

Prairie View A&M University

Double Barrel House



Sean Benson Team Leader – Net Zero Energy Design I & II
Bachelor of Science in Architecture, Dec 2016



Alexis Borman Net Zero Energy Design II
Bachelor of Science in Architecture, May 2016



Christopher Brown AIA COTE, Net Zero Energy Design I & II
Bachelor of Science in Architecture, May 2016

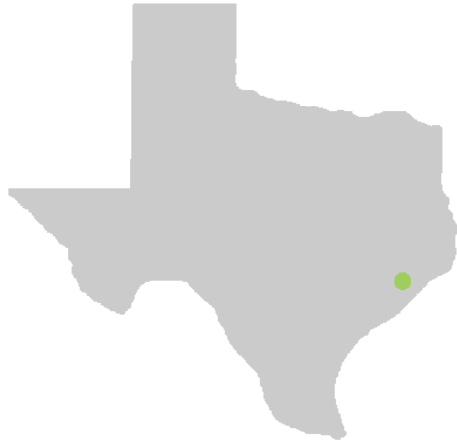


Devonta Magee Net Zero Energy Design II
Bachelor of Science in Architecture, Aug 2016

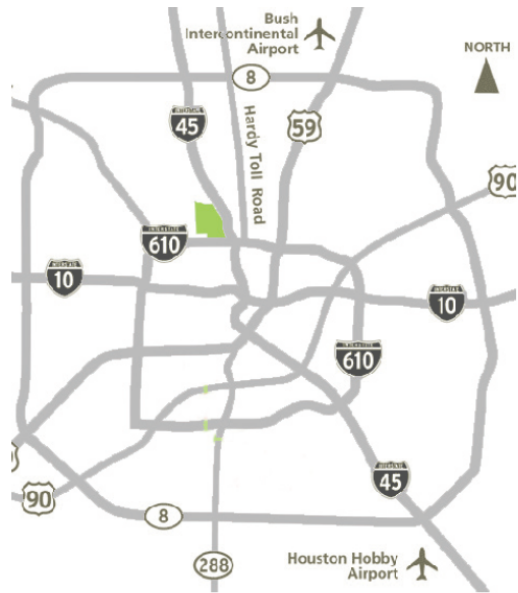


Yasmine Parker Net Zero Energy Design II
Bachelor of Science in Architecture,
Bachelor of Science in Construction Science, May 2017

Shelly Pottorf Faculty Advisor – AIA; LEED AP, CPHC
Adjunct Assistant Professor, Prairie View A&M University School of Architecture



Houston, TX



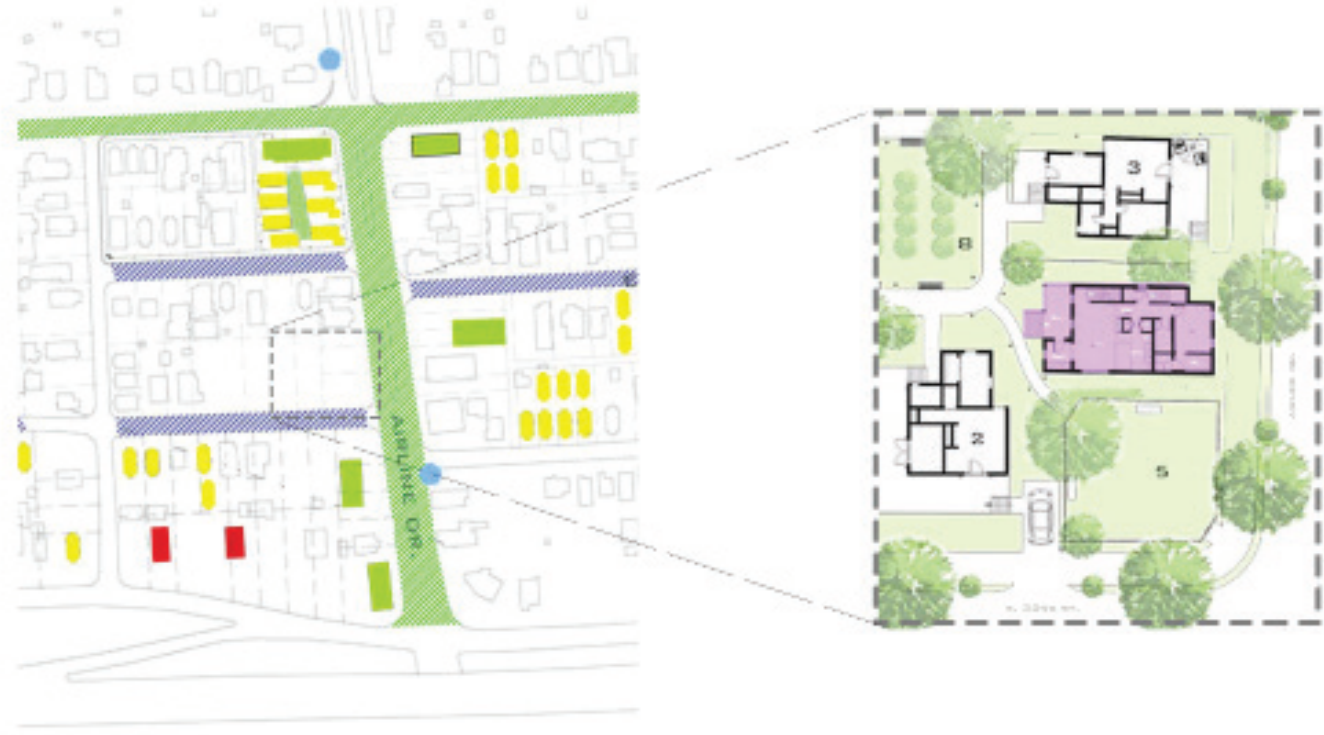
Independence Heights, Houston, TX



Independence Heights

● Site Location

Context – Site Plan



Independence Heights - Demographics

Area	3.390 Sq. Mi.
Population	13,404
Population Density	3,954
Median Household Income	\$55,450
Male Population	6,590
Female Population	6,812
Male Median age	34.8
Female Median Age	36.4
Average Household Size	3.0 Persons
Percentage of Family Households	46.9%
Percentage of Married Couple Families	36.3%
Percentage of Single Mother Households	8.6%
Percentage of Never Married Females 15 yrs. and Older	16.3%
Average number of Cars or Other Vehicles Available in Houses/ Condos	1.7
Percentage of Population Below the Poverty Level	41.6%

Houston- Demographics

Population Density	3,704
Median Household Income	\$63,900
Male Median Age	31.6
Median Female Age	33.2
Average Household Size	2.7 Persons
Percentage of Family Households	50.4%
Percentage of Married Couple Families	38.8%
Percentage of Single Mother Households	11.3%
Percentage of Never Married Females 15 yrs. and Older	18.0%
Average number of Cars or Other Vehicles Available in Houses/ Condos	1.2
Percentage of Population Below the Poverty Level	23.8%

Project Goals



Design a resilient home that reflects the perseverance of the Independence Heights community



Design a home that meets the affordability standards in the Independence Heights Area



Create a response that addresses the area's proneness to flooding



Consider the architectural dynamics of the neighborhood and create a home that fits within its architectural fabric



Meet or exceed the requirements to achieve passive House Institute Certification in the United States

