Passive House Object Documentation
1031 Crest Ave Passive House – ID 4490

Single family residence in Pacific Grove, California

Project designer	Lizzie Adams[1]	
	PAE Engineers	pae-engineers.com

1031 Pacific Grove is a custom home built for a private client in Pacific Grove, California. The building is a renovation and significant addition to an existing. The building is two levels with wood-frame and raised floor construction.

Special features	Solar photovoltaic array Phase-change material within selected wall cavities		
U-Value exterior wall	0.33 W/(m²K)	PHPP annual heat demand	**15 kWh/(m²a)**
U-Value raised floor	0.13 W/(m²K)		
U-Value roof	0.16 W/(m²K)	PHPP primary energy demand	**98 kWh/(m²a)**
U-Value windows	1.3 W/(m²K)		
Heat recovery efficiency	73%	Pressure test n_{50}	0.59/h

[1] The project was completed while Lizzie Adams worked at Beyond Efficiency, beyondefficiency.us

2 Construction task

Designed and built by Carmel Building and Design, the two-story wood-frame building has three bedrooms, including an upstairs master bedroom. The garage is outside of the thermal envelope.

The building is oriented along the east-west axis with the main entry to the north and a backyard to the south. This site layout supported minimal windows on the east and west, blocking views into neighbor properties and controlled solar gain from the southern windows.

There was some shading from nearby buildings and tress, although this is minimal as the neighborhood predominantly detached houses less than two stories.

Assemblies include:

- 2x6 (new) and 2x4 (existing) wood stud walls filled with low-density foam
- 9 ½" wood joist (new) and 2x6 wood stud (existing) floors filled with low-density foam
- 9 ½" wood joist (typical) roof filled with low-density foam

3 Exterior photos

Figure 1 Front (north) elevation

Figure 2 East elevation from the north (left) and the south (right)

Figure 3 Clockwise from top left: West elevation during construction; West half of south elevation; East half of south elevation

4 Interior photos

Figure 4 Living area and kitchen

Figure 5 Kitchen (left) and master bathroom (right)

