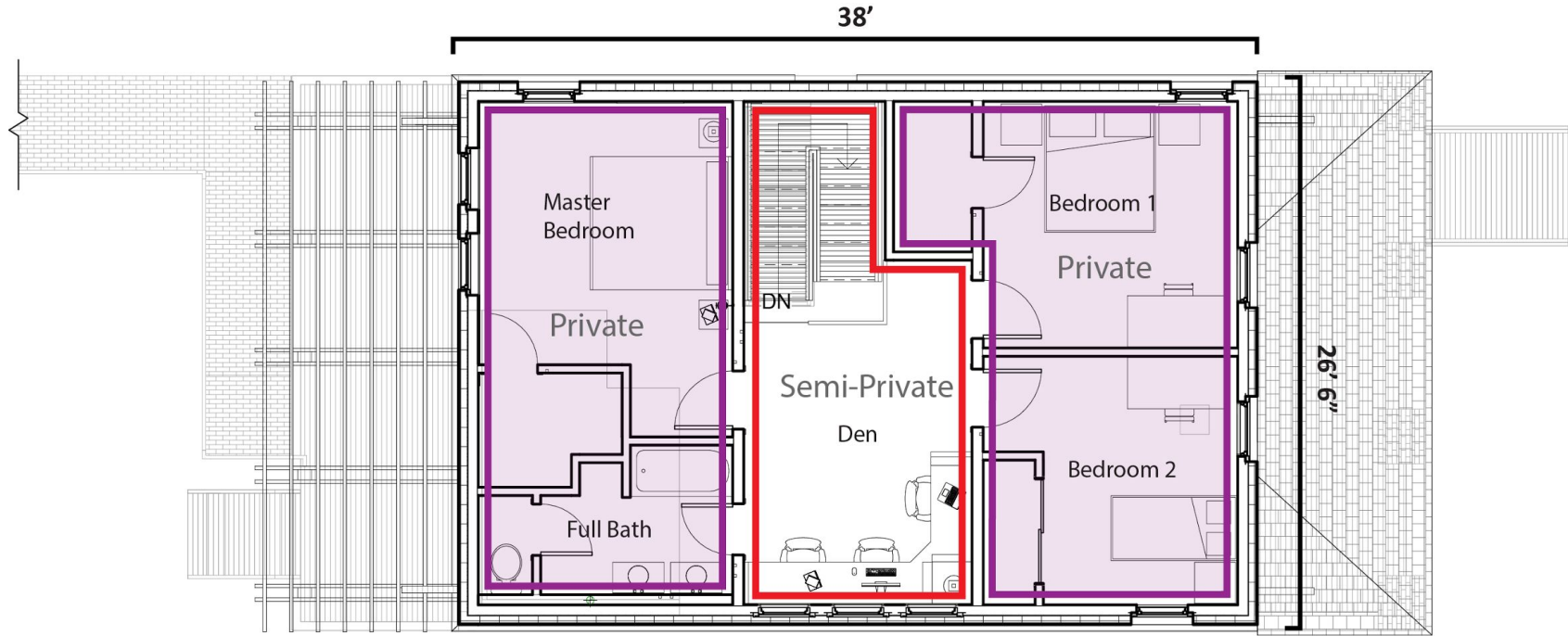


Livability



Indoor Air Quality

Architectural Design



Livability

Bedrooms:

- Large storage closet
- Craftsman accents
- Windows bring in natural light and ventilation

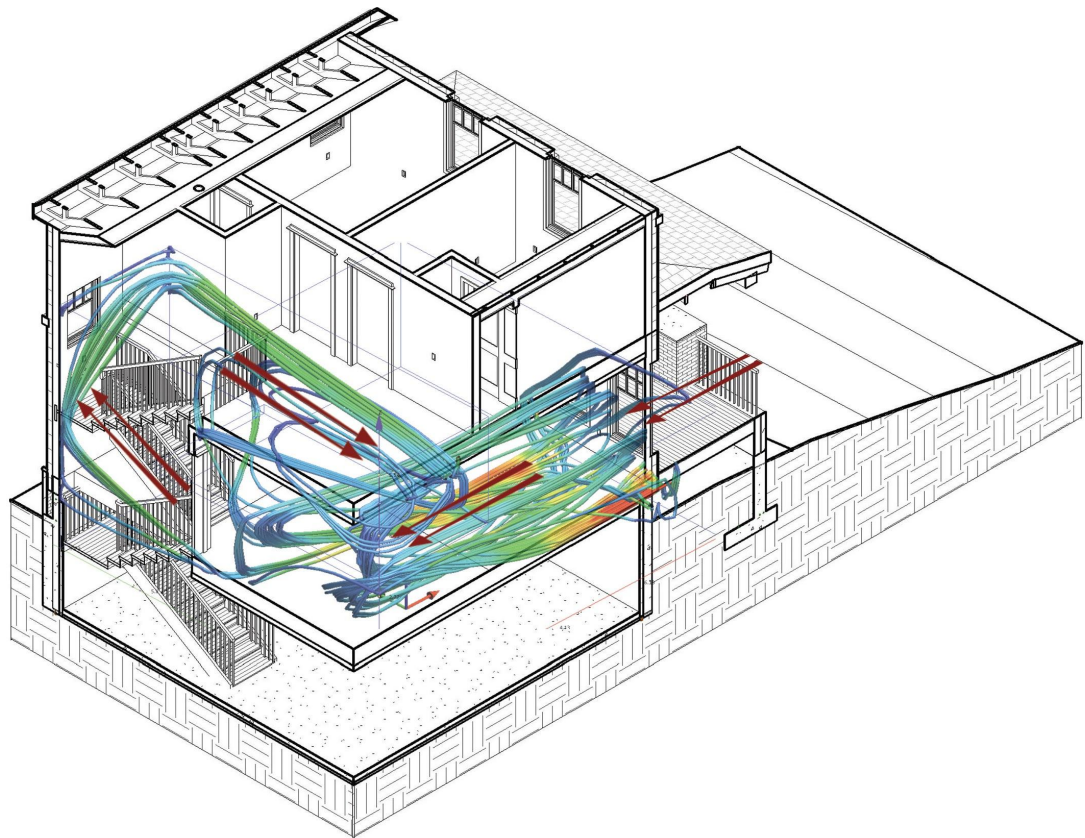


Livability



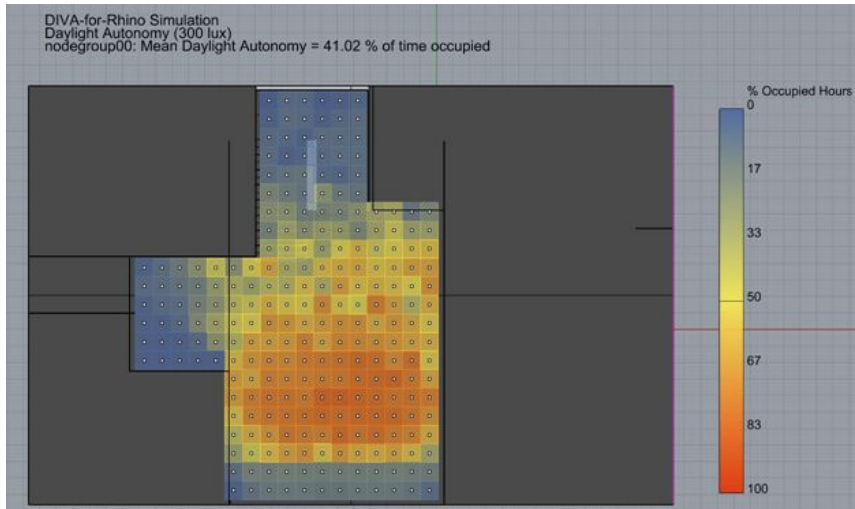
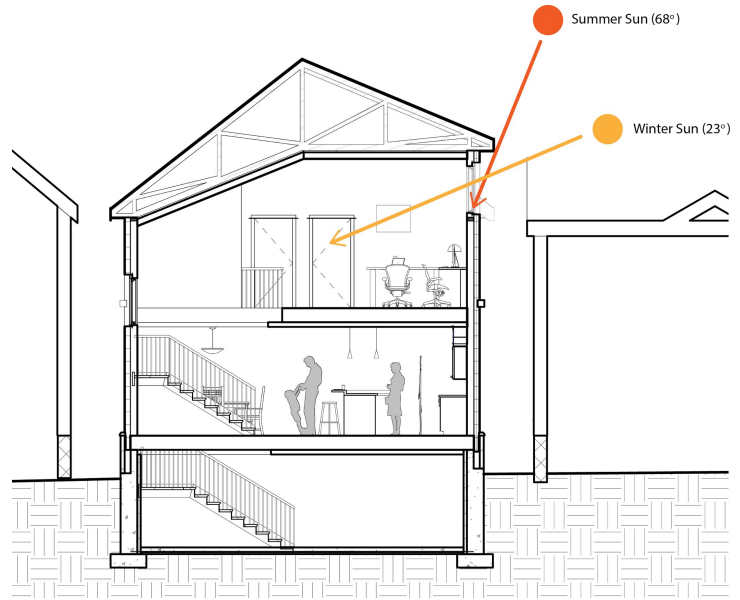
Indoor Air Quality