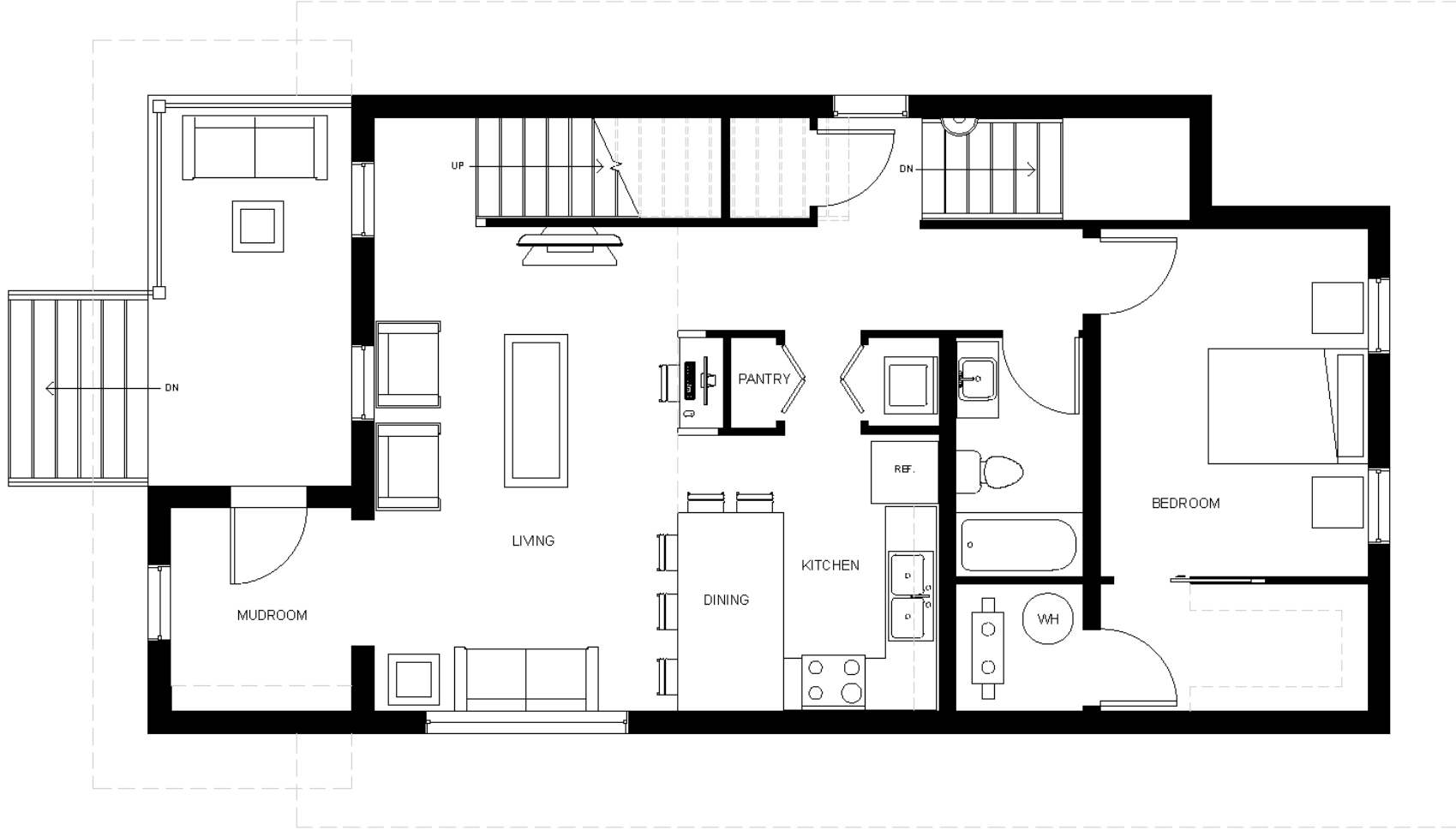


Design a Net Zero Energy Ready Home

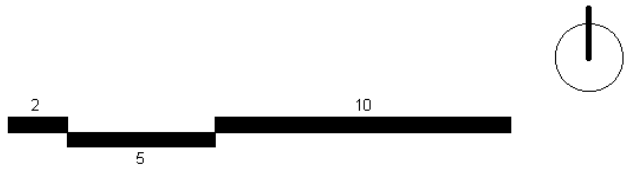
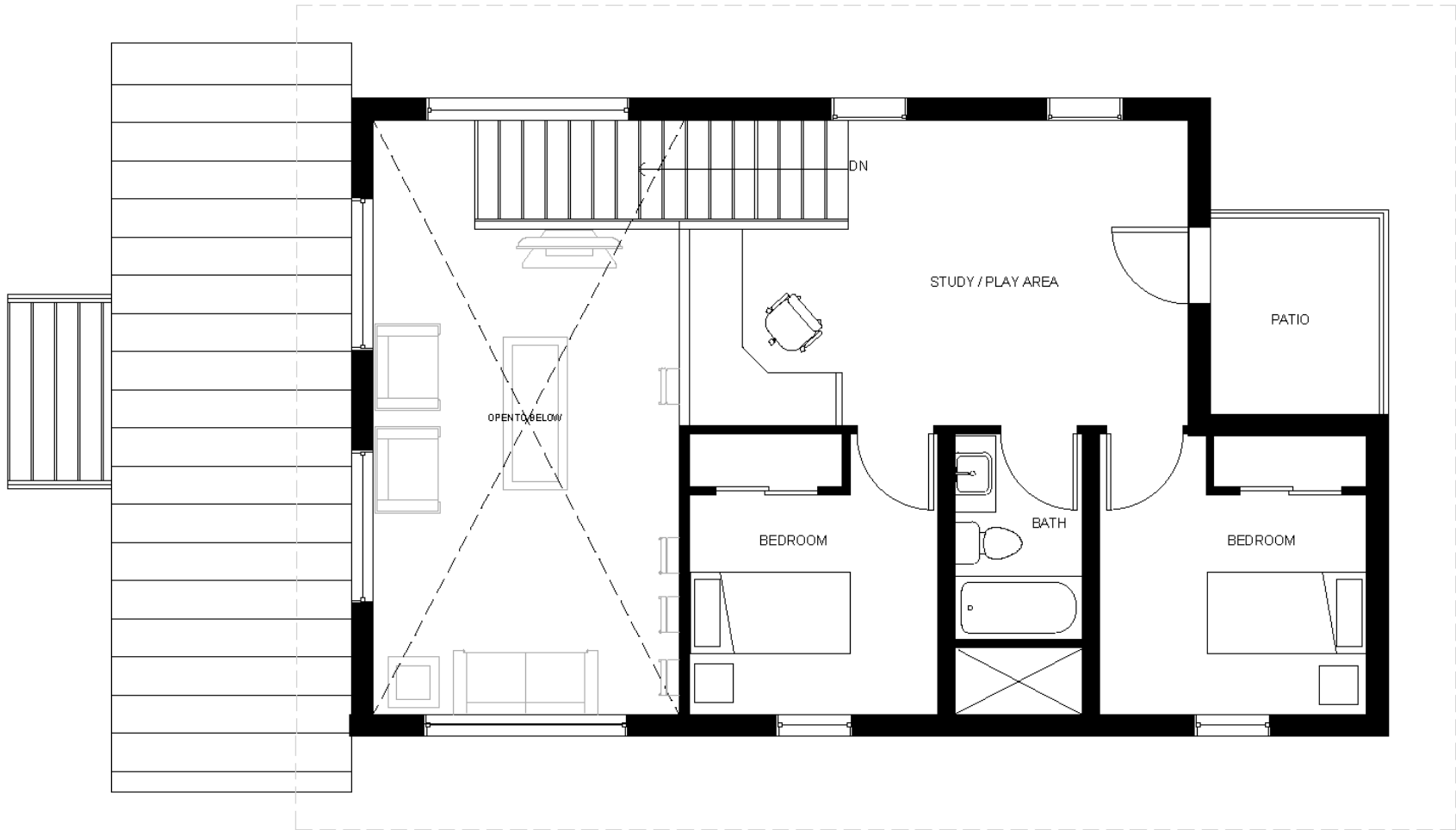