5 Cross section

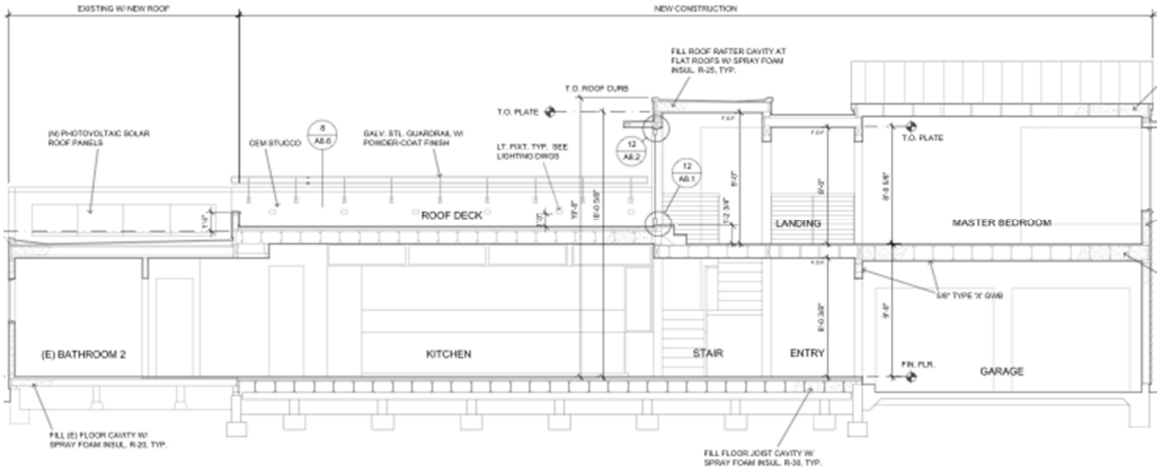


Figure 6 Cross Section

6 Floor plan

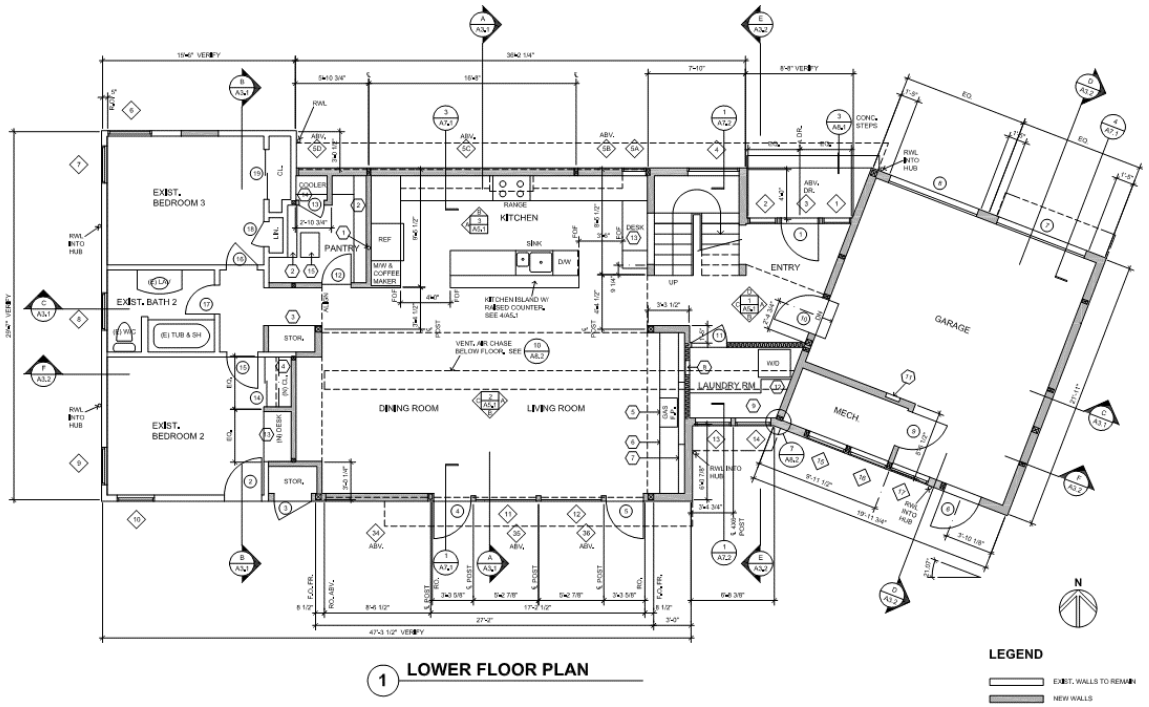


Figure 7 Lower Floor Plan

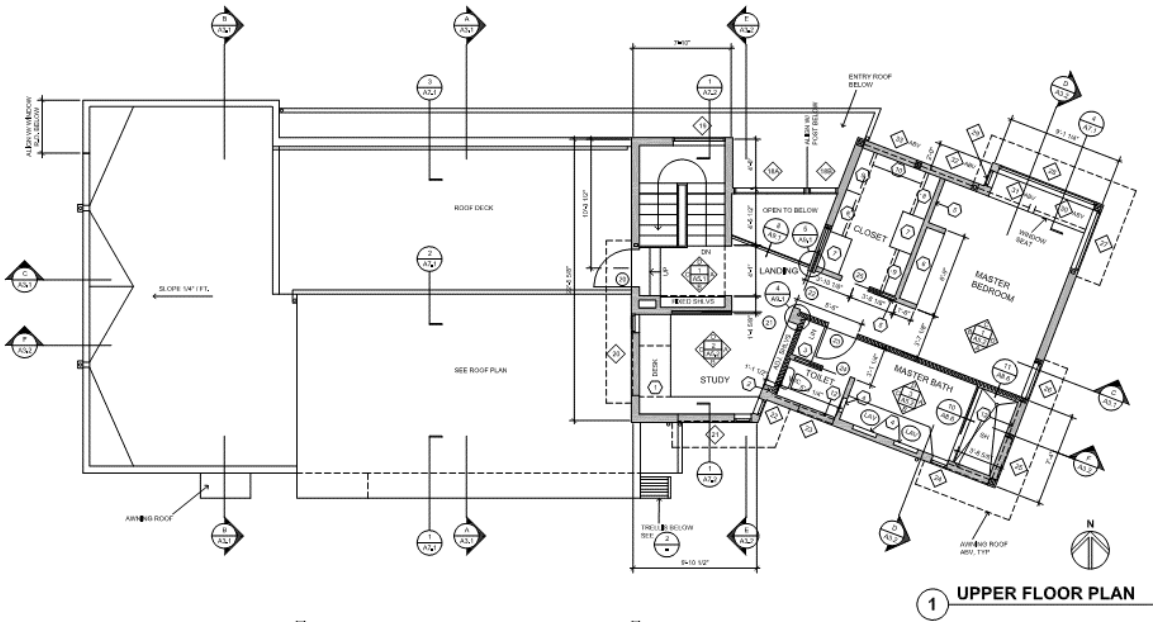


Figure 8 Upper Floor Plan

7 Construction details

The building construction is wood framing, with low-density spray foam insulation throughout. The bedrooms and bathroom on the west side of the house have existing framing that was retained. Typical assemblies are:

- Floor: 9 ½" joists at 16" OC with low-density spray foam
- Wall: 2x6 wood studs at 16"OC with low-density spray foam
- Roof: 2x10 wood rafters at 24" OC with low-density spray foam
- Flat roof deck: 9 ½" joists at 16" OC with low-density spray foam

The images below provide additional detail of these assemblies.

a. Floor

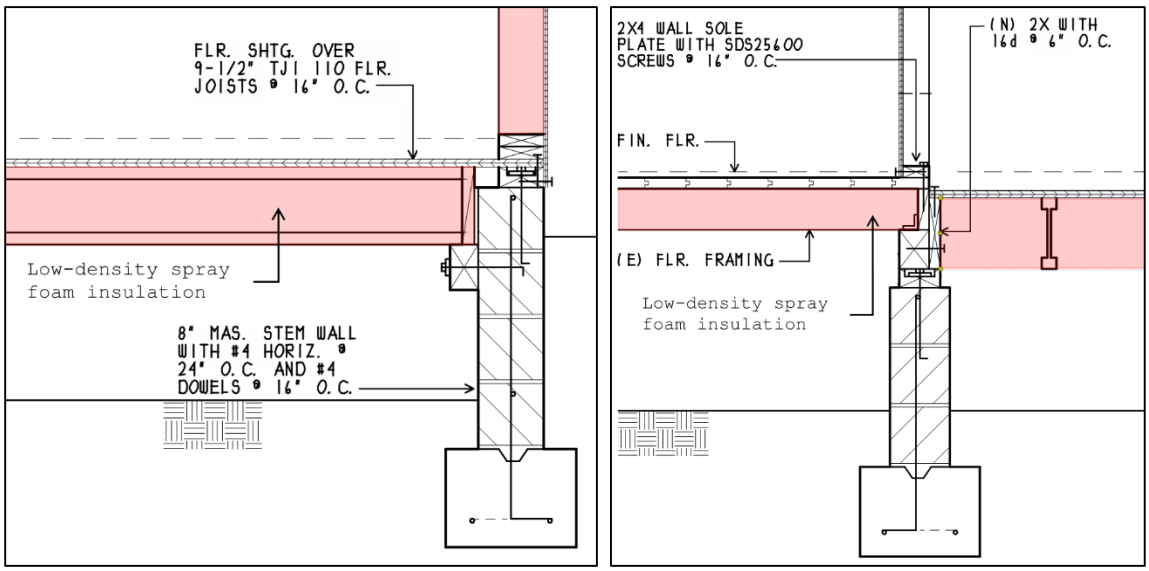


Figure 9 Floor details of new raised floor (left) and intersection between the existing and new floors (right)