Architectural Design

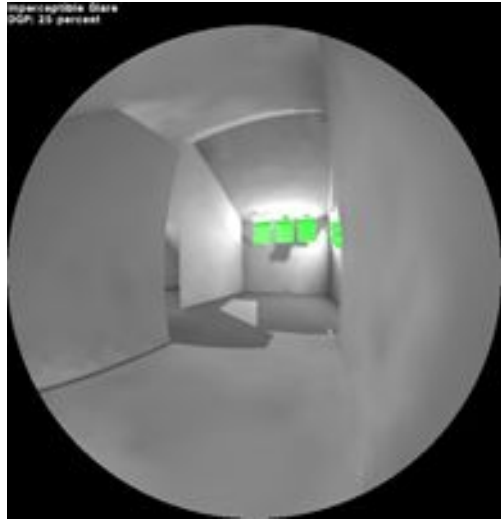


Indoor Air Quality

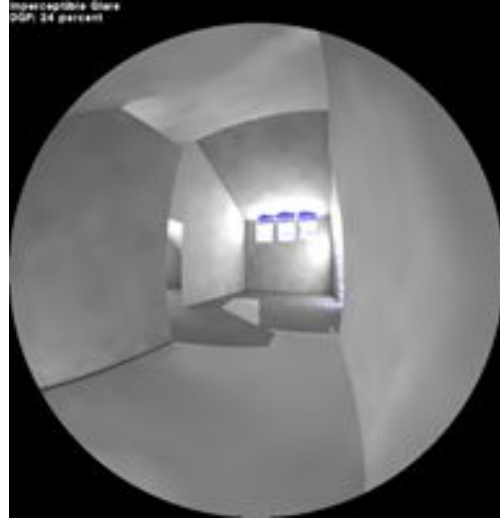
Architectural Design



Livability



Dec. 21st 9:00 AM



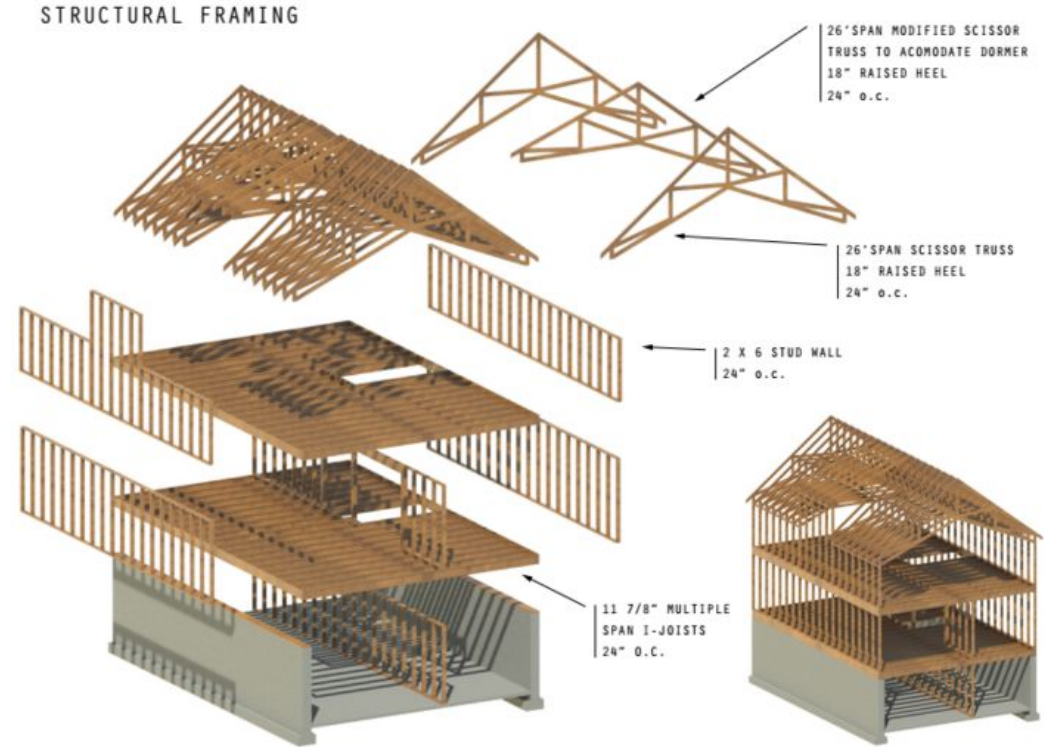
June 21st 9:00 AM



Livability

Envelope Durability

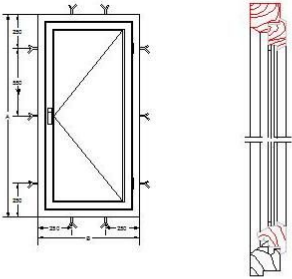
- 2 x 6 stud wall assembly
 - common system thanks to Building America and Net Zero Energy-Ready Guidelines
- Shop-fabricated wooden scissor trusses save on materials and cost