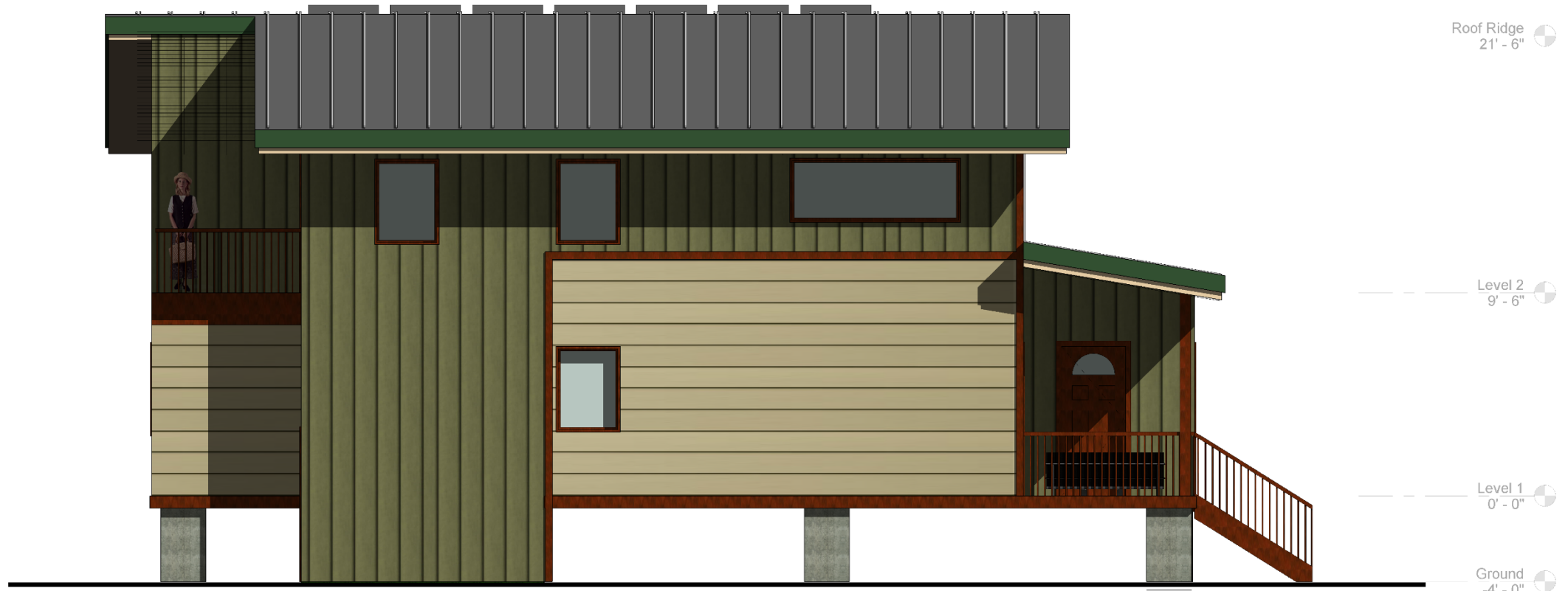
Level 1



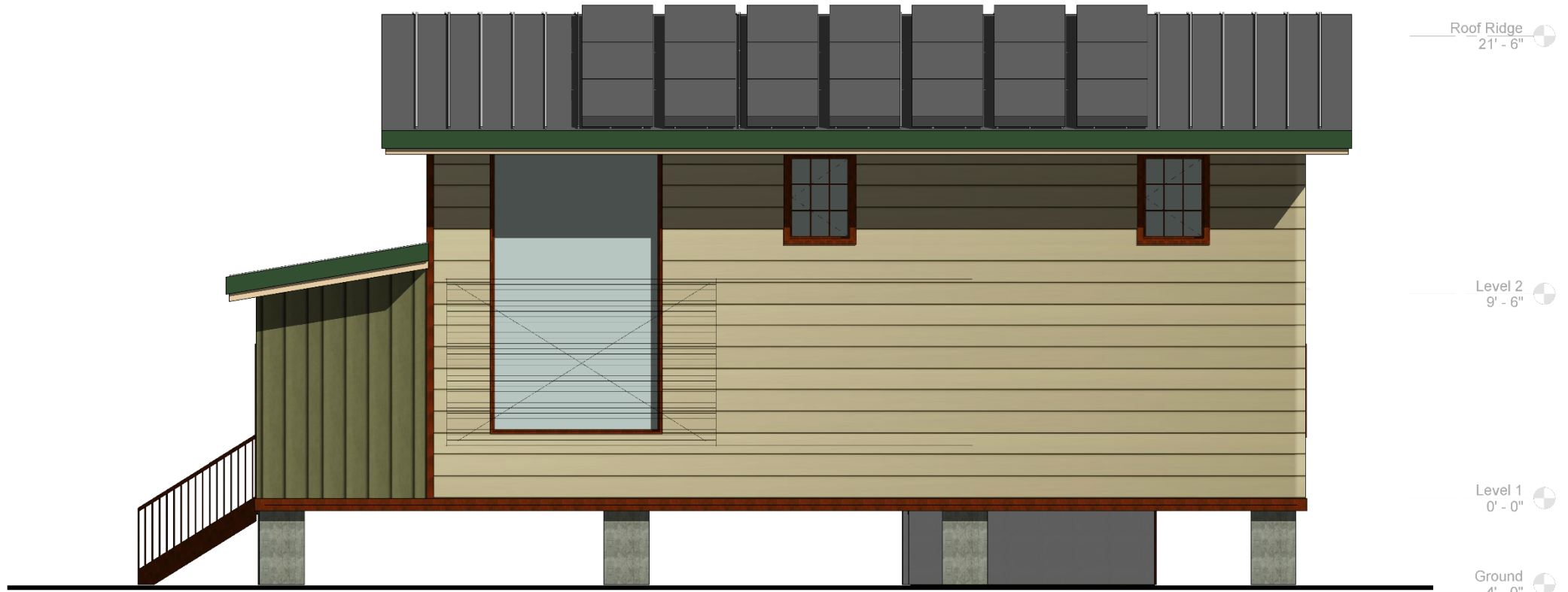
Level 2



North Elevation



South Elevation



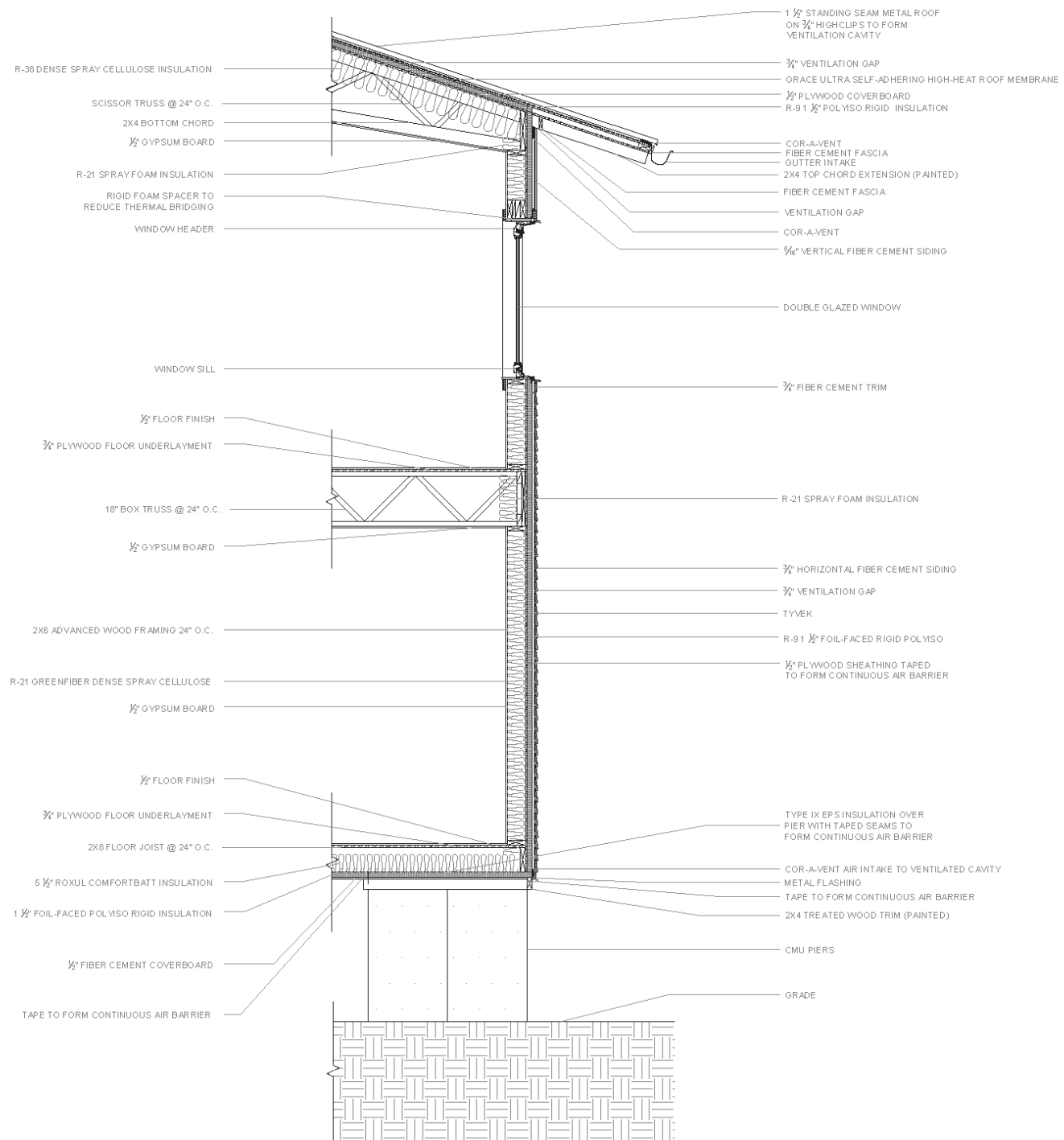
East Elevation



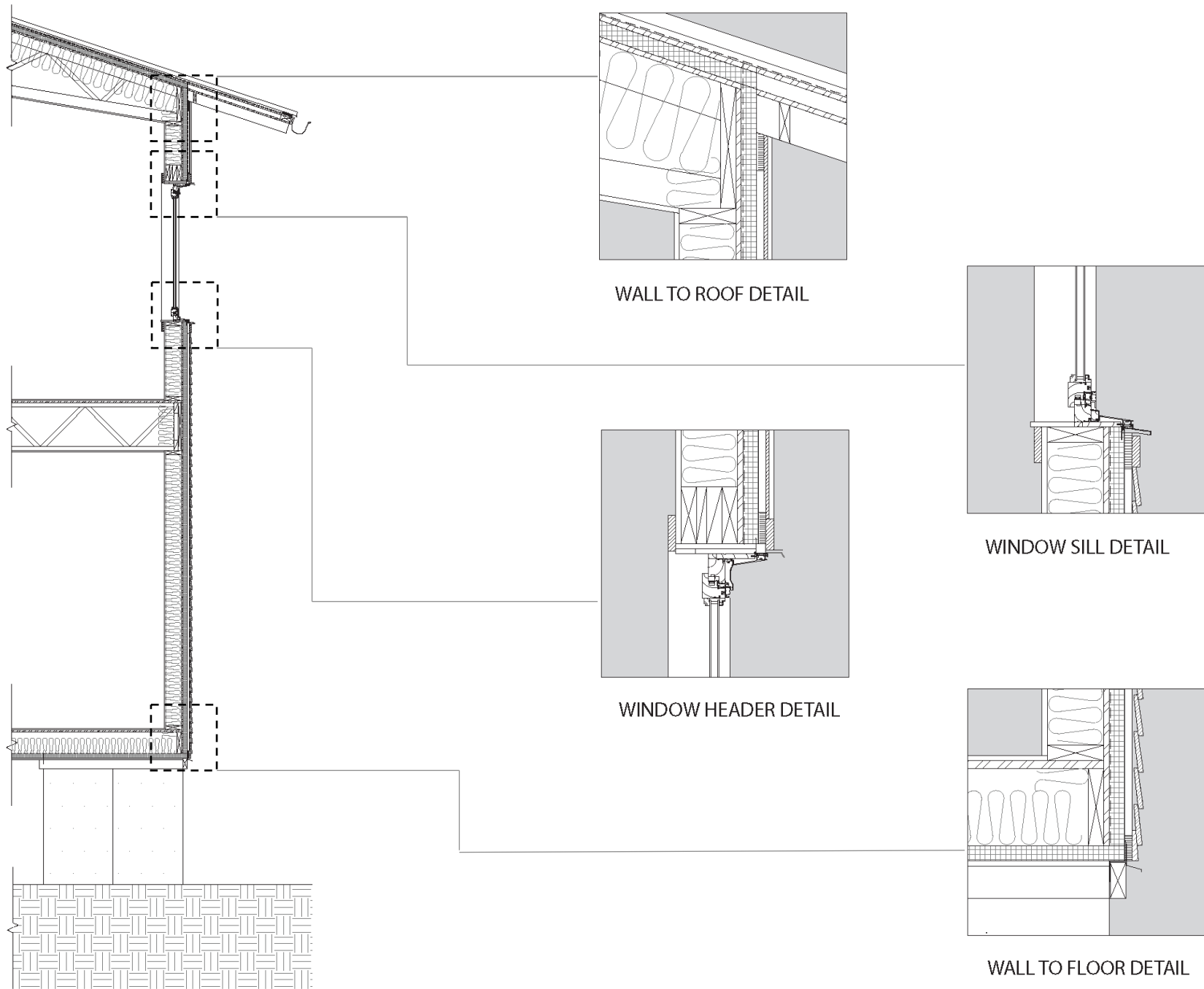
West Elevation



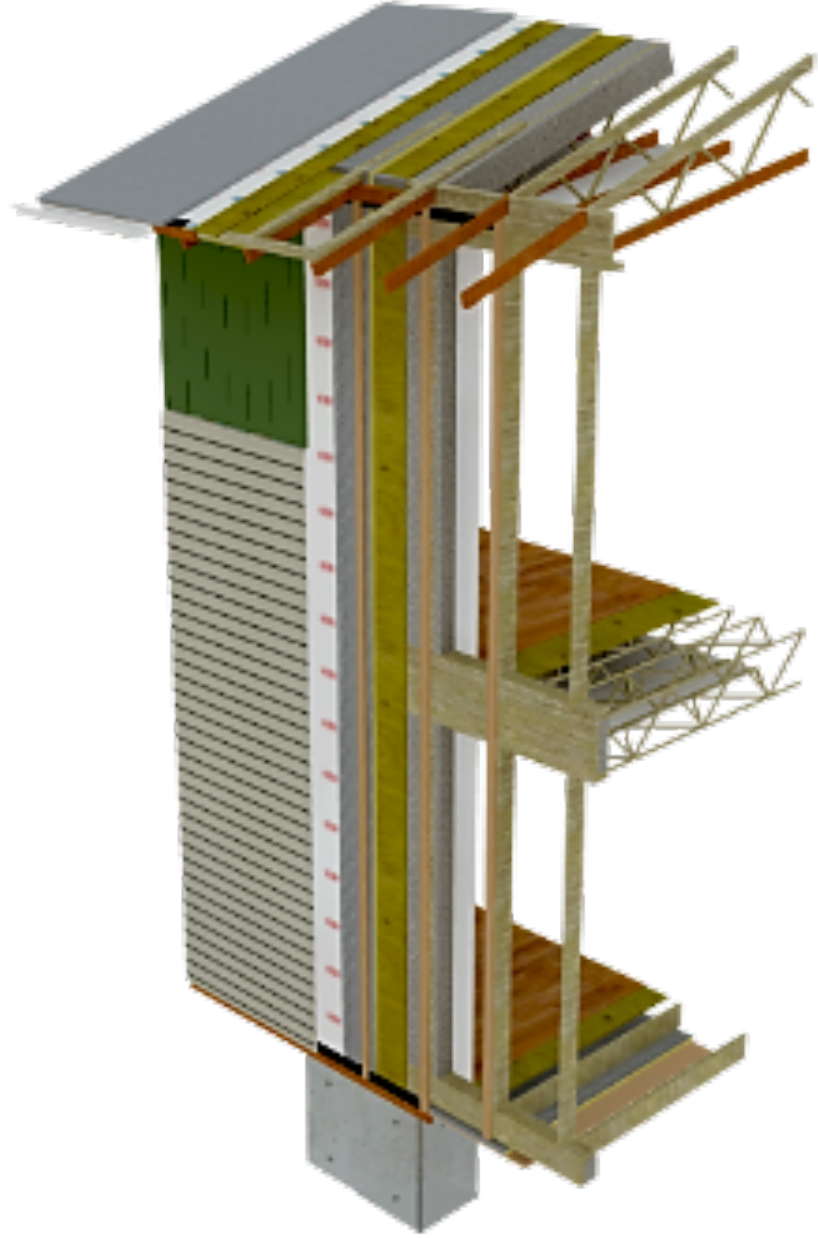
Envelope



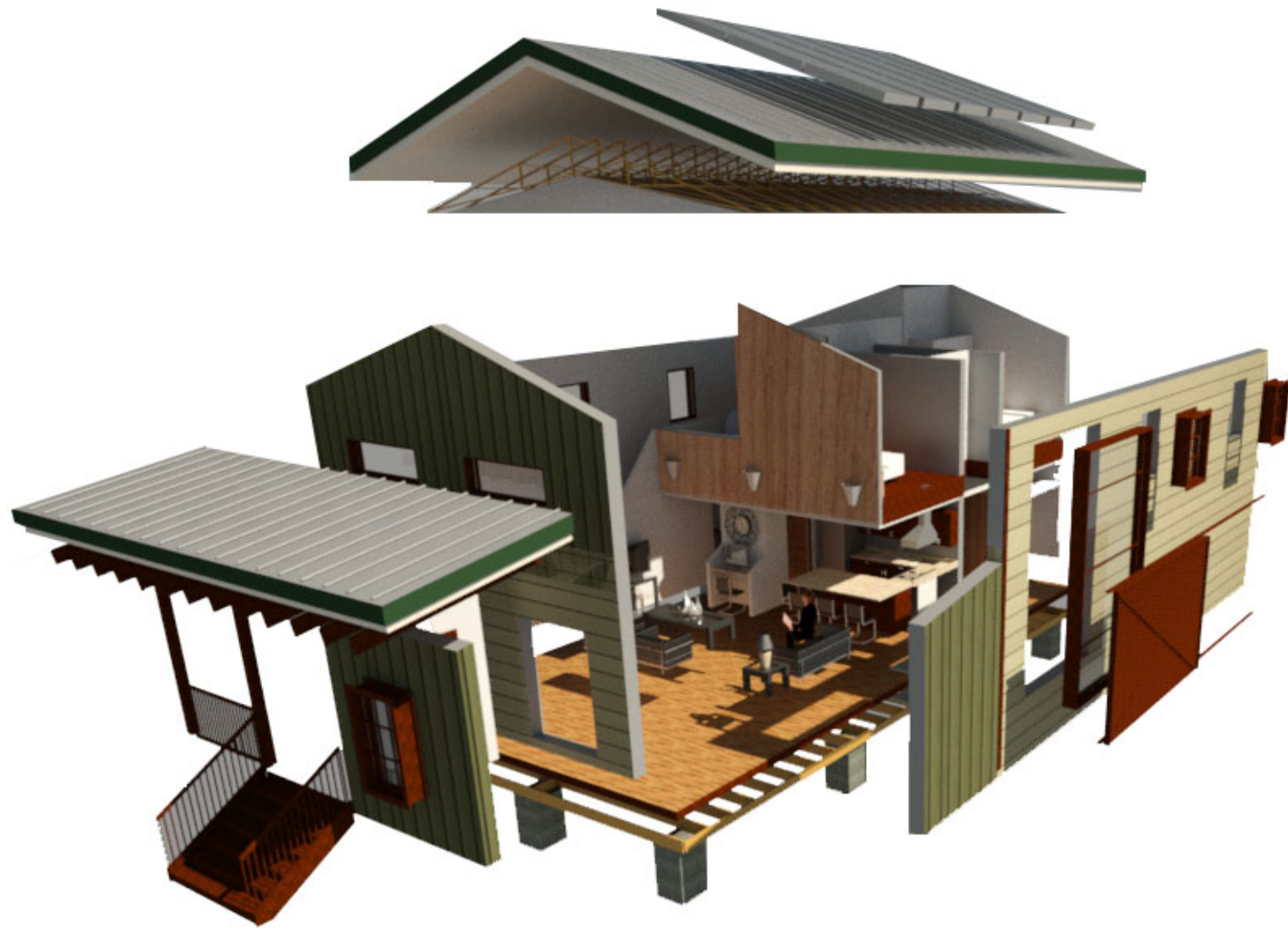
Envelope Details



Envelope

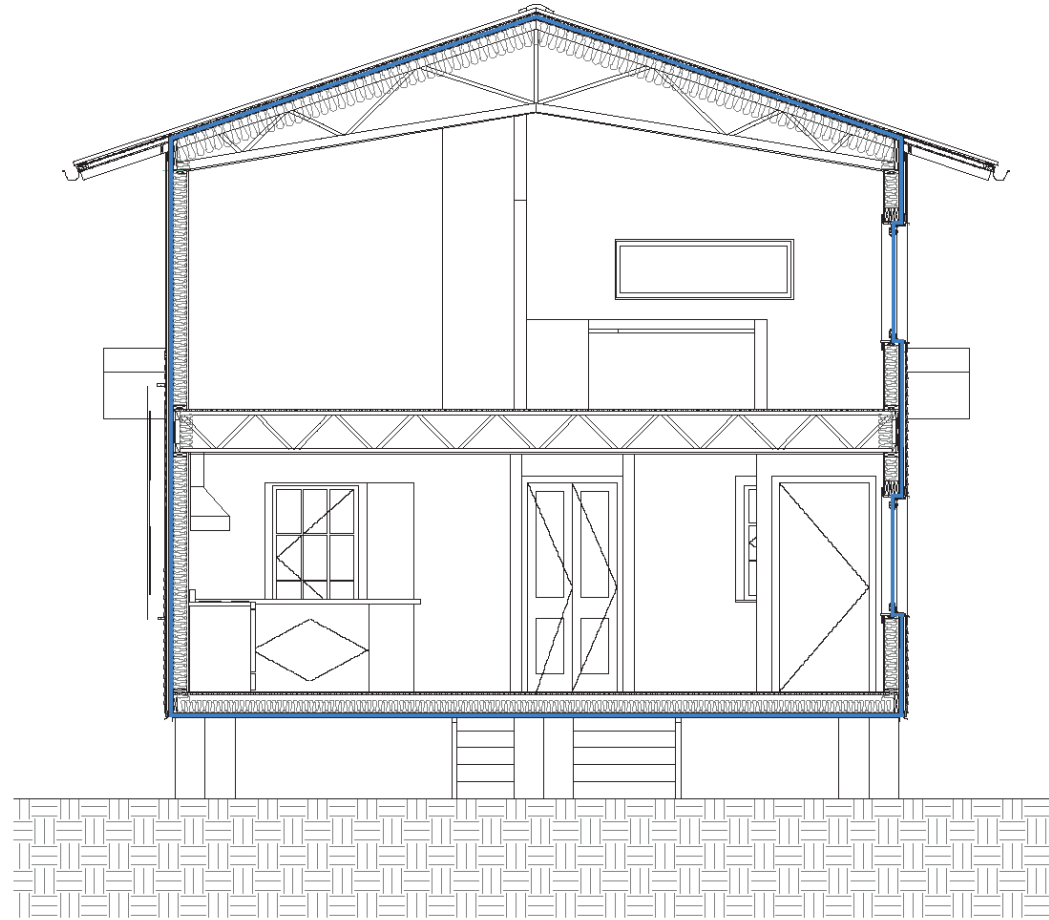


Exploded Structure



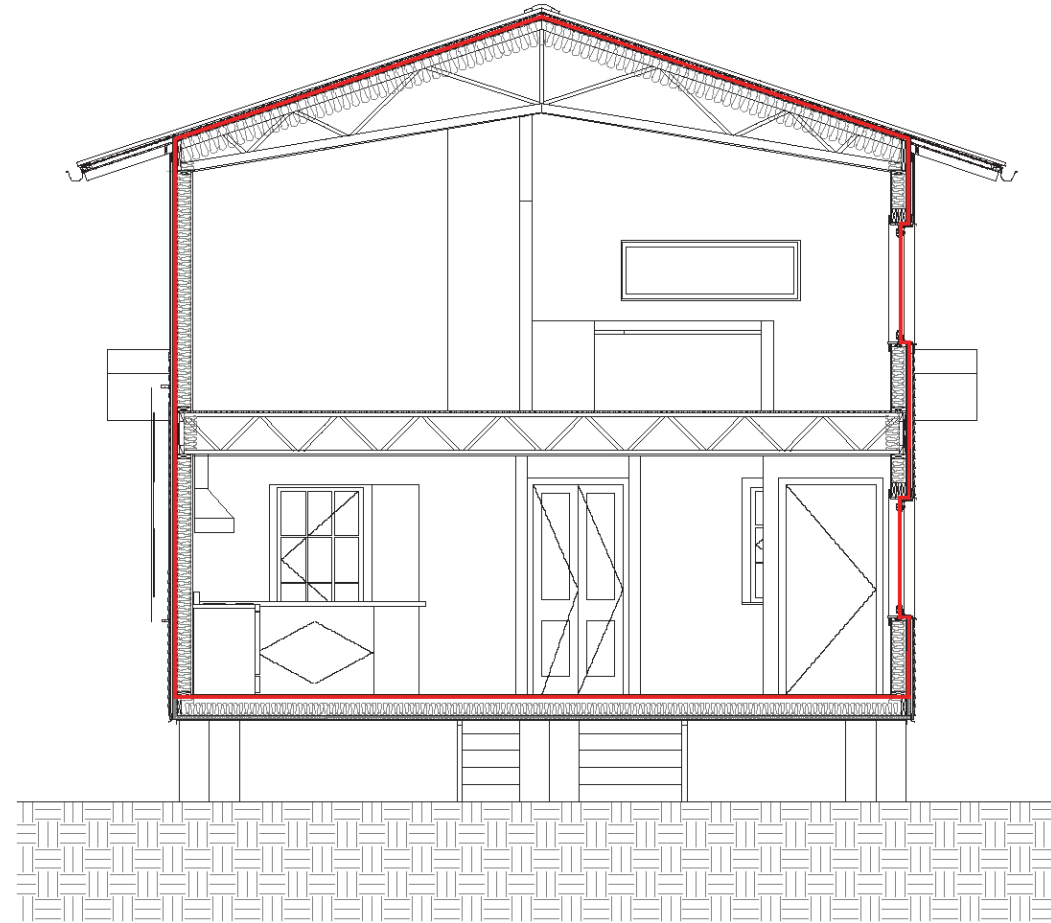
Building Section

