Passive House Documentation

Single Family House, Masonville, Colorado, USA

Certified Passive House
Passive House Institute

Andrew Michler, Project Designer, MARTaK Passive House www.baosol.com/martak

MARTaK Rest/Work Space is a vision of how sustainable building can resolve current needs without compromising the needs of the future generations. Built foam free and off-grid in a Ponderosa Pine mountain forest the project uses solar energy for electricity and primarily for heat (with a small back up hydronic system) to maintain comfort. Completed 2015.

Exterior wall Rvalue 73.3 to 115.2

Floor Rvalue 61.3

Roof Rvalue 96.0

window U-value 0.14 Btu/h·ft²

PHPP annual heating 3.12 kBTU/ft2/yr

PHPP primary energy demand 27.9 kBTU/ft2/yr

Airtightness 0.5 ACH @50P

Heat recovery 75%

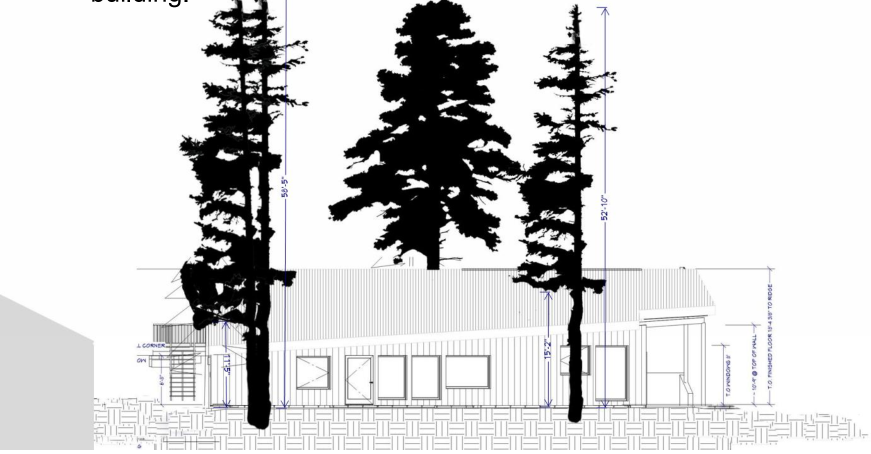
baosol llc

2 Project Narrative

Imagine a self supporting building that can last for many generations but when the metal roof and triple pane windows are removed the structure will decompose back into the environment, providing resources for a perhaps a future garden. The approach uses the Cradle to Cradle model by carefully selecting materials that are either fully recyclable or completely organic.

Natural materiality takes a prominent role. Only naturally regenerative materials or fully recyclable products is used, and using Cradle to Cradle methodology materials it will be easy to separate at the end of their use cycle. Most of the materials will have the capacity to be reabsorbed into the mountain environment when the building reaches its lifespan. No foams or other petroleum based products are used below grade besides drain pipes. In fact we don’t have to use foam anywhere. Remaining materials can be reabsorbed into current industrial technical cycles. The project reuses most of the material from an existing shop, including a tire wall foundation.

The 1275 square foot building holds a guest room, bath, sleeping loft, office which can be easily reconfigured for multiple uses in the future and is age-in-place optimized. The unique wedge shape is informed and inspired by the local hogback mountains in the area. The angled face of the building also increases solar gain improving performance while reducing materials and cost. The advanced triple pane windows are solar gain optimized, providing excellent passive energy and low energy loss with a tilt and turn operation that encourages natural ventilation and cooling. A 1500 gallon rainwater catchment tank fed from the roof supplies non potable water needs including the toilet and gardens. Firewise construction adds to the fortification of the building.



Interior

Interior great room utilizes open floor plan inspired by small Japanese home design. Parametric walls compress and release spaces. View is to the south and east. Gypsum board wall and ceiling, tile and plywood floor.

3 Building Elevations

North

North side of building's large mass is broken by steel (hard) and cedar (soft). Two storage bays open directly to the drive way. Mechanical room is also accessible.