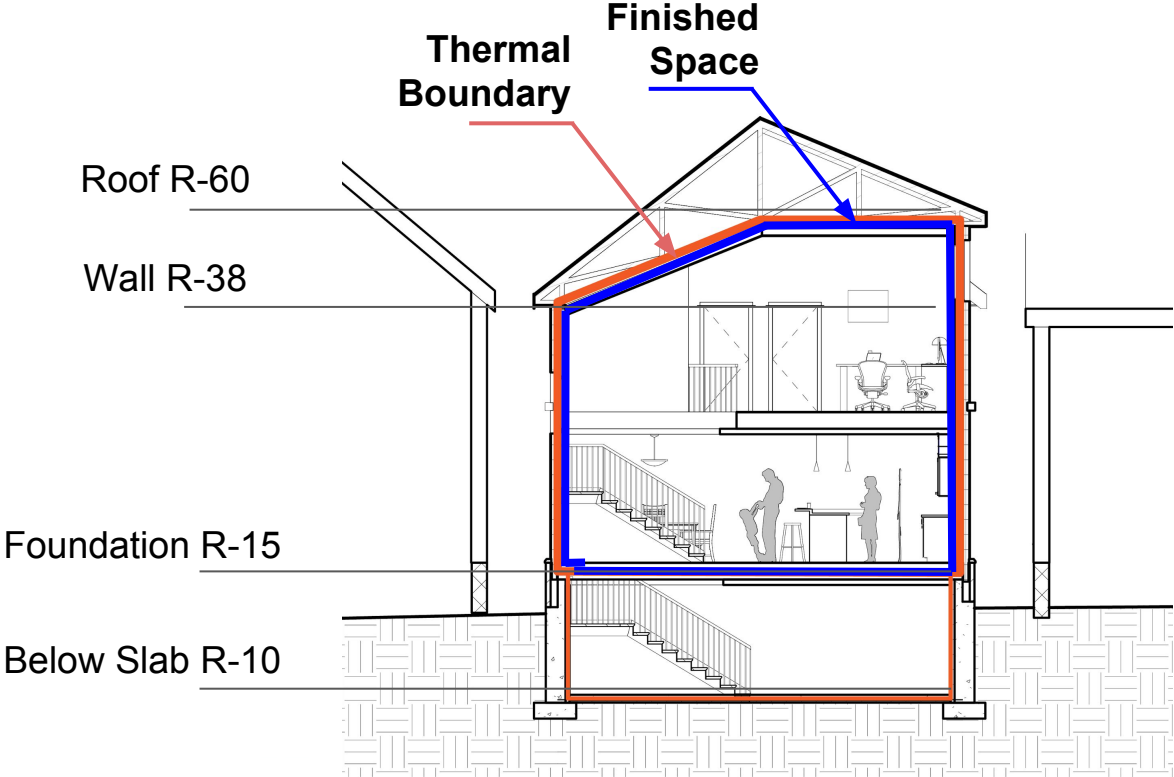
Affordability

Envelope Durability

Thermal Considerations



Window U-Value: 0.22
Window SHGC: 0.19

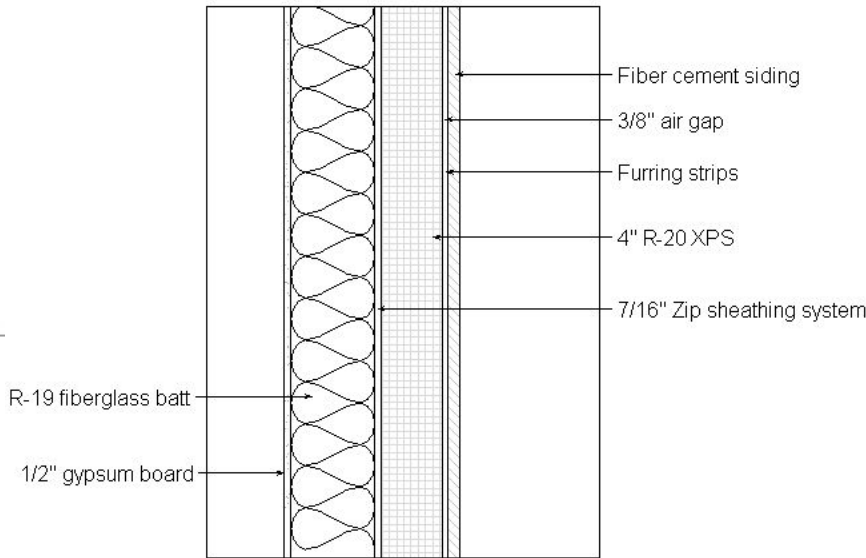
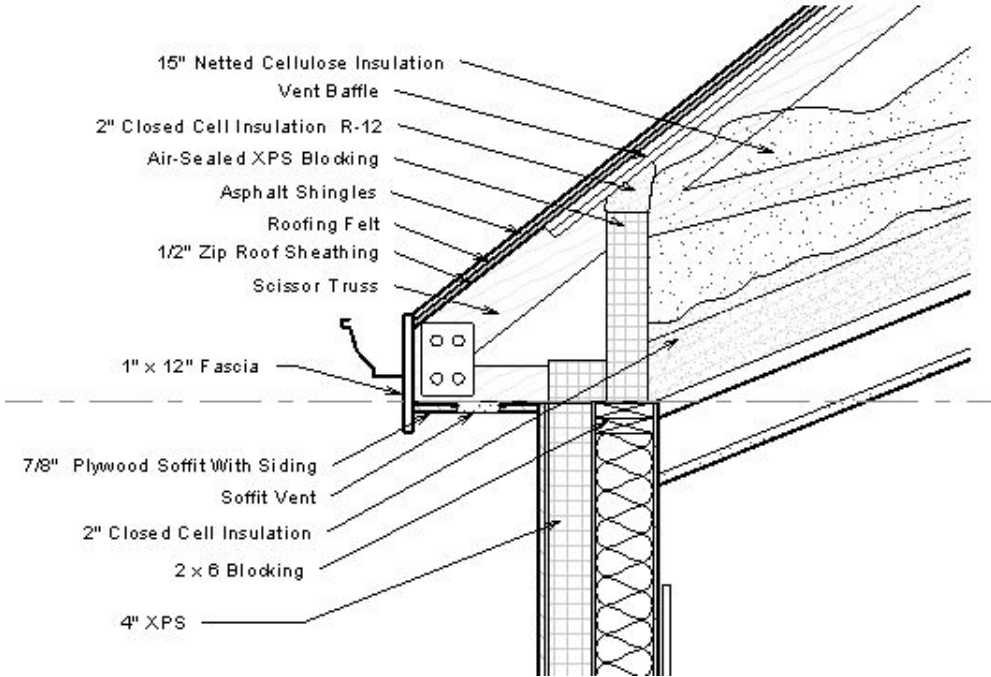