b. Walls

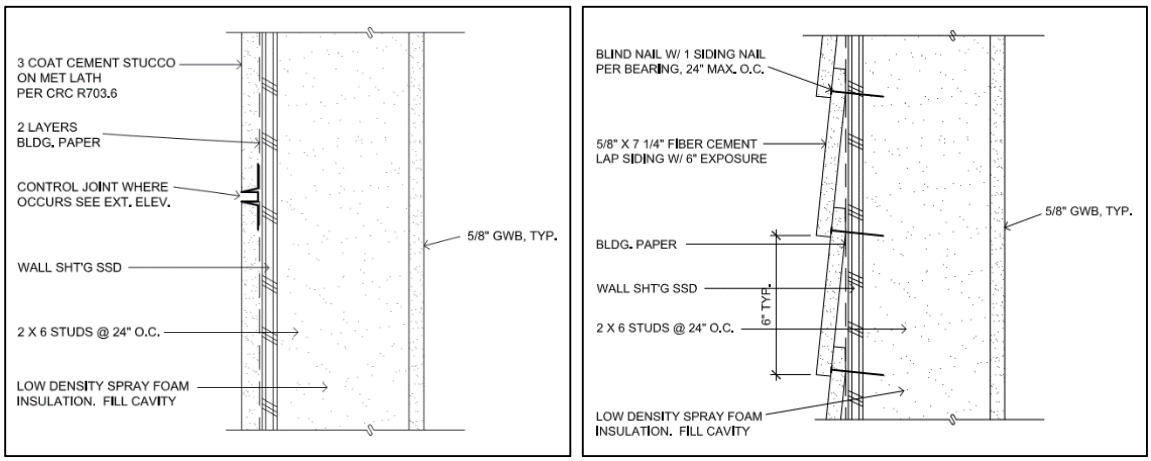


Figure 10 Wall details with stucco (left) and fiber cement siding (right)

c. Roof

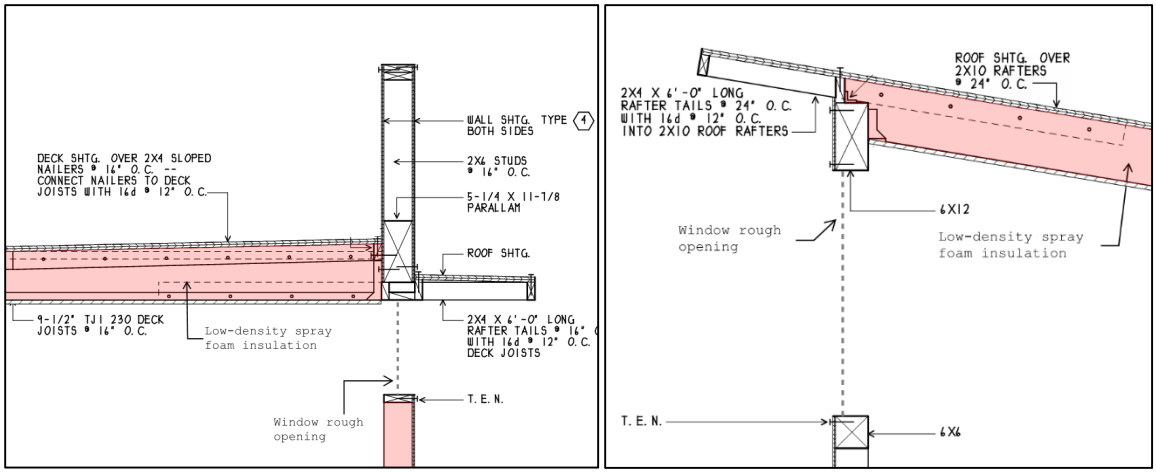


Figure 11 Roof details, below roof deck (left) and at sloped roof (right)

d. Windows

The windows are double-pane Alpen 725 fiberglass-frame casement or fixed with either high-gain or low-gain glazing depending on their location. The high gain glazing has a center of glass SHGC of 0.53 and the low gain glazing has a center of glass SHGC of 0.32. Higher gain glazing was used in specific south-facing locations where additional solar gain was preferred. Window U-values include:

- Fixed Frame U-Value (U_f): 0.262 BTU/(hr·ft²·°F)
- Casement/Awning U-value (U_f): 0.250 BTU/(hr·ft²·°F)
- Glazing U-Value (U_g): 0.13 BTU/(hr·ft²·°F) low gain or 0.14 BTU/(hr·ft²·°F) high gain
- Assembly U-value: 0.16 – 0.17 BTU/(hr·ft²·°F)

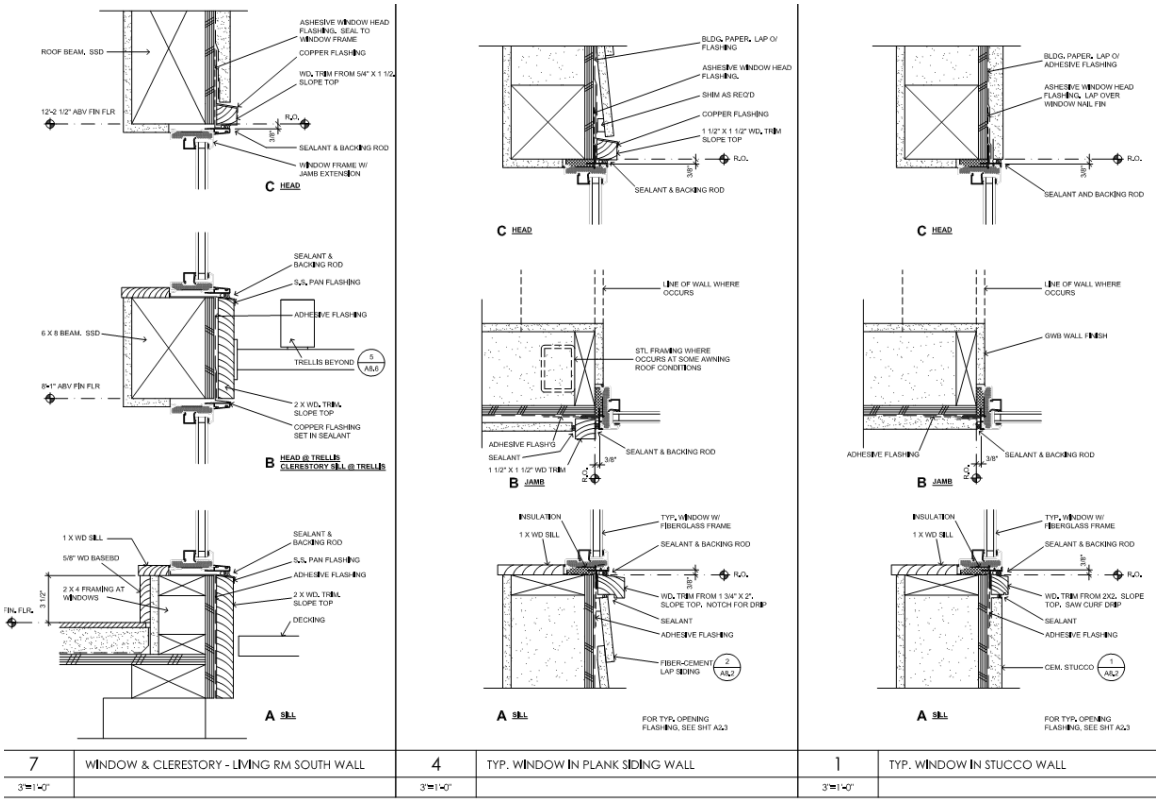


Figure 12 Window installation details for clerestory windows (left), windows in plank siding wall (middle), and windows in stucco wall (right)

e. Air-tightness

The air barrier was the exterior sheathing, which was taped at seams and penetrations. The images below show some of the typical air sealing conditions, including one of the existing floor, which was less than 1/3 of the total floor area.

The final air tightness result was 0.57 ACH_{50}, as shown in the blower door test results below.

Figure 13 Air sealing details for a typical exterior wall (top left), a window (top right), an exposed floor (lower left) and the existing floor with crawlspace (lower right).