East side is inspired by local hogback mountain formations and is the outdoor living space protected from prevailing winds. Egress for wheeled transport is accessed from back side. Upper window provide cross ventilation. An over sized built-in seat for relaxing.

East

3 Building Elevations

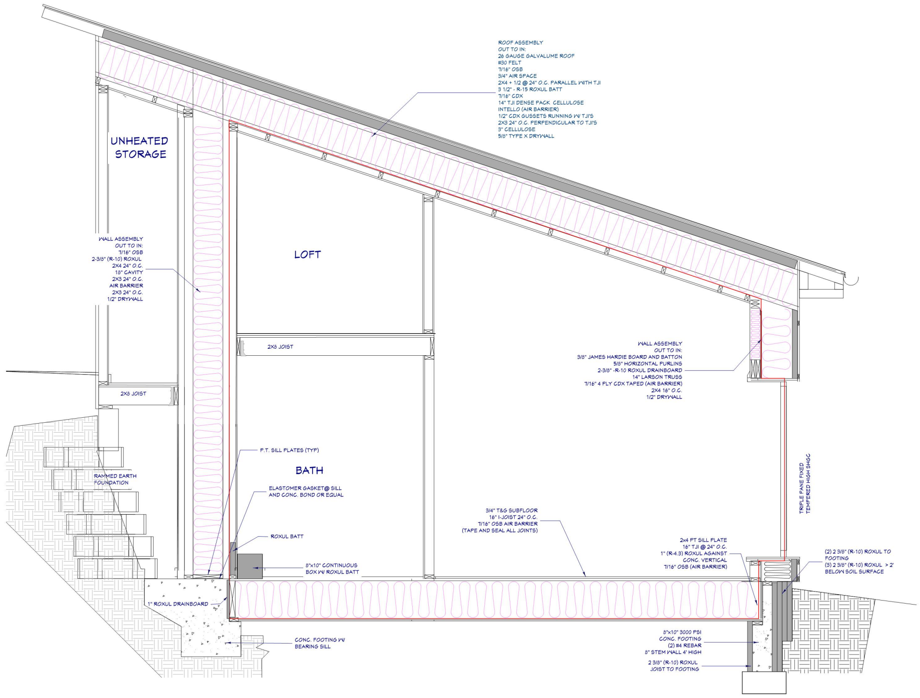
South

The building's wedge front aligns the southern wall to solar south. The footprint also keeps three mature pine trees intact next to building, two which are incorporated as shade control.

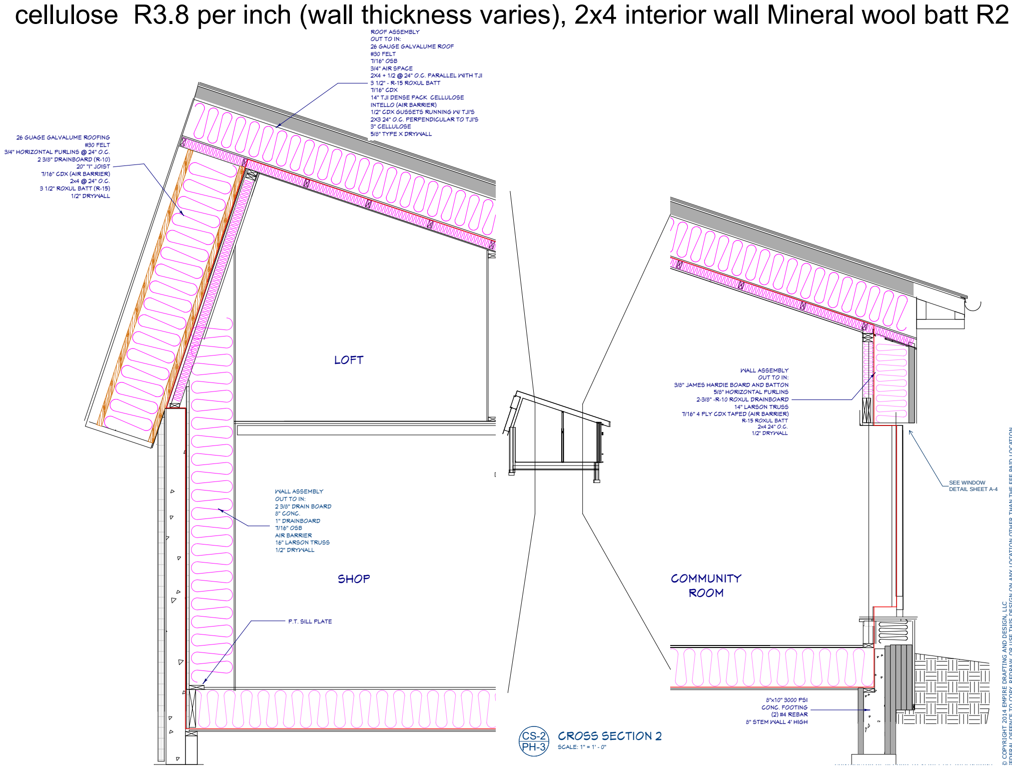
West wall with deck over 1500 gallon rain water cistern.