Energy Efficiency



Thermal Comfort

Envelope Durability

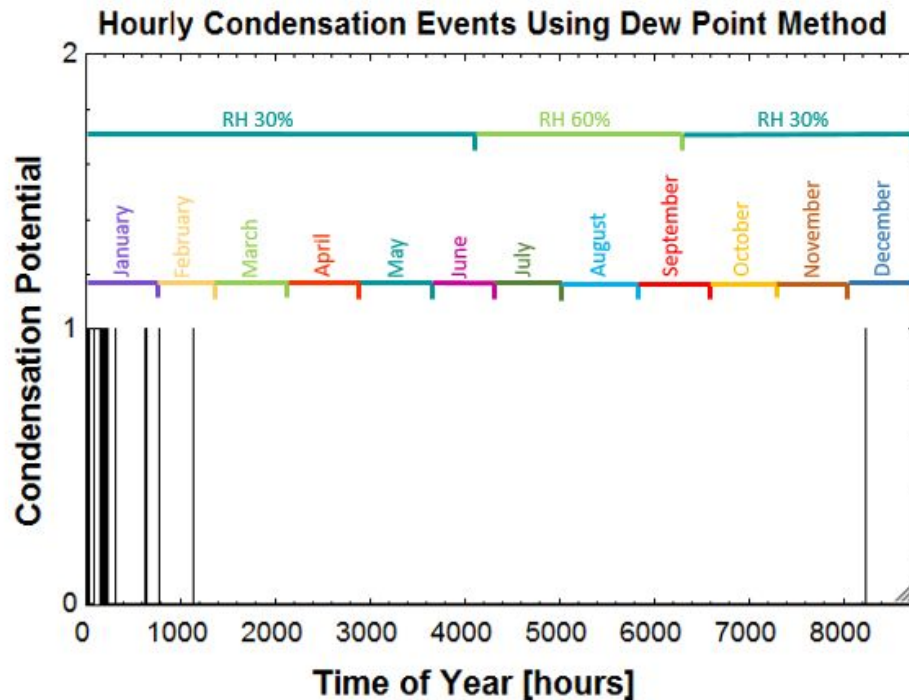


Moisture Infiltration

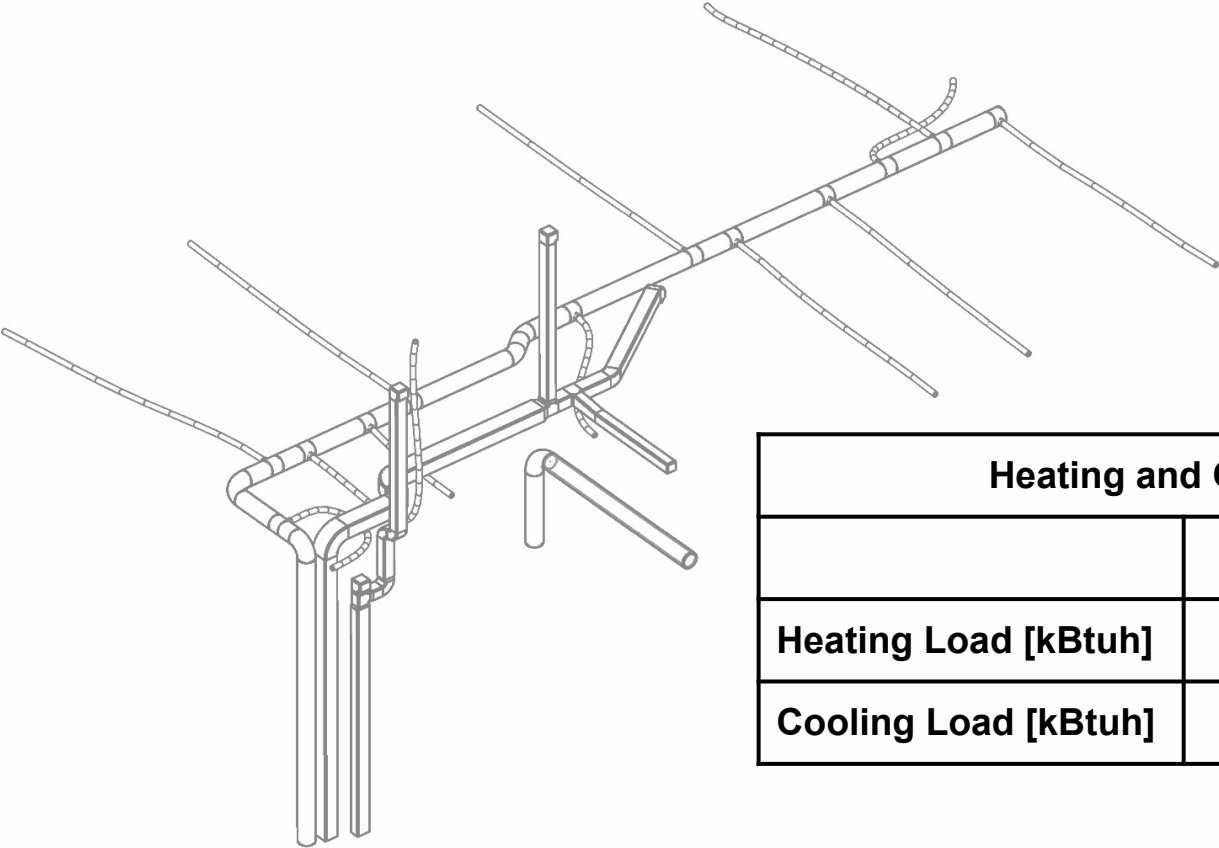
$$T_{sheathing} = T_{in} - \Delta T(R_{cavity}/R_{total})$$

R-38 Wall

- 4" R-20 XPS exterior insulation
- 7/16" Zip sheathing
- R-19 Insulation



Mechanical Systems



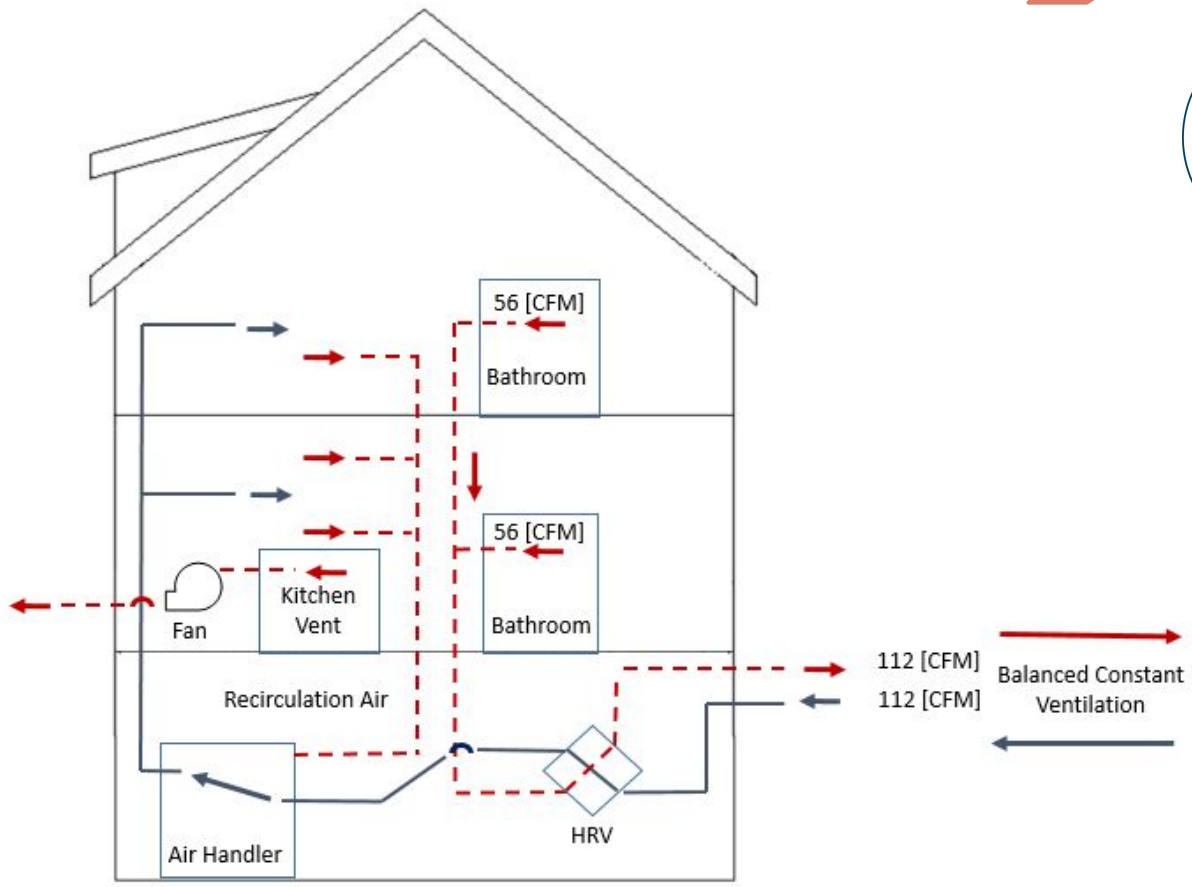
Heating and Cooling Loads		
	<u>REM/Rate</u>	<u>EES</u>
Heating Load [kBtuh]	16.9	16.4
Cooling Load [kBtuh]	9	5.9



Thermal Comfort

Mechanical Systems

Overall Strategy



Indoor Air Quality

Mechanical Systems

The heating and cooling strategy was to balance cost and efficiency

- Heat Pump
 - Provides heating and cooling
- Tankless water heater
 - Heats hot coil in air handler
 - Turns on at 42 [F]
 - Heats domestic hot water
 - Priority controlled