Date of Test: 4/23/2014		Technician:	Steven Jungerberg
Test File: Warner PHI 4-23-2014-5		Project Number:	2014-01
Customer:	Bruce & Laurie Warner 1031 Crest Avenue Pacific Grove, CA 93950 Phone: Fax:	Building Address:	Warner Residence 1031 Crest Avenue Pacific Grove, CA 93950

	Depressurization	Pressurization	Average
Test Results at 50 Pascals:			
V50: cfm Airflow	169 (+/- 3.1 %)	179 (+/- 3.0 %)	174
n50: 1/h Air Change Rate	0.56	0.59	0.57
w50: cfm/ft² Floor Area	0.0919	0.0972	0.0945
q50: cfm/ft² Envelope Area	0.0300	0.0317	0.0309
Leakage Areas:			
Canadian EqLA @ 10 Pa (in²)	15.7 (+/- 20.8 %)	18.3 (+/- 22.4 %)	17.0
in²/ft² Surface Area	0.0028	0.0032	0.0030
LBL ELA @ 4 Pa (in²)	7.8 (+/- 31.4 %)	9.7 (+/- 34.2 %)	8.8
in²/ft² Surface Area	0.0014	0.0017	0.0016
Building Leakage Curve:			
Air Flow Coefficient (Cenv) (cfm/Pa^n)	10.2 (+/- 47.5 %)	13.8 (+/- 52.1 %)	
Air Leakage Coefficient (CL) (cfm/Pa^n)	10.2 (+/- 47.5 %)	13.8 (+/- 52.1 %)	
Exponent (n)	0.718 (+/- 0.116)	0.655 (+/- 0.129)	
Correlation Coefficient	0.99024	0.98553	

Test Standard:	EN 13829
Test Mode:	Depressurization and Pressurization
Type of Test Method:	A
Regulation complied with:	Passive House

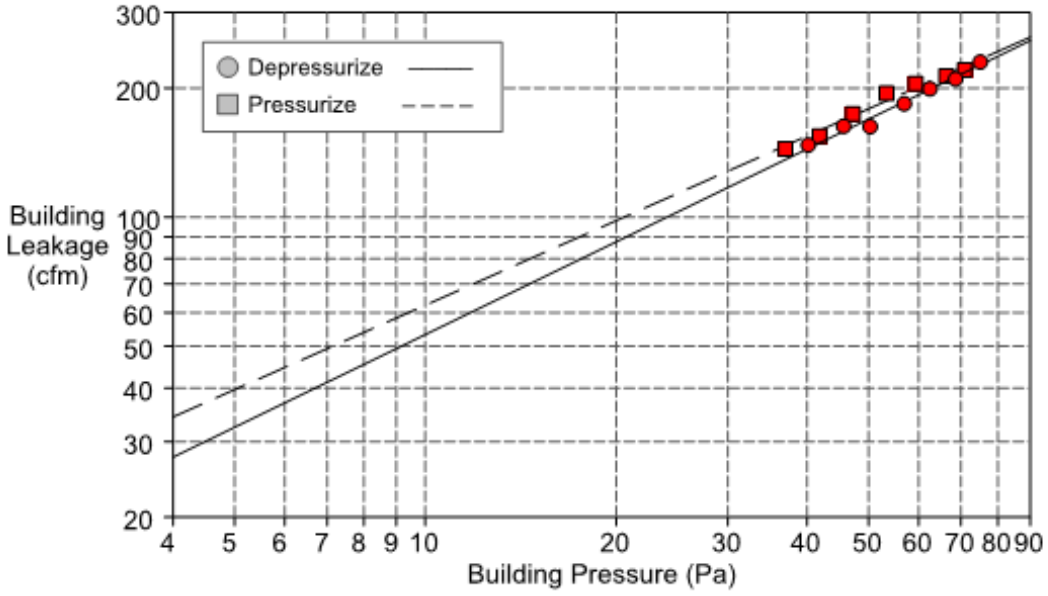


Figure 14 Blower door test results showing 0.57 ACH_{50} air tightness.

f. Ventilation

Filtered outside air is distributed to all living spaces and bedroom and extracted from all bathrooms. Heat is recovered from the extracted air using a Zehnder Comforair 350 which has an effective heat recovery efficiency of 73.7% and an electric efficiency of 0.49W/cfm. The heat is transferred to the incoming outside air, so that the air supplied to the living spaces is tempered. During summer when untempered outside air is preferable, the system automatically bypasses the heat exchanger and provides untempered air to living spaces.