— Continuous Thermal Barrier

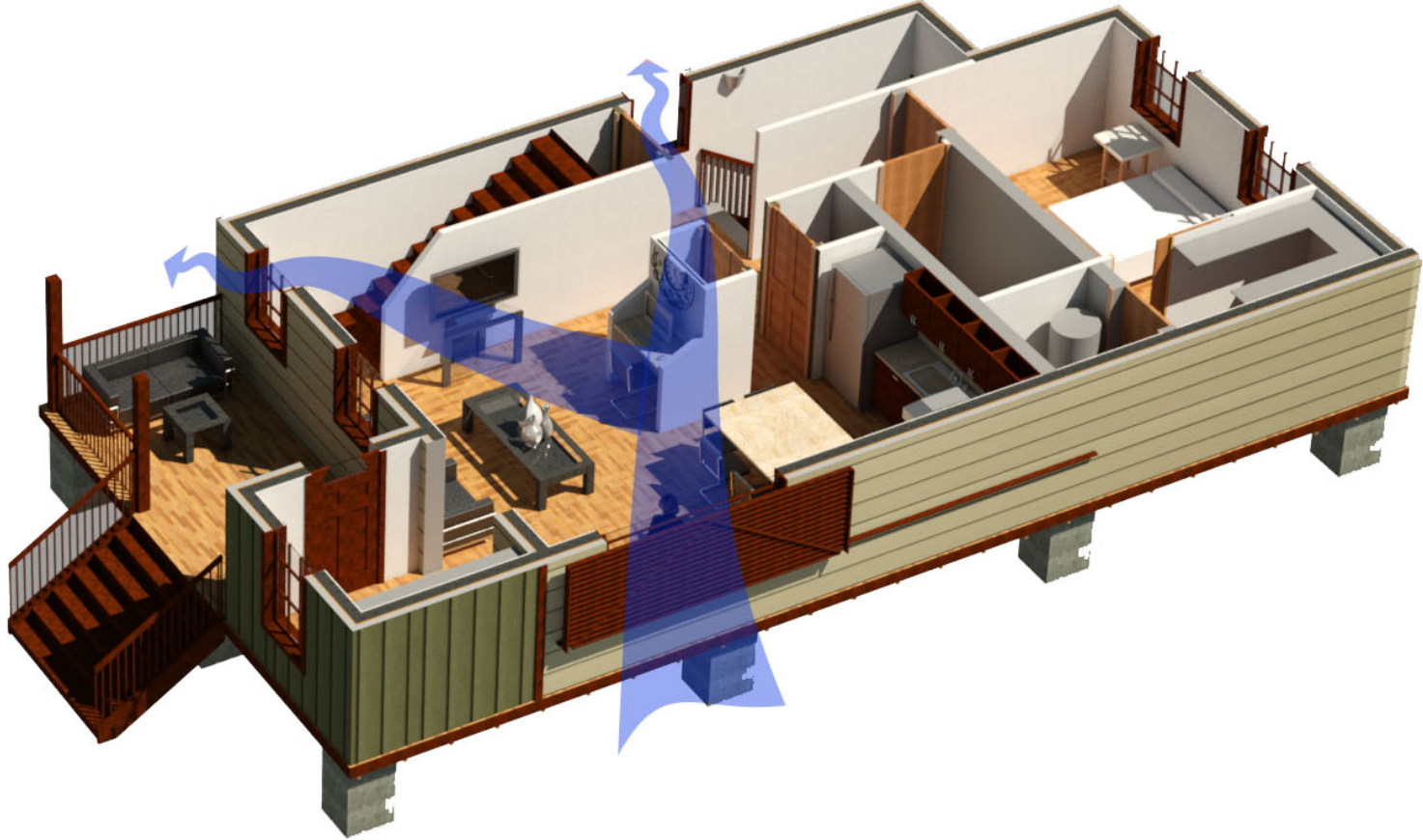


Building Section

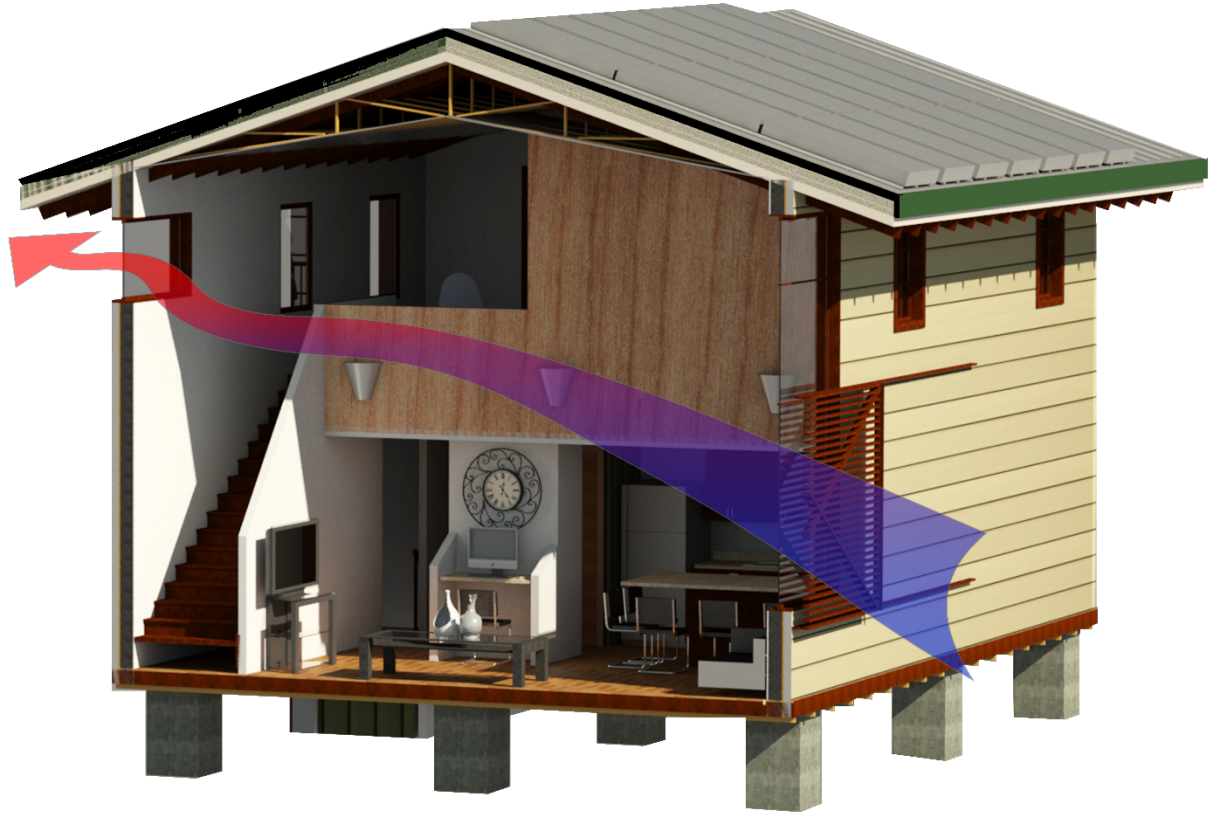
— Continuous Air Barrier



Natural Ventilation



Natural Ventilation





Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at <http://sam.nrel.gov>) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

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The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a fixed (open rack) PV system at the location.