IS24G065



M2430CL1-A Cooling Coil



Rinnai RUC981



M2430CL1-H Hot water Coil

Images from Rinnai and UNICO



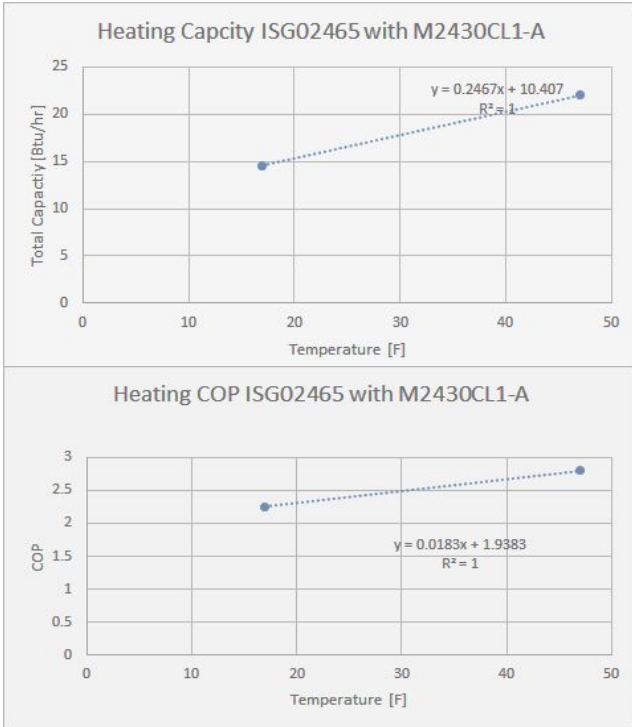
Thermal Comfort



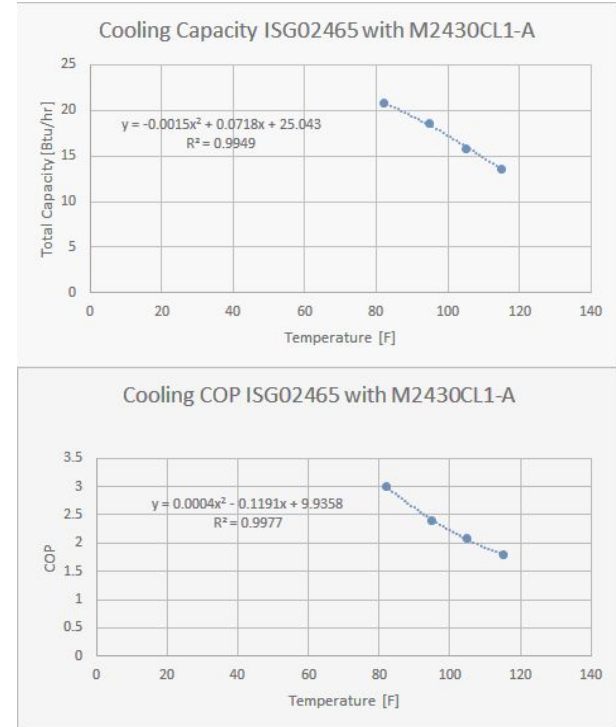
Energy Efficiency

Mechanical Systems

Capacity and COP curve fits allowed hourly TMY data to be analysed



Heat Cool



The HRV provides large energy savings with low energy input

Venmar X24 HRV ECM

- 80% SRE
- 3.5 (CFM/Watt)
- ECM motor
- ENERGY STAR Rated



VB0209

Image from Venmar. Note: not the actual unit depicted

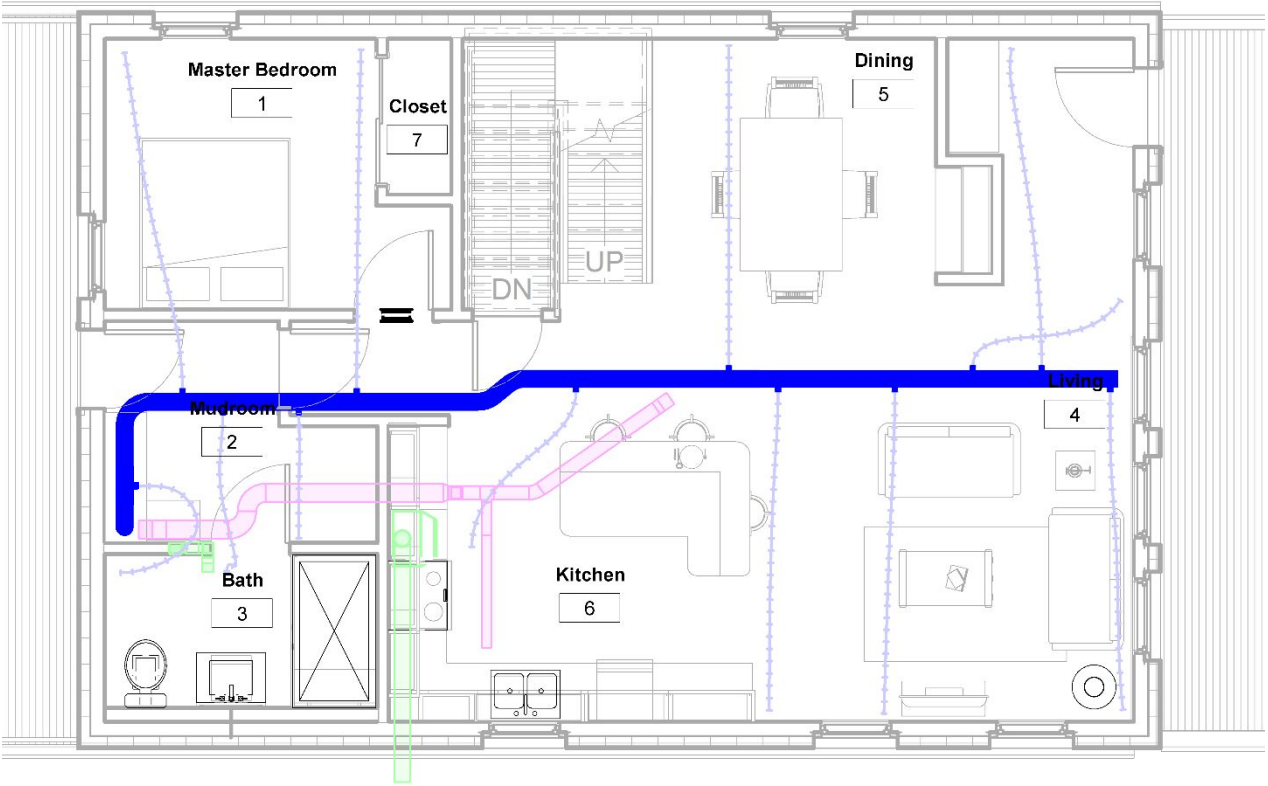


Thermal Comfort



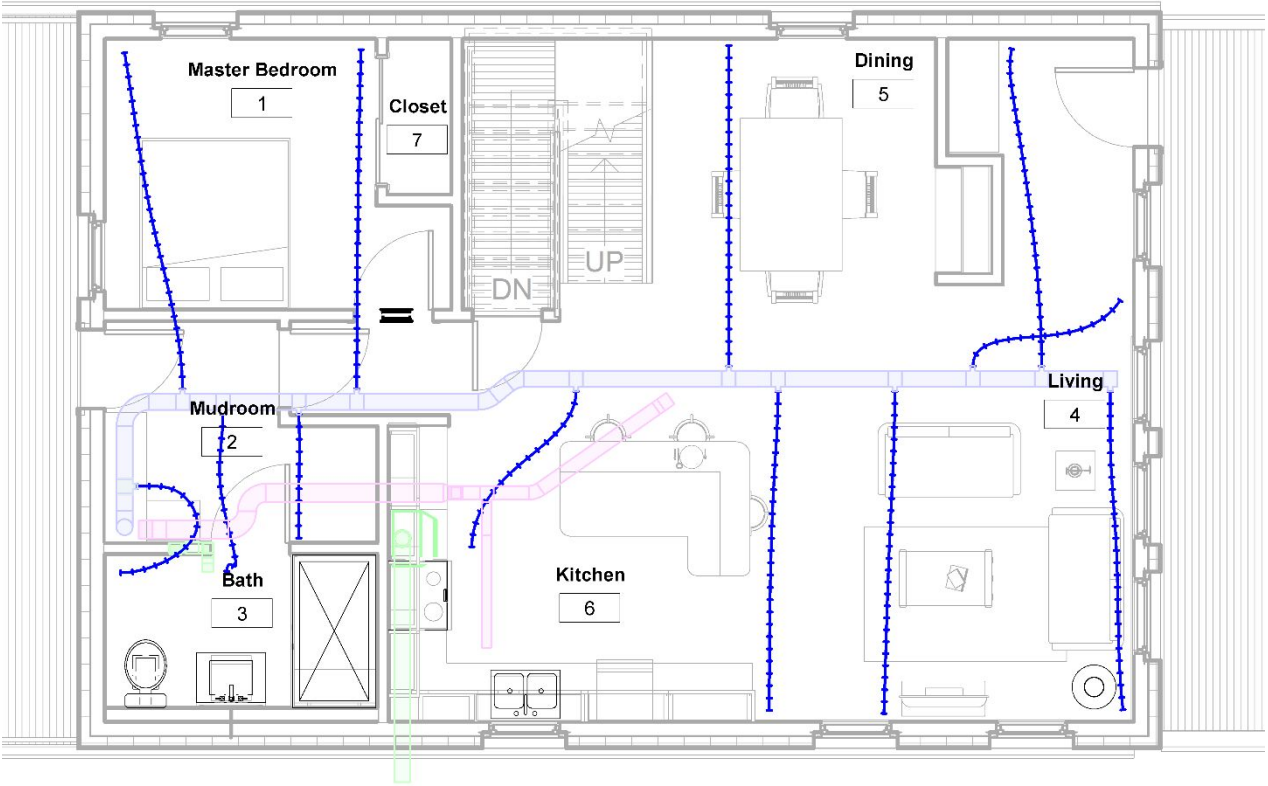
Energy Efficiency

Mechanical Systems



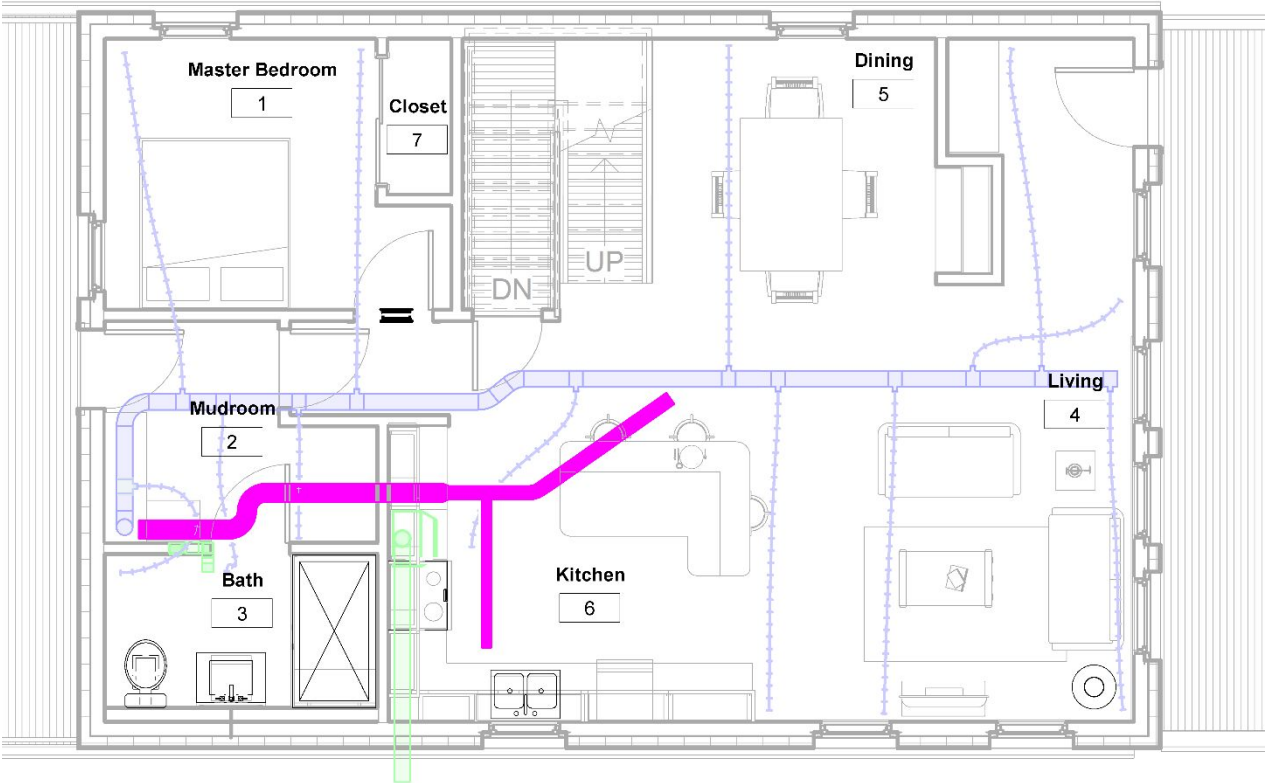
Indoor Air Quality

Mechanical Systems



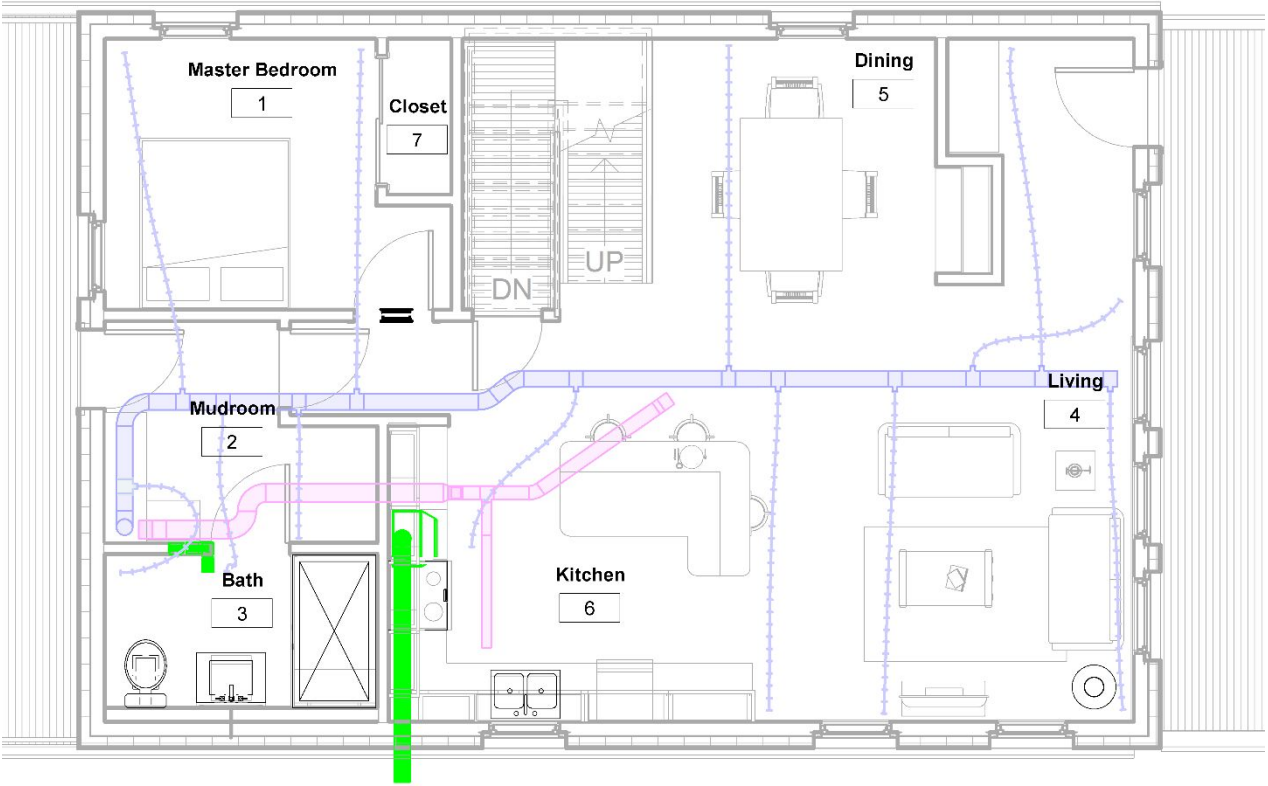
Indoor Air Quality