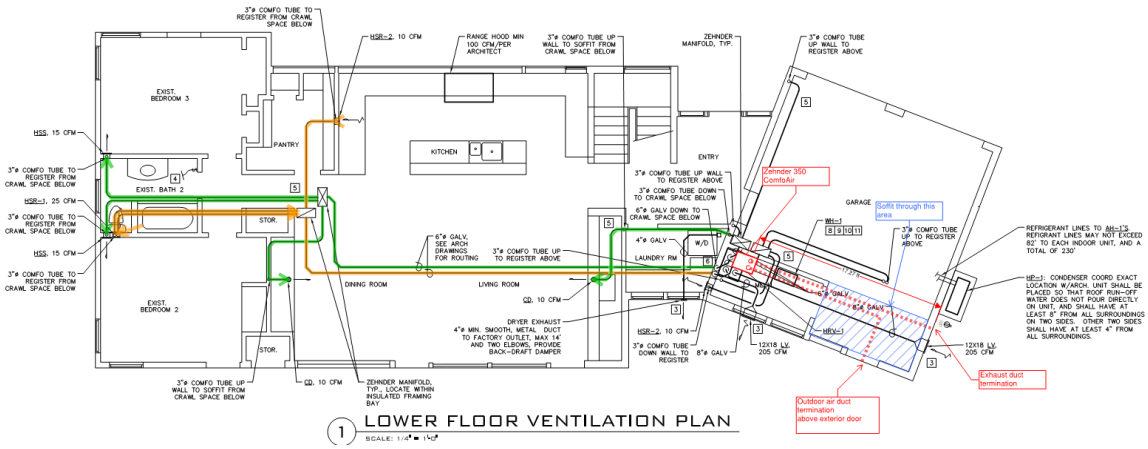
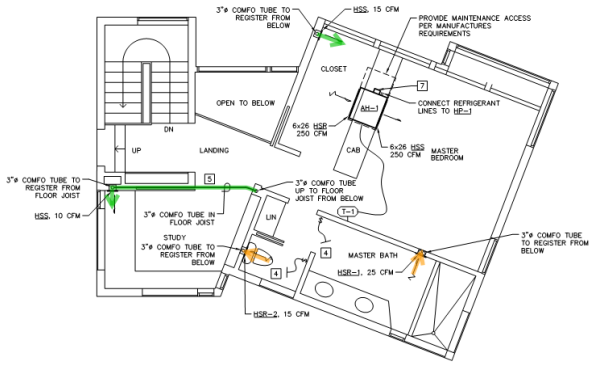


Figure 15 Lower level ventilation plan, supply air highlighted in green, extract air highlighted in orange.



2 UPPER FLOOR VENTILATION AND HEATING PLAN
SCALE: 1/4" = 1'-0"

Figure 16 Upper level ventilation plan, supply air highlighted in green, extract air highlighted in orange.

Figure 17 Marked images of the heat recovery ventilation system, Zehnder ComfoAir 350 (top left), duct work from HRV into drop ceiling in garage (top right), location of ducts in drop ceiling (lower left) and outside termination/supply points (lower right).

g. Heating and Cooling

There are two separate heating systems in the building:

- The lower floor is heated by a natural gas fireplace located in the open plan living room
- The upper floor is heated by a concealed mini-split heat pump located in the master bedroom

The fireplace is shown in Figure 4 in the interior photo of the living room. It is a sealed, natural gas, fan powered, high efficiency fireplace and is designed to heat all downstairs areas, as well as partially heating the upstairs study which is partially open to below.