RESULTS

8,413 kWh per Year *

System output may range from 8,139 to 8,639kWh per year near this location.

Month	Solar Radiation (kWh / m ² / day)	AC Energy (kWh)	Energy Value (\$)
January	3.39	538	59
February	3.92	554	61
March	4.72	726	80
April	5.08	743	82
May	5.52	818	90
June	5.90	831	91
July	5.75	829	91
August	5.61	813	89
September	5.34	758	83
October	4.94	733	80
November	3.98	588	65
December	3.05	484	53
Annual	4.77	8,415	\$ 924

Location and Station Identification

Requested Location	3200 Columbia St, Houston, TX 77007
Weather Data Source	(TMY2) HOUSTON, TX 13 mi
Latitude	29.98° N
Longitude	95.37° W

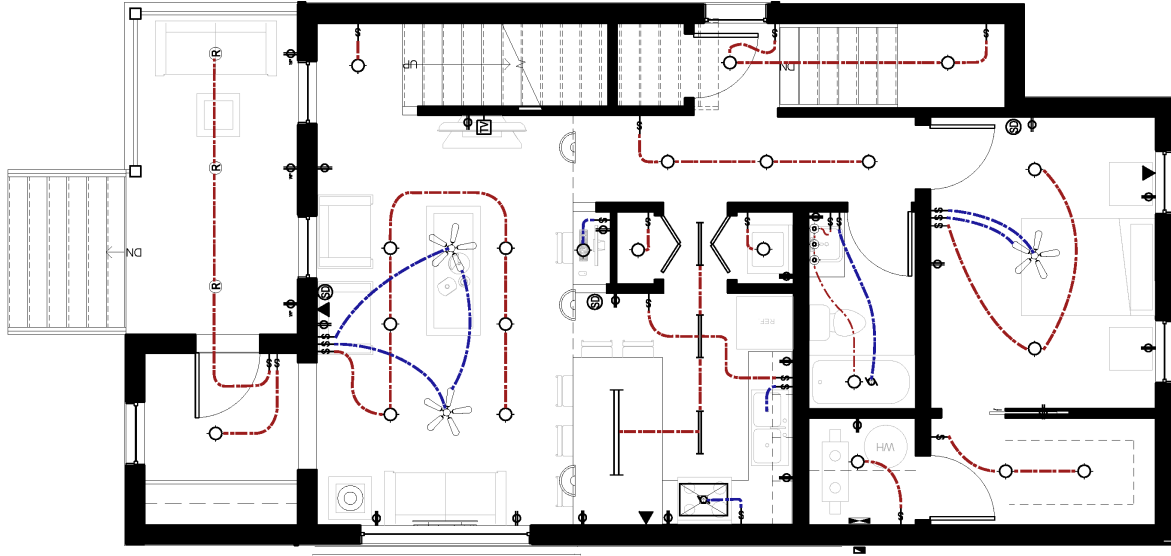
PV System Specifications (Residential)

DC System Size	6.3 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	18.4°
Array Azimuth	180°
System Losses	14%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

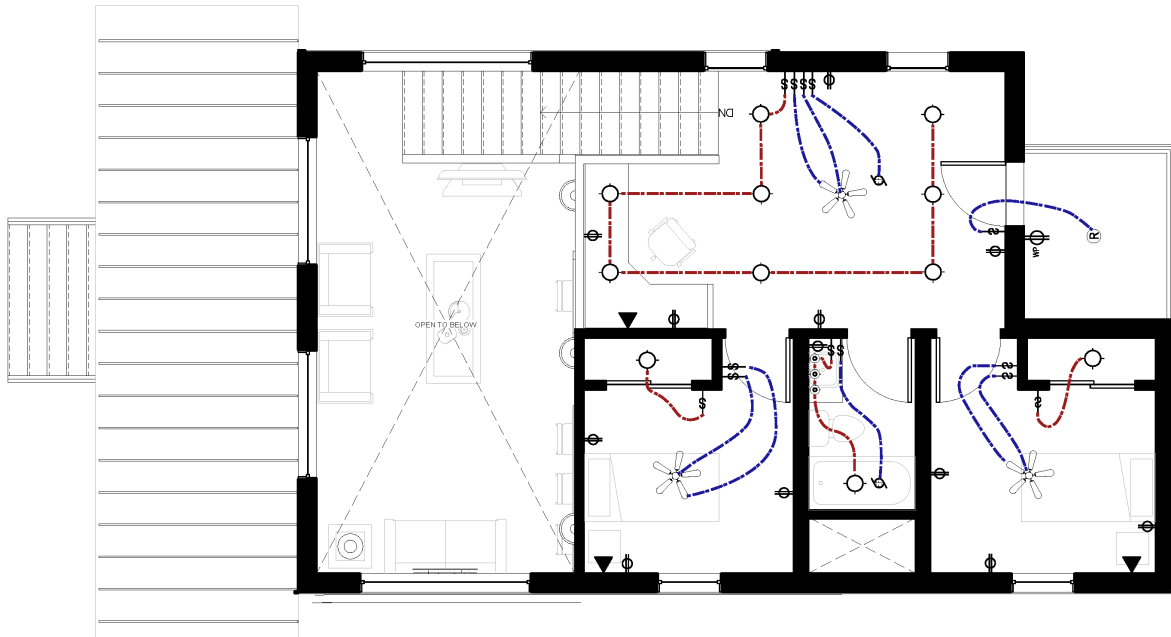
Initial Economic Comparison

Average Cost of Electricity Purchased from Utility	0.11 \$/kWh
Initial Cost	3.30 \$/Wdc
Cost of Electricity Generated by System	0.20 \$/kWh