West

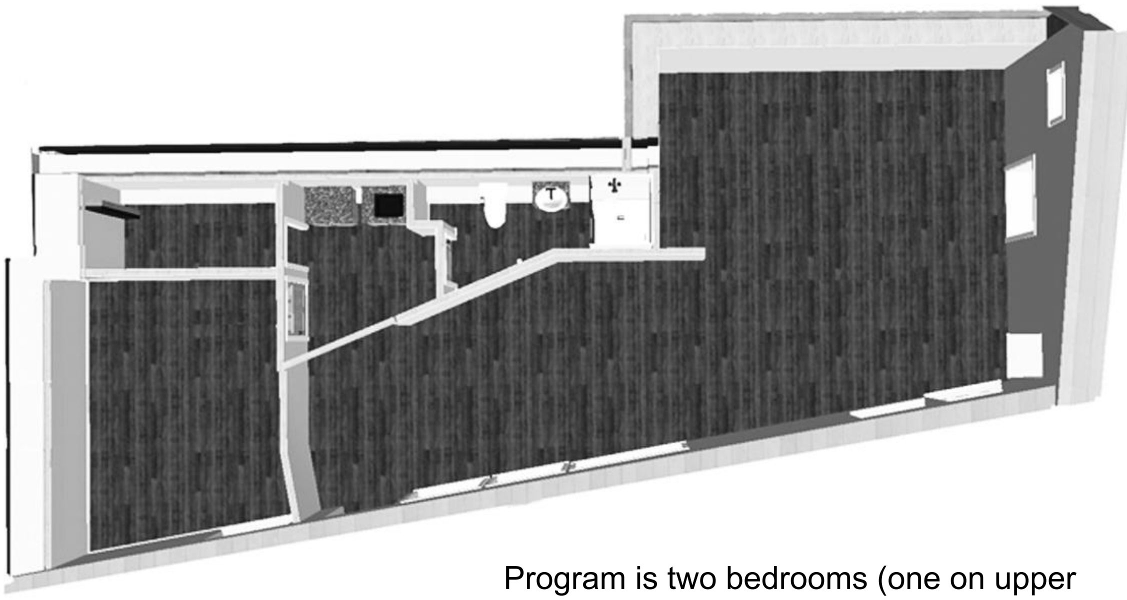
5 Section



The building structure is composed of dimensional lumber (2x4) for the walls. Sheathing is 1/2inch plywood, taped as air barrier. Larson trusses are attached to the exterior of the sheathing , then 2.3/8" Roxul Drainboard.
The roof assembly is 14" I-joists, sheathing, built up with 2x4 then roof sheathing. An air tight membrane is applied to the underside, then a service cavity.
Floor assembly is 16" I-joist over crawl space. The air barrier is OSB attached to the underside.
The north-west retaining wall is a reclaimed tire wall from a previous building. A service cavity and storage is between the thermal envelope and exterior wall.
The north-east retaining wall is concrete insulated from the interior.
The assemblies allows any vapor driven moisture in the envelope to escape to ether the interior or exterior.
R-value of wall assembly from outside in: 2.3/8" Drainboard R10, Larson truss wall cavity Dens-pack cellulose R3.8 per inch (wall thickness varies), 2x4 interior wall Mineral wool batt R21