Mechanical Systems



Indoor Air Quality

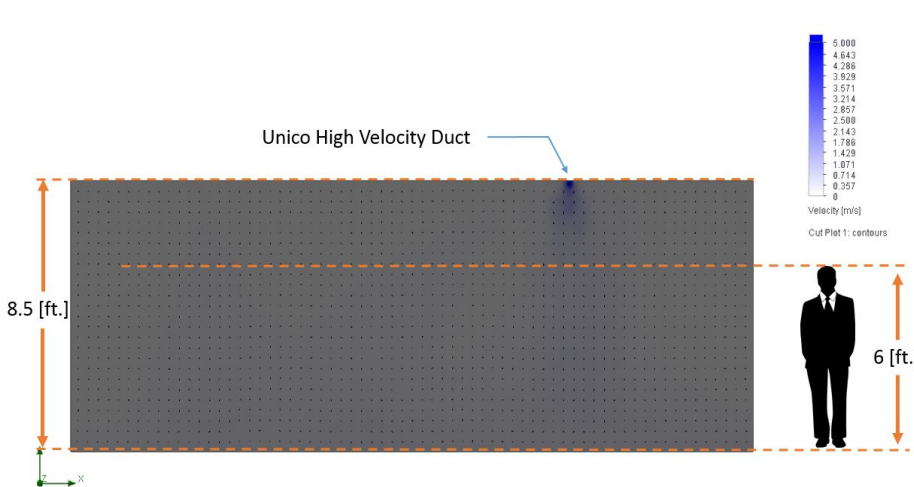
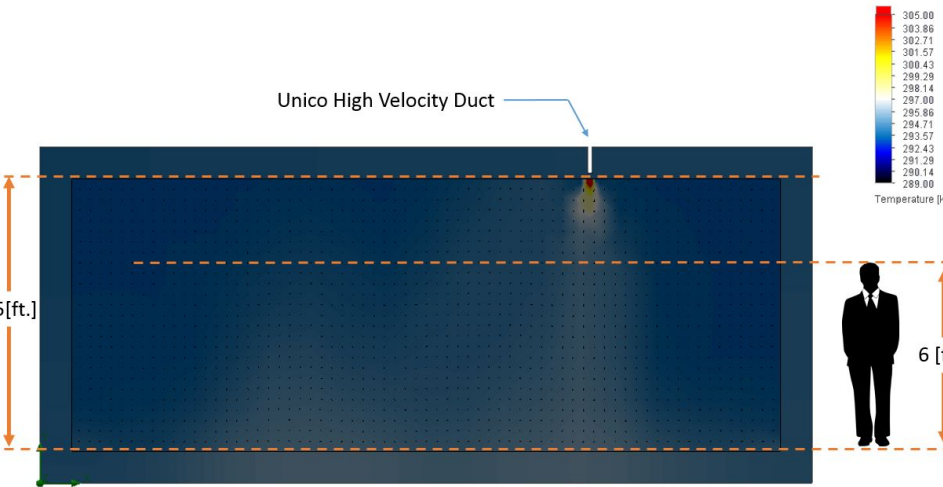
Mechanical Systems



Indoor Air Quality

Mechanical Systems

Unico High Velocity ducts allow for proper mixing and comfort



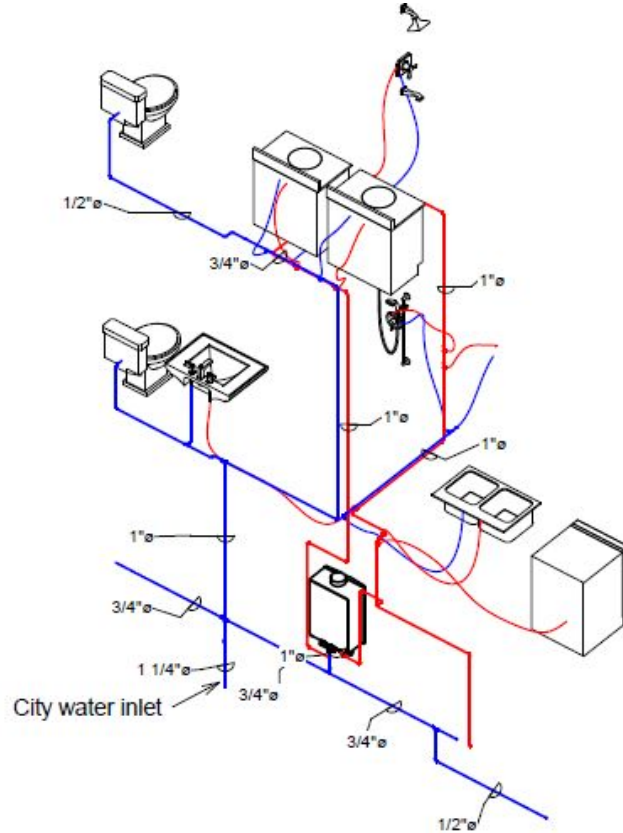
Thermal Comfort



Mechanical Systems

Domestic Hot Water

- Tankless hot water heater with buffer tank
- Short circulation loop
- Closely grouped fixtures



Water Conservation

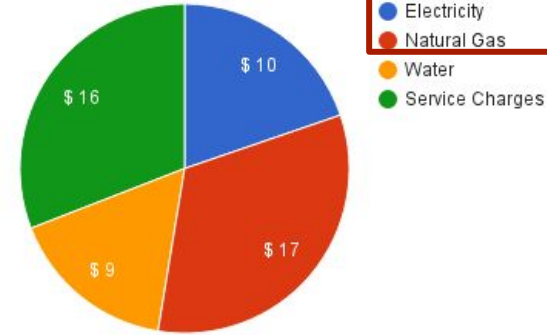
Energy Analysis

Low Energy Consumption provides residents with low utility bills

Monthly Cost

- Forward House's bill: \$51
- National average: \$160

Cost Distribution for \$51 Average Monthly Utility Bill



Forward House Rem/Rate Annual Energy Consumption

Energy Type	Heating		Cooling	Water heating		Lights and Appliances	Photovoltaics
	Gas	Electrical	Electrical	Gas	Electrical	Electrical	Electrical
[MMBtu/year]	21	2.73	1.7	9.4	20.20	36.5	
[kWhr/year]	6154	800	498.219	4249.53	5920.01	10697.06	
[Therms/year]	210			93			
Yearly Cost	\$ 143.45	\$ 104.88	\$ 65.32	\$ 63.53	\$ 776.11	\$ (826.60)	
Total Yearly Cost	\$						326.69
Montly Cost	\$						27.22




Affordability

Energy Analysis

Different energy and cost saving technologies were evaluated for Forward House

Energy Saving Technologies Analysis					
Technology	Approximate Cost [\$]	Energy Savings [MMBtu/year]	Savings [\$/year]	Simple Payback [Years]	Decision
Drain water heat recovery	\$ 903.00	0.74	\$ 5.00	180.6	No
Desuperheater	\$ 1,100.00	1.62	\$ 11.00	100	No
Tesla Powerwall	\$ 3,000.00	0.00	105.45 - 200.62	14.95-28.14	No
HRV	\$ 3,000.00	12.60	\$ 116.00	25.8621	Yes