Electrical

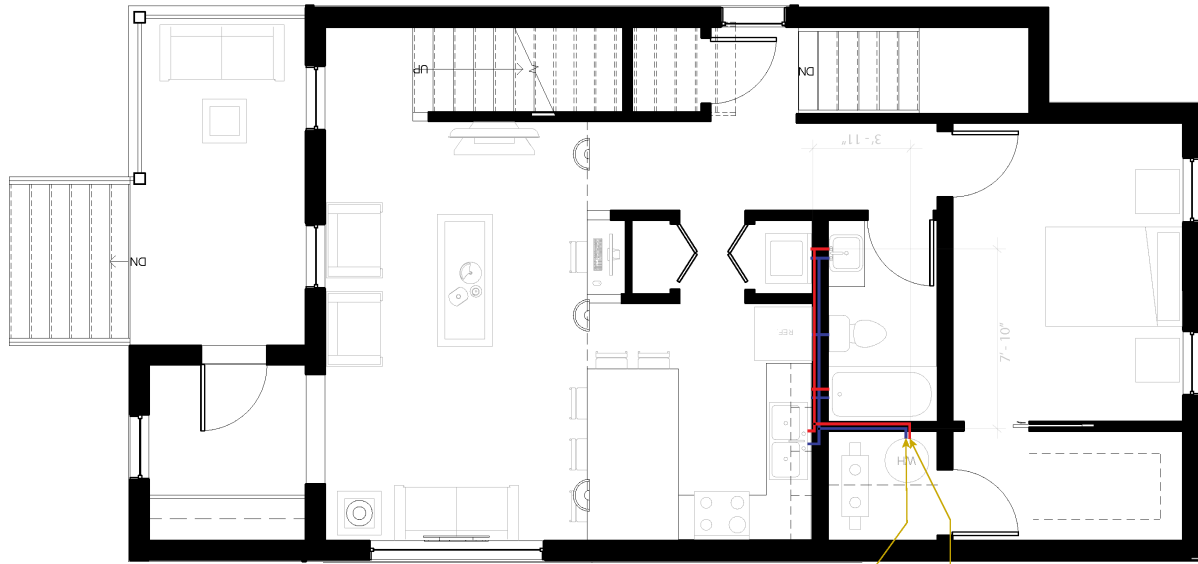


Level 1



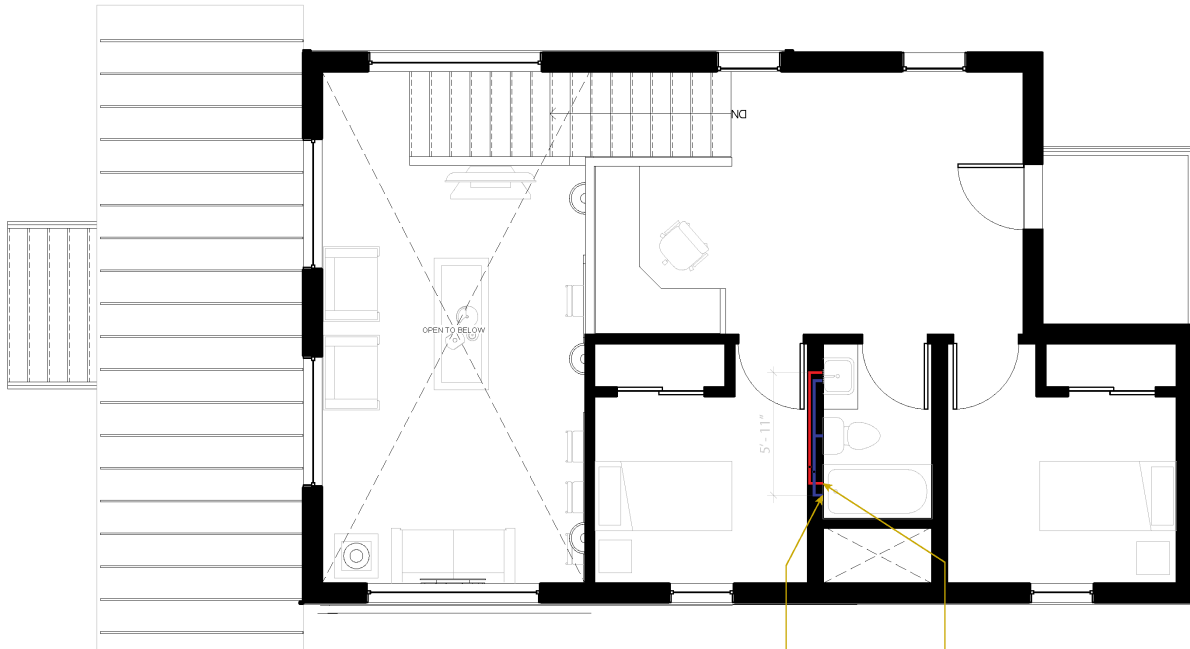
Level 2

Plumbing



Level 1

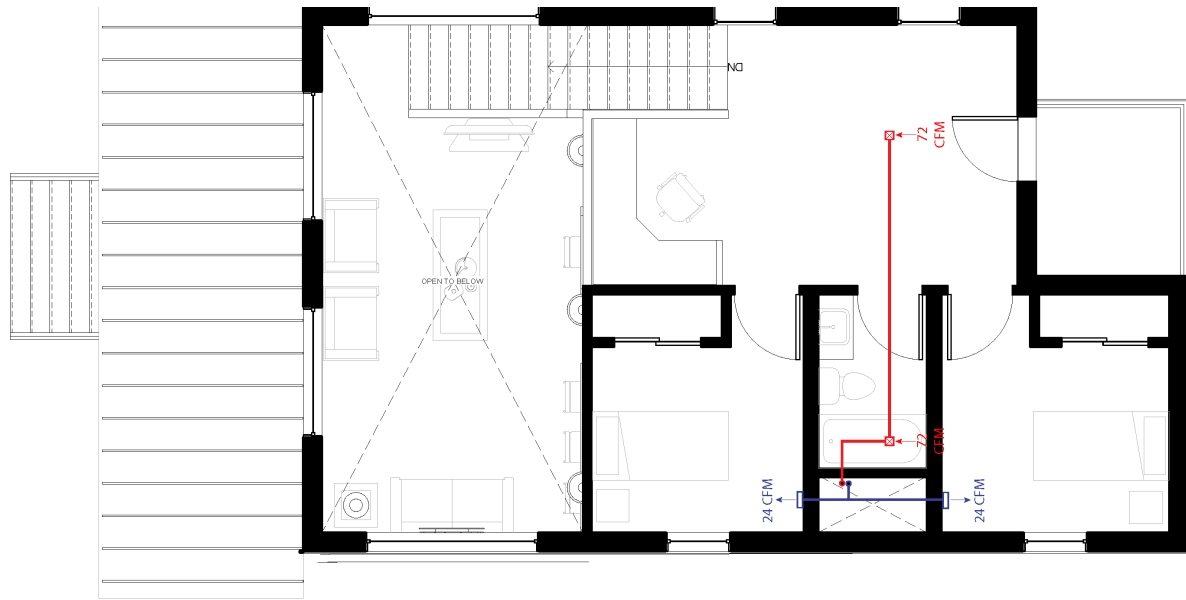
3/4" Cold Water Line 3/4" Hot Water Line



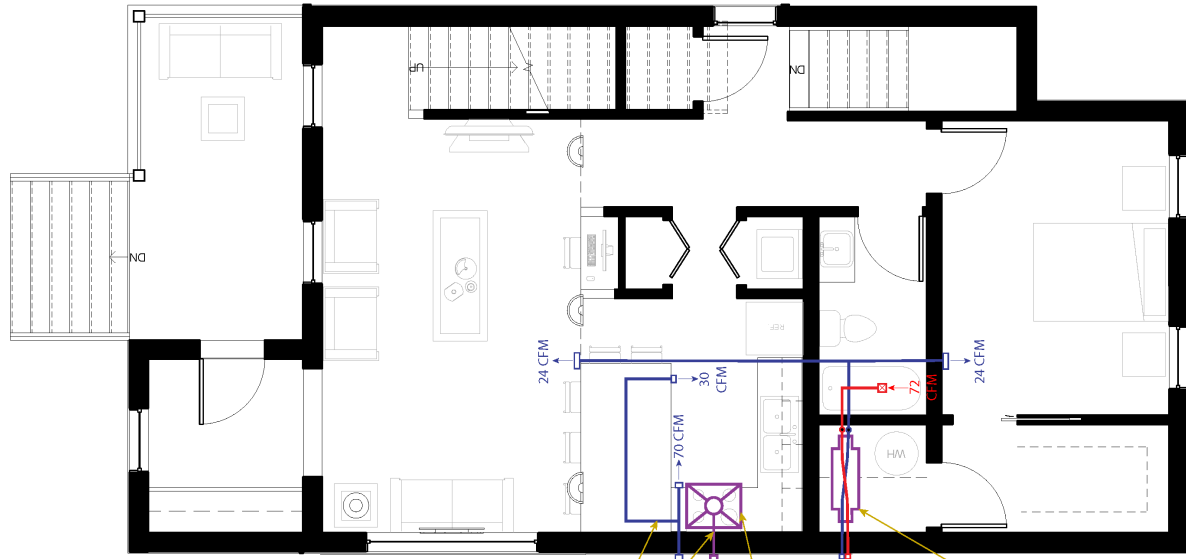
Level 2

3/4" Cold Water Line 3/4" Hot Water Line

Energy Recovery Ventilation

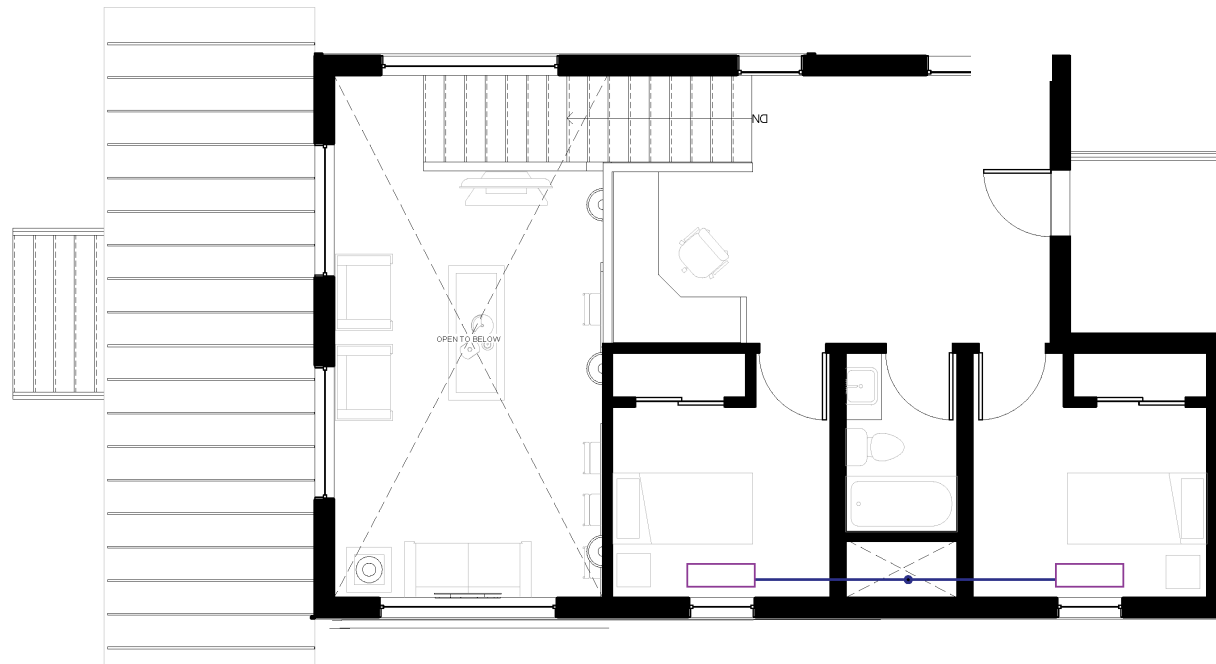
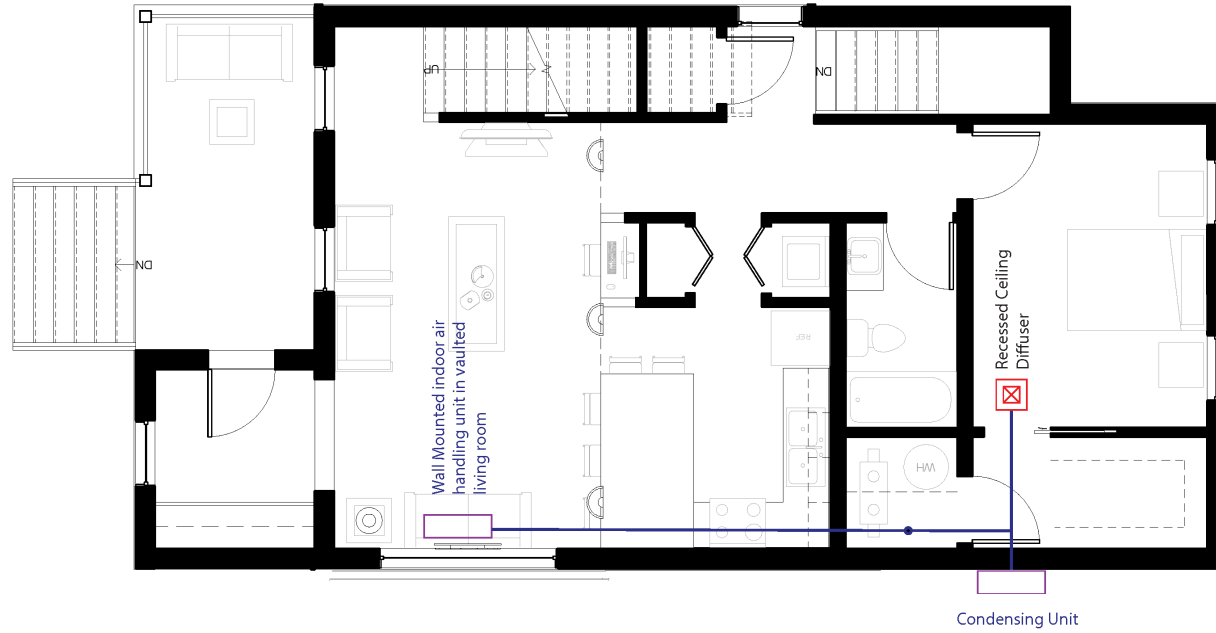


Level 2

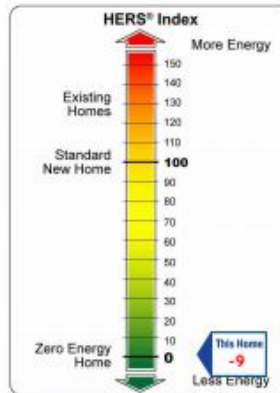


Level 1

Mini-Split

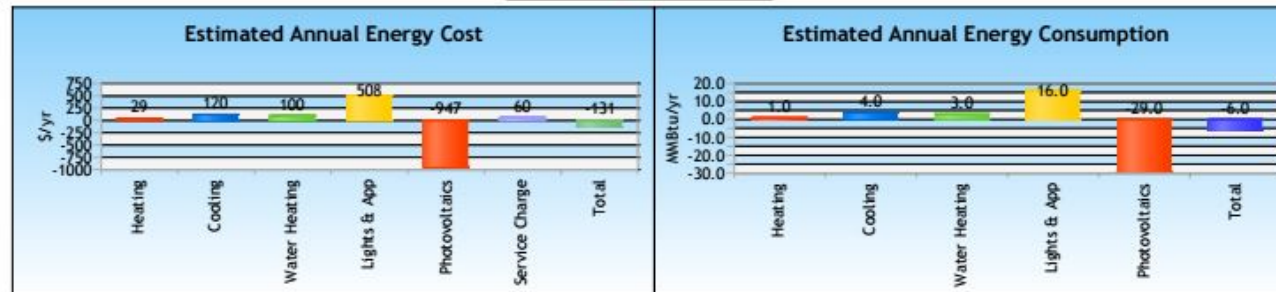


RESNET HERS Index



ENERGY RATING CERTIFICATE

Projected Rating: Based on Plans - Field Confirmation Required.



Address 3200 Columbia St
Houston, TX 77007

House Type Single-family detached

Cond. Area 1567 sq. ft.