The mini-split heat pump is installed between the master bedroom and the closet and is concealed in custom cabinetry. It provides heating and cooling (as needed) to this space. The heating COP is calculated to be 3.08 in the Pacific Grove climate. This mini-split is able to provide cooling, although based on modeling results and the Pacific Grove climate, this is not expected to be used.

8 PHPP results

Passive House verification

Building:	1031 Crest Avenue		
Street Address:	1031 Crest Avenue		
City, State, Zip:	Pacific Grove, CA		
Country:	US		
Building type:	Single - Family		
Climate:	CA, San Francisco	Altitude of building site (feet above sea level):	75
Home owner / Client:	Bruce & Laurie Warner		
Street Address:	4204 Casterson Court		
City, State, Zip:	Pleasanton, CA 94566		
Architecture:	William E. Foster Architecture		
Street Address:	716 Lighthouse Ave, Ste F		
City, State, Zip:	Pacific Grove, CA 93950		
Mechanical system:	Monterey Energy Group		
Street Address:	227 Forset Avenue, Suite 5		
City, State, Zip:	Pacific Grove, CA 93950		

Year of construction:	2012		Interior temperature winter:	68.0	°F	Enclosed volume V_e ft³:	22918
No. of dwelling units:	1		Interior temperature summer:	77.0	°F	Mechanical cooling:	
No. of occupants:	4.8		Internal heat sources winter:	0.67	BTU/h.ft²		
Spec. capacity:	23	BTU/F per ft² TFA	Ditto summer:	1.12	BTU/h.ft²		

Specific building demands with reference to the treated floor area

					Requirements	Fulfilled?*
	Treated floor area	1816	ft²			
Space heating	Heating demand	**4.71**	**kBTU/(ft²yr)**	99% of	4.75 kBTU/(ft²yr)	yes
	Heating load	**4.32**	**BTU/(hr.ft²)**	136% of	3.17 BTU/(hr.ft²)	-
Space cooling	Overall specif. space cooling demand		**kBTU/(ft²yr)**		-	-
	Cooling load		**BTU/(hr.ft²)**		-	-
	Frequency of overheating (> 77 °F)	7.7	%		-	-
Primary energy	Heating, cooling, auxiliary electricity, dehumidification, DHW, lighting, electrical appliances	**31.2**	**kBTU/(ft²yr)**	82% of	38.0 kBTU/(ft²yr)	yes
	DHW, space heating and auxiliary electricity	21.5	kBTU/(ft²yr)		-	-
	Specific primary energy reduction through solar electricity		kBTU/(ft²yr)		-	-
Airtightness	Pressurization test result n_{50}	**0.6**	**1/h**		0.6 1/h	yes

* empty field: data missing; '-': no requirement

Passive House?	yes

9 Construction costs

Information not available

10 Operational costs

Information not available

11 Architect

The home was designed by:
William E. Foster Architecture
716 Lighthouse Ave, Ste F
Pacific Grove, CA 93950

The home was built by:
Carmel Building and Design
26350 Carmel Rancho Lane, Suite 105
Carmel, CA 93923

12 Building Services Engineer

The mechanical services were designed by:
Monterey Energy Group
227 Forest Avenue, Suite 5
Pacific Grove, CA 93950

The lighting was designed by:
Sanford Lighting Design
2231 South Court
Palo Alto, CA 94301

13 Structural Engineer

The structural engineering was completed by:
Jeff M Stiles
317 Grand Ave
Pacific Grove, CA 93950

14 Experiences and Operation

The occupants have remarked that the house is very quiet and comfortable. The building has operated well, aside from some minor commissioning items. The Passive House consultants, Katy Hollbacher and Lizzie Adams, were afforded the opportunity to stay the night in the home and similarly found the building a delightful and comfortable space.

15 Other studies/publications

The home was part of the building tour for Passive House California's 2013 conference – Building Carbon Zero Monterey Bay.

The building was also featured in the Monterey Herald on October 23rd, 2014 in an article titled *Passive house design: Pacific Grove home goes far beyond typical notion of energy-efficiency*.