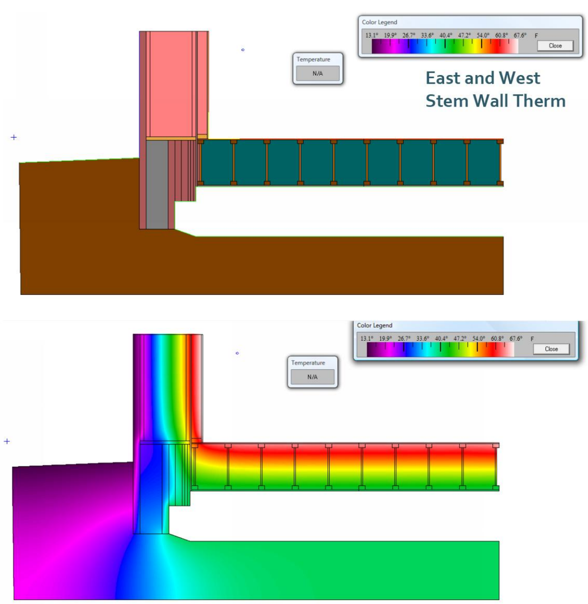


6 Floor Plan

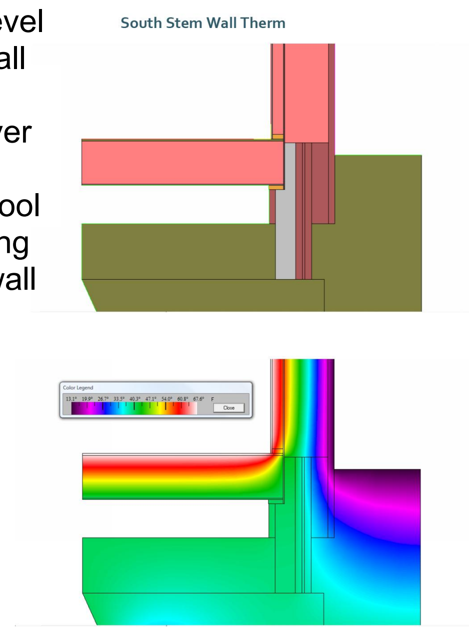


Program is two bedrooms (one on upper loft), great room, work area, bath, kitchen, walk in closet. The angled south wall in relationship with shed roof provides unique spacial arrangements. The program is elongated so the footprint will rest between existing trees. The trees also act as a exterior shade by their proximity and height.