Rating No. 2016-03-01

Issue Date March 24, 2016

Certification Verified

Annual Estimates*
CO2 emissions(Tons): -1

Annual Savings**: \$2473

* Based on standard operating conditions
** Based on a HERS 130 Index Home

EC Pro
P.O. Box 240695
San Antonio, Texas 78224

Certified Rater Polly Ledvina

Rater ID 6948517

Registry ID

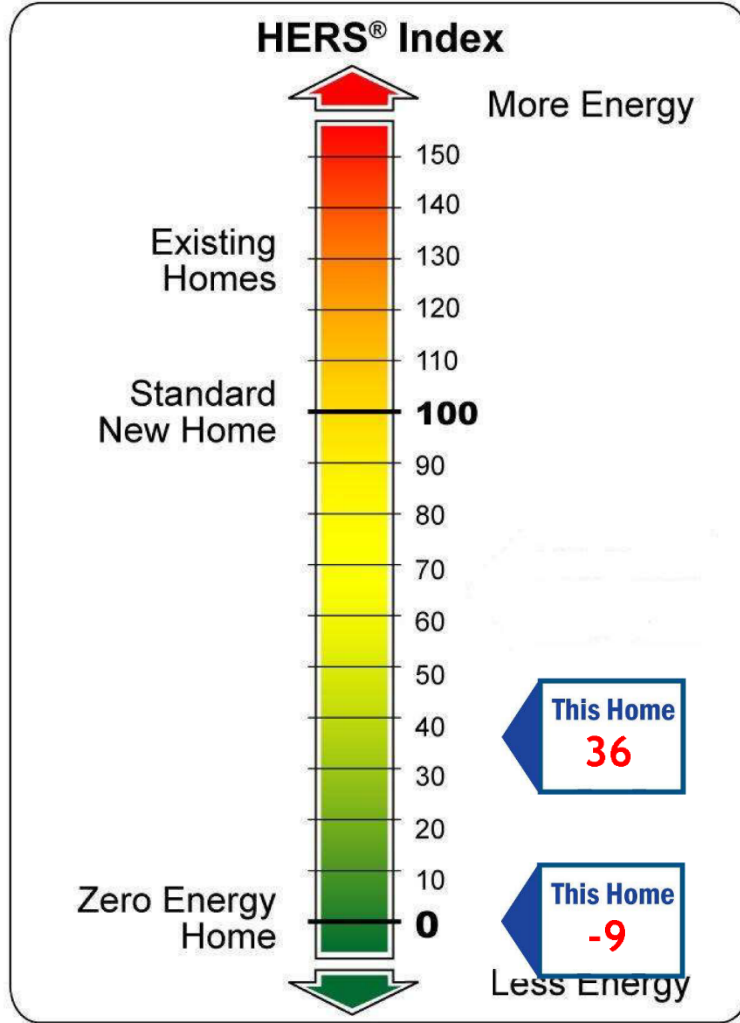
Rating Date 3/16/2016

Signature

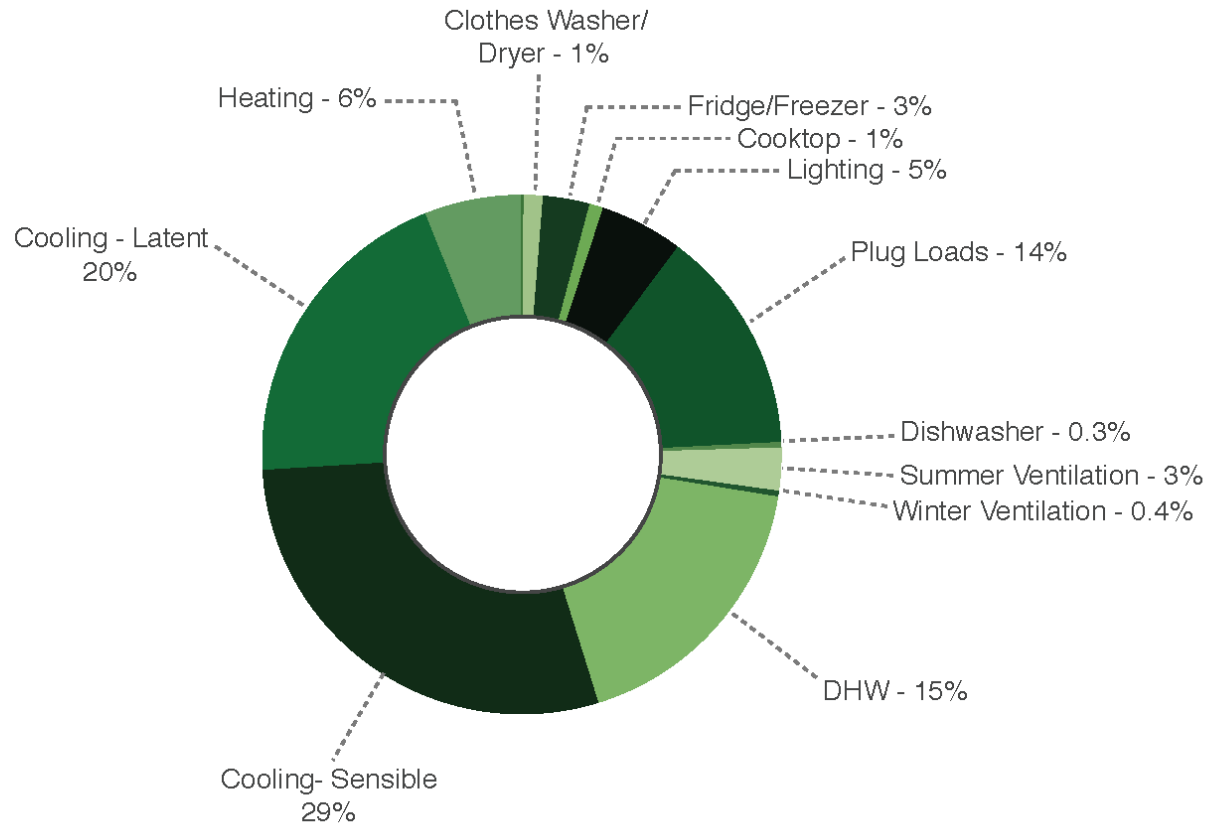
REM/Rate - Residential Energy Analysis and Rating Software v14.6.1

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The Home Energy Rating Standard Disclosure for this home is available from the rating provider.

Energy Analysis



Energy Analysis



Energy Analysis

Energy Modeling Results	Energy Star v3.0 Certification Criteria	DOE ZEHR Certification Criteria	REM/Rate Base Design ¹	PHIUS+ 2015 Certification Criteria	WUFI-Passive Upgraded Design Option A ²	WUFI-Passive Upgraded Design Option B ³
Heating Demand	10,000 kBtu/yr	meet ESv3 min	1,800 kBtu/yr	3,290 kBtu/yr	2,429 kBtu/yr	2,586 kBtu/yr
Cooling Demand	19,400 kBtu/yr	meet ESv3 min	10,400 kBtu/yr	20,840 kBtu/yr	19,430 kBtu/yr	19,133 kBtu/yr
Heating Load	-	-	4.59 Btu/hr ft ²	3 Btu/hr ft ²	2.99 Btu/hr ft ²	2.88 Btu/hr ft ²
Cooling Load	-	-	6.64 Btu/hr ft ²	6 Btu/hr ft ²	2.82 Btu/hr ft ²	2.86 Btu/hr ft ²
Primary Energy	-	-	-	6,200 kWh/Person	5,840 kWh/Person	5,932 kWh/Person
Water Heating	9,400 kBtu/yr	meet ESv3 min	2,800 kBtu/yr	-	7,038 kBtu/yr	7,038 kBtu/yr
Lights/Appliances	19,100 kBtu/yr	meet ESv3 min	15,700 kBtu/yr	-	9,787 kBtu/yr	9,787 kBtu/yr
HERS Index	69	56	36	-	36	36
Design Notes: Thermal & Air Barrier Performance	1. Walls: R-30.8 Floor: R-30.8 Roof: R-47.8 Windows: U-0.16, SHGC-0.25 Airtightness: 0.60 ACH50 2. Walls: R-33 Floor: R-48 Roof: R-55 Windows: U-0.16, SHGC-0.25 Airtightness: 0.97 ACH50 (0.05 CFM) 3. Walls: R-33 Floor: R-36 Roof: R-47.8 Windows: U-0.16, SHGC-0.25 Airtightness: 0.60 ACH50					

Energy Analysis

	BEopt PHIUS+2015 Base for Houston	Prairie View Base Design	Notes
House Type	3 Bedroom	3 Bedroom	
House Size	2,080 SF	1,567 SF	We designed a smaller footprint home in order to meet affordability objectives. Note that this smaller footprint works against us in meeting Passive House criteria.
Wall Insulation	R-13 cavity + R-12 c.i.	R-21 cavity + R-9 c.i.	We utilized advanced framing and added a ventilated rainscreen w/ a radiant barrier.
Roof Insulation	R-49 @ ceiling	R-38 cavity + R-9 c.i.	We moved the thermal plane to the roof to bring the attic into the conditioned space.
Roof Finish	Composite Shingles, medium color	Standing Seam Metal, galvalume finish	We selected a standing seam metal roof for durability. We are holding the roof 3/4" off of the underlayment with high clips to provide a ventilation cavity and radiant barrier.
Floor Insulation	None- slab on grade	R-21 cavity + R-9 c.i.	We raised the floor on piles to address being in the 100 yr. flood plain.
Windows	15%; Double Pane, Low-E, Insul. Frame	15%, Double Pane, SHGC-0.2, U-0.15	We selected Passive House certified windows for our climate.
Window Shading	2 ft overhangs	2 ft overhangs; 8 ft porch; movable exterior horizontal louvers	We have provided fixed shading horizontal and vertical devices to completely shade all windows. The full effect of this is not accounted for in the energy models.

Energy Analysis

	BEopt PHIUS+2015 Base for Houston	Prairie View Base Design	Notes
Airtightness	0.60 ACH50	0.60 ACH50	Although PHIUS+2015 requirements are not as tight, we elected to comply with the old standard.
Ventilation	Exhaust	Balanced- ERV	We selected a Passive House certified ERV, but have isolated the kitchen exhaust.
Space Conditioning	SEER 27 Mini-Split	SEER 23 Mini-Split	A lower SEER mini-split was selected as an affordability measure.
Water Heater	80 gal Heat Pump	80 gal Heat Pump	
Hot Water Distribution	R-2, Trunk Branch	R-2, Trunk Branch	The delivery system is designed such that no more than 0.5 gallons of hot water will remain in any line (RE: REM/Rate Assumptions)
Lighting	767 kWh	604.6 kWh	80% of Fixtures are Energy Star qualified.
Appliances	Energy Star, Electric	Energy Star, Electric	
Annual Energy Cost	\$1,788.00	\$756.00	We believe the BEopt cost includes a 2kW PV system, whereas ours is prior to inclusion of a 6kW PV system that zeros out energy costs.

Financial Analysis

NAHB 2013 Average Sq. Ft. 2607 sq.ft.
 NAHB Lot Size Sq. Ft. 14359 sq.ft.
 Team sq.ft. 1567 sq.ft.
 Lot Size Sq. Ft. 2367 sq.ft.

If a cell in column H is colored 'green', justification/notes is required.