Higher Energy Savings = Lower HERS 

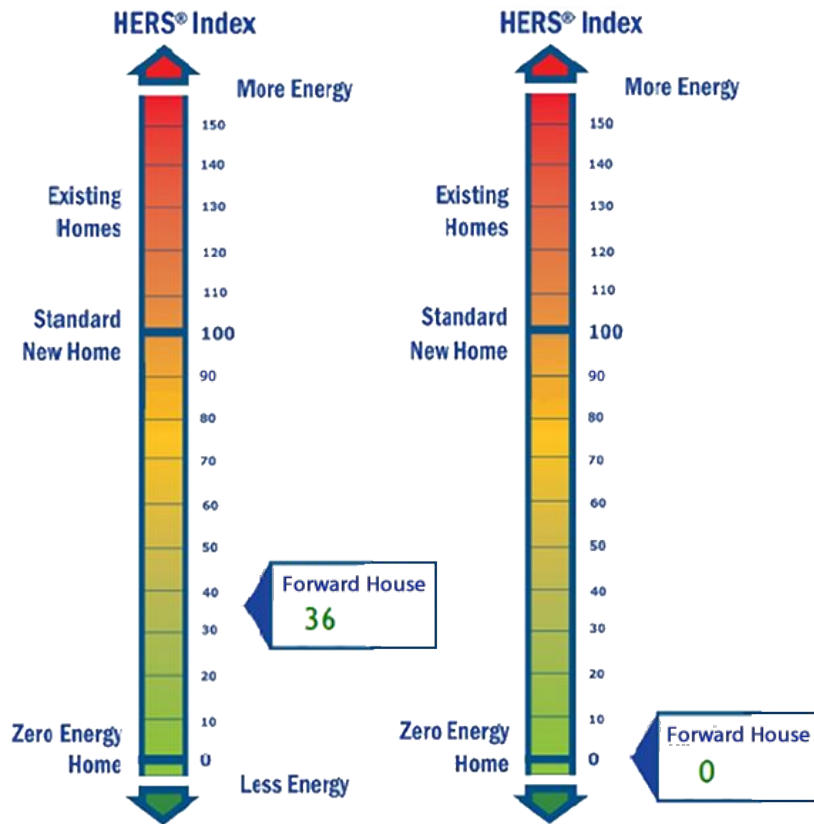
Energy Analysis

HERS score

- Forward House w/ PV = 0
- Forward House w/o PV = 36



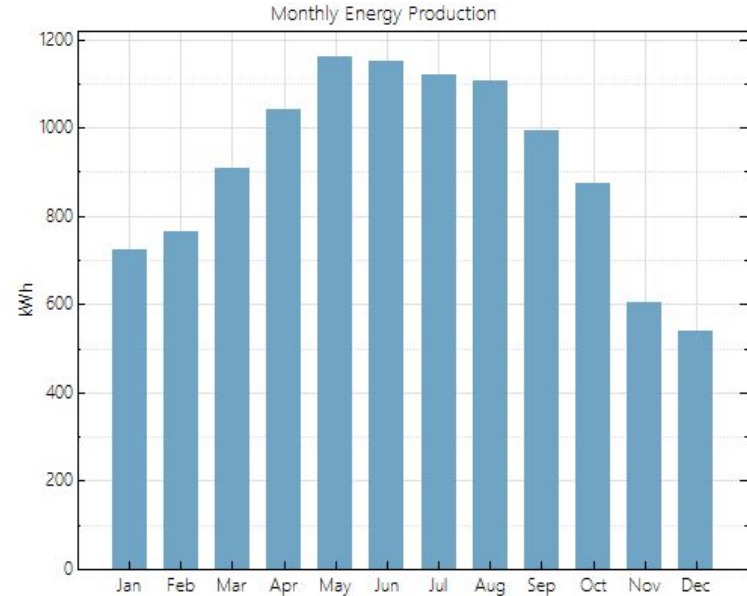
Grape Solar



Energy Analysis

Photovoltaic Analysis

- Basic System Design
 - 8.2 kW system
 - 552 ft² array area
 - 180° Azimuth
 - 38° Inclination angle
- Analysis Methods
 - PVWatts
 - RETScreen
 - SAM
- Energy Production
 - 10,993 kWh/year



Our photovoltaic SAM monthly energy production

Energy Analysis

Photovoltaic Financial Analysis

- Life Cycle Analysis
- System Advisor Model (SAM)
- Renewable Energy Rebates
 - Renewable Energy System
30% Federal Tax Credit
 - Focus on Energy Solar Electric
System Incentive

Metric	Value
Annual energy (year 1)	10,991 kWh
Capacity factor (year 1)	15.3%
Energy yield (year 1)	1,340 kWh/kW
Levelized COE (nominal)	15.67 ¢/kWh
Levelized COE (real)	11.23 ¢/kWh
Electricity bill without system (year 1)	\$1,869
Electricity bill with system (year 1)	\$441
Net savings with system (year 1)	\$1,428
Net present value	\$21,958
Payback period	14.2 years
Net capital cost	\$24,577
Equity	\$0
Debt	\$24,577

Our photovoltaic SAM summary.



Affordability



Energy Analysis

Lighting and Appliances

- All appliances are ENERGY STAR rated
- 100% ENERGY STAR rated lighting fixtures
- Programmable Thermostat
 - Smartphone monitoring
- pureWash laundry system



pureWash



+



Nest



Energy Efficiency

Financial Analysis

Construction Costs: \$248,261

NAHB Sales Price Breakdown	2013 Value			Team Default Estimate	Team Adjusted Estimate
Finished Lot Cost (including financing costs):	\$74,509			\$76,710	\$5,000
Financing Costs	\$5,479			\$5,641	\$5,641
Overhead and General Expenses	\$17,340			\$17,852	\$17,852
Marketing Cost	\$4,260			\$4,386	\$4,386
Sales Commission	\$14,235			\$14,655	\$14,655
Profit	\$37,255			\$38,356	\$38,356
Total Sales Price	\$399,532			\$411,333	\$334,150

Debt to Income Ratio

Goal: 38%

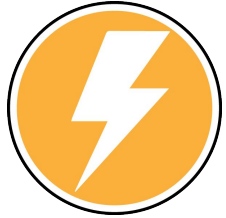
Achieved: 53%



Affordability



Successes



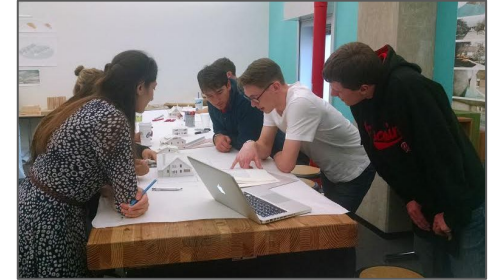
Energy Analysis



Architecture

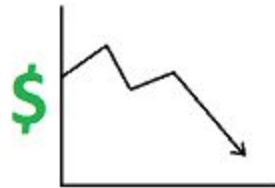


Applicability



Integrative design process

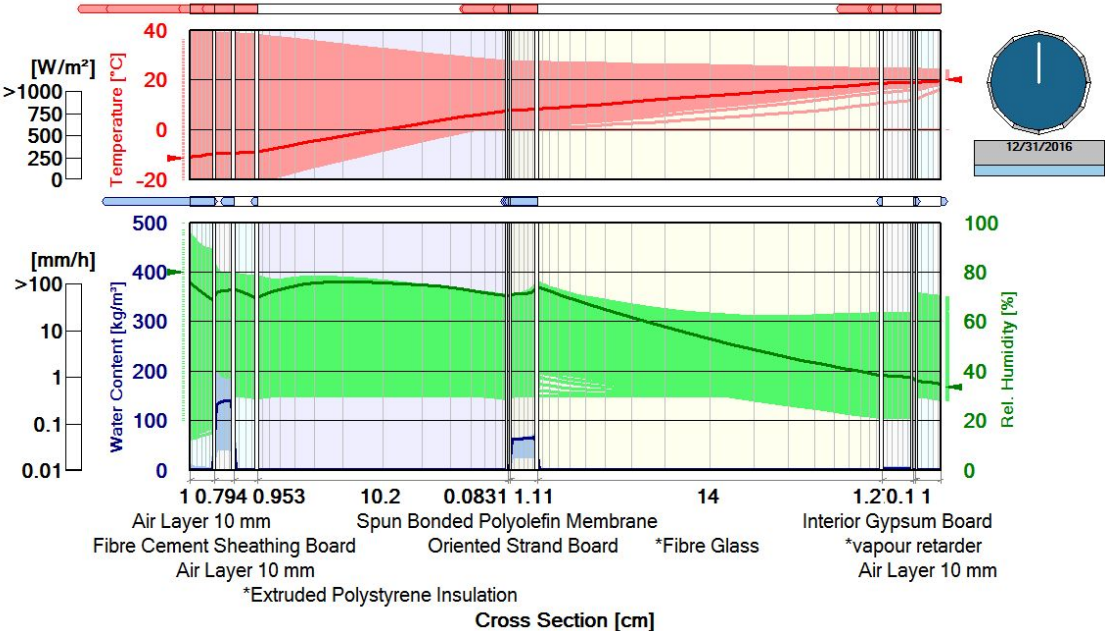
Opportunities for improvement



Affordability

Envelope Durability

Moisture Infiltration



WUFI Data for Madison, WI