Construction Cost Breakdown	NAHB 2013 Value Share of Construction Value [1]	Per sq.ft.	Team Default Estimate for Share of Construction Value	Team Estimate Share of Construction Value	Team Estimate Per sq.ft.	Justification Required?	Justification/Notes
Site Work (sum of A to E)	\$ 16,825	\$ 6.45	\$ 10,113				
A Building Permit Fees	\$ 3,647	\$ 1.40	\$ 2,192	\$ 3,647	\$ 2.33	YES	Based on Project Sq Ft
B Impact Fee	\$ 3,312	\$ 1.27	\$ 1,991	\$ 3,312	\$ 2.11	YES	Based on Project Sq Ft
C Water & Sewer Fees Inspections	\$ 4,346	\$ 1.67	\$ 2,612	\$ 4,346	\$ 2.77	YES	Based on Project Sq Ft
D Architecture, Engineering	\$ 3,721	\$ 1.43	\$ 2,237	\$ 3,721	\$ 2.37	YES	Based on Project Sq Ft
E Other	\$ 1,799	\$ 0.69	\$ 1,081	\$ 1,799	\$ 1.15	YES	Based on Project Sq Ft
Foundations (sum of F to G)	\$ 23,401	\$ 8.98	\$ 14,066				
F Excavation, Foundation, Concrete, Retaining w	\$ 23,028	\$ 8.83	\$ 13,842	\$ 23,028	\$ 14.70	YES	Based on Project Sq Ft
G Other	\$ 373	\$ 0.14	\$ 224	\$ 373	\$ 0.24	YES	Based on Project Sq Ft
Framing (Sum of H to L)	\$ 47,036	\$ 18.04	\$ 28,272				
H Framing (including roof)	\$ 36,438	\$ 13.98	\$ 21,902	\$ 16,550	\$ 10.56	YES	Industry Partner Est. W/O Labor (Habitat for Hum.)
I Trusses (if not included above)	\$ 5,461	\$ 2.09	\$ 3,282	\$ -	\$ -	YES	Trusses Included in above (Line H)
J Sheathing (if not included above)	\$ 2,332	\$ 0.89	\$ 1,402	\$ -	\$ -	YES	Sheathing included in above (Line H)
K General Metal, Steel	\$ 1,604	\$ 0.62	\$ 964	\$ 1,604	\$ 1.02	YES	Accept NAHB Estimate for Team SqFt
L Other	\$ 1,201	\$ 0.46	\$ 722	\$ 1,201	\$ 0.77	YES	Accept NAHB Estimate for Team SqFt
Exterior Finishes (sum of M to P)	\$ 35,473	\$ 13.61	\$ 21,322				
M Exterior Wall Finish	\$ 16,867	\$ 6.47	\$ 10,138	\$ 6,600	\$ 4.21	YES	Industry Partner Est. W/O Labor
N Roofing	\$ 7,932	\$ 3.04	\$ 4,768	\$ 7,932	\$ 5.06	YES	Accept NAHB Estimate for Team SqFt
O Windows and Doors (including garage door)	\$ 10,117	\$ 3.88	\$ 6,081	\$ 15,000	\$ 9.57	YES	High-performance windows
P Other	\$ 557	\$ 0.21	\$ 335	\$ 557	\$ 0.36	YES	Accept NAHB Estimate for Team SqFt
Major Systems Rough-ins (sum of Q to T)	\$ 32,959	\$ 12.64	\$ 19,811				
Q Plumbing (except fixtures)	\$ 11,823	\$ 4.54	\$ 7,106	\$ 9,700	\$ 6.19	YES	Industry Partner Est.
R Electrical (except fixtures)	\$ 9,967	\$ 3.82	\$ 5,991	\$ 5,200	\$ 3.32	YES	Industry Partner Est.
S HVAC	\$ 10,980	\$ 4.21	\$ 6,600	\$ 5,100	\$ 3.25	YES	Industry Partner Est.
T Other	\$ 189	\$ 0.07	\$ 114	\$ 189	\$ 0.12	YES	Based on Project Sq Ft
Interior Finishes (sum of U to AE)	\$ 72,241	\$ 27.71	\$ 43,422				
U Insulation	\$ 4,786	\$ 1.84	\$ 2,877	\$ 15,400	\$ 9.83	YES	Industry Partner Est. Based on Passive House Ins. Rq
V Drywall	\$ 9,376	\$ 3.60	\$ 5,636	\$ 1,900	\$ 1.21	YES	Industry Partner Est. W/O Labor
W Interior Trims, Doors, and Mirrors	\$ 10,536	\$ 4.04	\$ 6,333	\$ 1,300	\$ 0.83	YES	Industry Partner Est. W/O Labor
X Painting	\$ 8,355	\$ 3.20	\$ 5,022	\$ 1,800	\$ 1.15	YES	Industry Partner Est. W/O Labor
Y Lighting	\$ 3,008	\$ 1.15	\$ 1,808	\$ 3,008	\$ 1.92	YES	Based on Project Sq Ft
Z Cabinets, Countertops	\$ 12,785	\$ 4.90	\$ 7,685	\$ 2,500	\$ 1.60	YES	Industry Partner Est. W/O Labor
AA Appliances	\$ 4,189	\$ 1.61	\$ 2,518	\$ 1,850	\$ 1.18	YES	Industry Partner Est. W/O Labor (W/O Wash/Dry)
AB Flooring	\$ 12,378	\$ 4.75	\$ 7,440	\$ 3,000	\$ 1.91	YES	Industry Partner Est. Vinyl Plank
AC Plumbing Fixtures	\$ 4,265	\$ 1.64	\$ 2,564	\$ 4,265	\$ 2.72	YES	Based on Project Sq Ft
AD Fireplace	\$ 2,057	\$ 0.79	\$ 1,236	\$ -	\$ -	YES	Doesnt Exist

Financial Analysis

AE Other	\$ 506	\$ 0.19	\$ 304	\$ 506	\$ 0.32	YES	Based on Project Sq Ft
Final Steps (sum of AF to AJ)	\$ 16,254	\$ 6.23	\$ 9,770				
AF Landscaping	\$ 5,744	\$ 2.20	\$ 3,453	\$ 5,725	\$ 3.65	YES	Industry Partner Est. W/O Labor
AG Outdoor structures (deck, patio, porches)	\$ 2,891	\$ 1.11	\$ 1,738	\$ 2,891	\$ 1.84	YES	Based on Project Sq Ft
AH Driveway	\$ 3,741	\$ 1.43	\$ 2,249	\$ 3,741	\$ 2.39	YES	Based on Project Sq Ft
AI Clean up	\$ 2,261	\$ 0.87	\$ 1,359	\$ 1,350	\$ 0.86	YES	Industry Partner Est. Reduced Interior Cleaning (Vol)
AJ Other	\$ 1,617	\$ 0.62	\$ 972	\$ 1,617	\$ 1.03	YES	Based on Project Sq Ft
Other	\$ 2,265	\$ 0.87	\$ 1,361				
Total	\$ 246,454	\$ 94.54	\$ 148,137	\$ 160,712			

NAHB Sales Price Breakdown	2013 Value [2]	Team Default Estimate	Team Adjusted Estimate		Justification/Notes (Required for Values different than Default Value)
Finished Lot Cost (including financing costs):	\$ 74,509	\$ 44,786	\$ 1	YES	LARA / Houston Hope Land Bank Program
Financing Costs	\$ 5,479	\$ 3,293	\$ -	YES	LARA / Houston Hope Land Bank Program
Overhead and General Expenses	\$ 17,340	\$ 10,423	\$ -	YES	LARA / Houston Hope Land Bank Program
Marketing Cost	\$ 4,260	\$ 2,561	\$ -	YES	LARA / Houston Hope Land Bank Program
Sales Commission	\$ 14,235	\$ 8,556	\$ -	YES	LARA / Houston Hope Land Bank Program
Profit	\$ 37,255	\$ 22,393	\$ -	YES	LARA / Houston Hope Land Bank Program
Total Sales Price	\$ 399,532	\$ 240,148	\$ 160,713		

Financial Analysis

Home Cost	Default Estimate	Value	Justification/Notes
Construction Costs		\$ 160,712	
Total Home Costs		\$ 160,713	

Property Tax			
Property Tax Rate		1.15%	2.60% Houston Property Taxes
Annual Property Tax	\$	3,986	\$ 4,179

Financing			
Annual Interest Rate		4.50%	4.5%
Years			30 years
Payments per Year			12
Number of Payments			360
Down payment	\$	69,316	\$ 32,143 20% of Total Home Cost
Principle Amount			\$ 128,570
Monthly Payment			\$ (651)

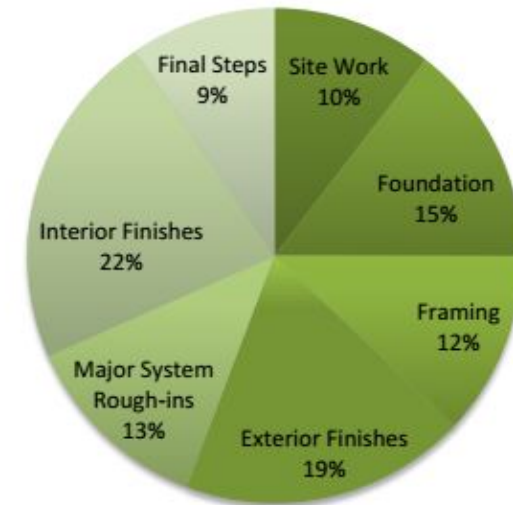
Affordability			
Annual Median Family Income (MFI)	\$	52,250	\$ 51,704 US - TX Average

Monthly Utility Costs			
Electricity	\$	111	\$ - US Average
Natural Gas	\$	31	\$ -
Water	\$	18	\$ 39 Houston, Family of Four
Other			\$ - None
Total	\$	39	

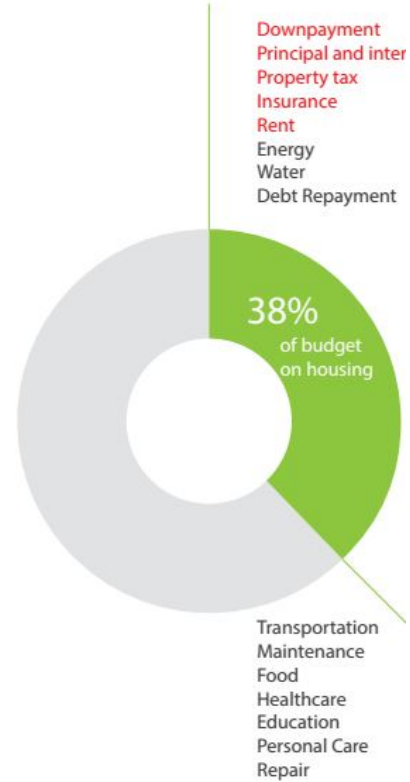
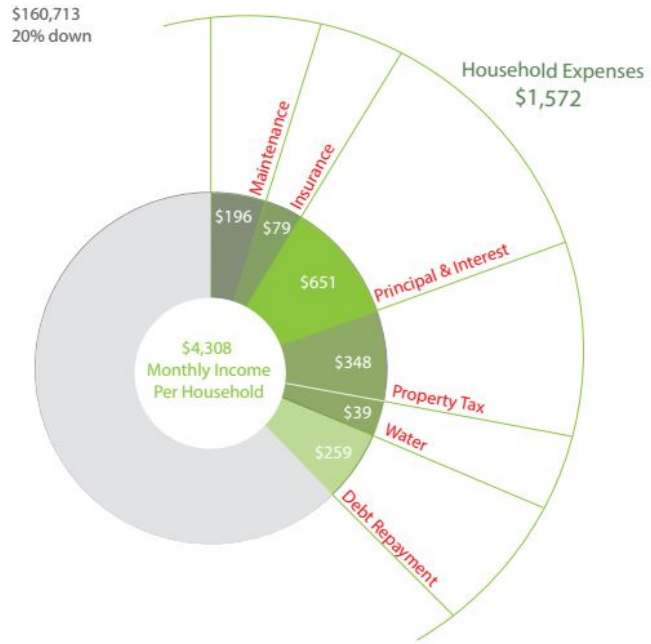
Debt to Income Ratio			
Monthly Household Debt (0.5% MFI)	\$	261	\$ 259
Operations and Maintenance Costs	\$	196	\$ 196
Monthly Utility Costs	\$	160	\$ 39
Property Tax	\$	332	\$ 348
Insurance	\$	79	\$ 79
Mortgage Payment	\$	1,405	\$ 651

Calculated Debt to Income Ratio 37% Homeownership Affordability Target is 38%

Construction Analysis



Financial Analysis



HOUSTON AMI	\$63,900
TEXAS AMI 80% of HOUSTON AMI	\$51,704
60% AMI	
50% AMI	
AMI INDEPEPNDENCE HEIGHTS	\$22,848
38% of TEXAS AMI per month	\$1,637
37% of TEXAS AMI per month	\$1,572

Thank You



Industry Partners

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