7 Envelope Details



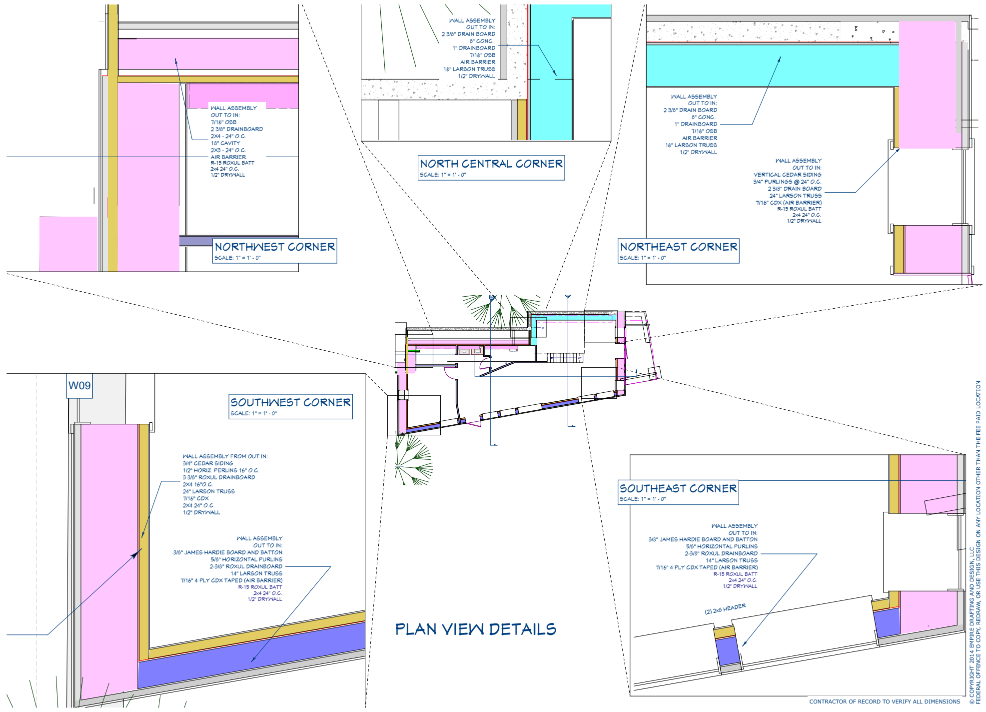
To bring exterior ground level to floor a concrete stem wall extends into the thermal envelope. The wall was over insulated from the exterior with Drainboard mineral wool to eliminate thermal bridging along the interior floor to wall connections.

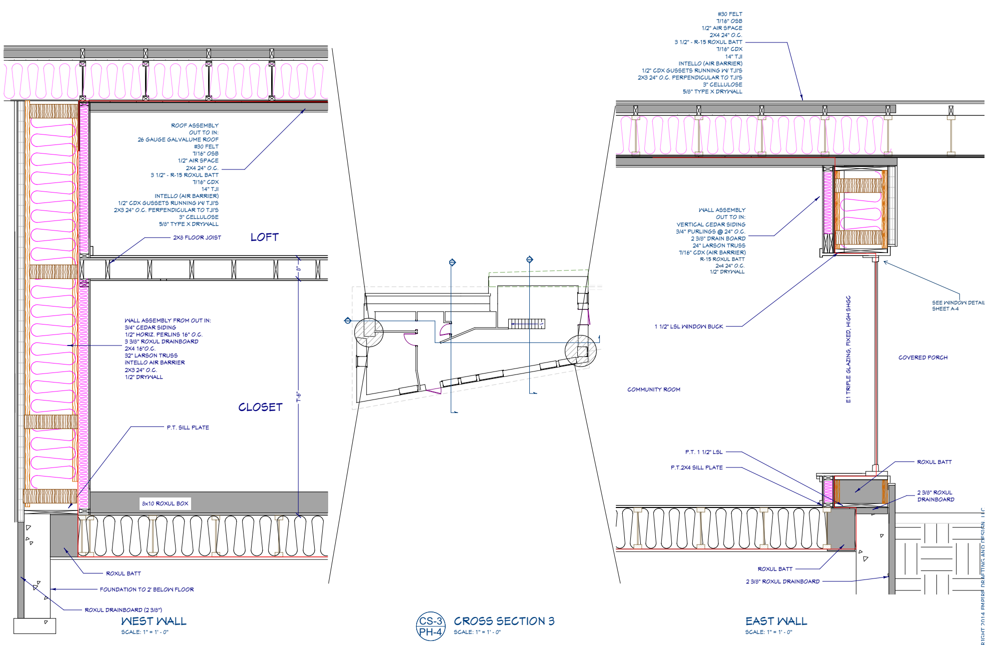


7.1-3 Envelope Details

The walls are thinner to the south where the majority of the glazing is. A continuous thermal envelope is achieved by keeping the structural layer to the interior with an out-board insulation cavity.

The out board insulation layer comprised of dense pack cellulose is protected from wind wash by the encapsulating mineral wool board. The mineral wool board, combined with cement siding provides a Class A fire assembly.





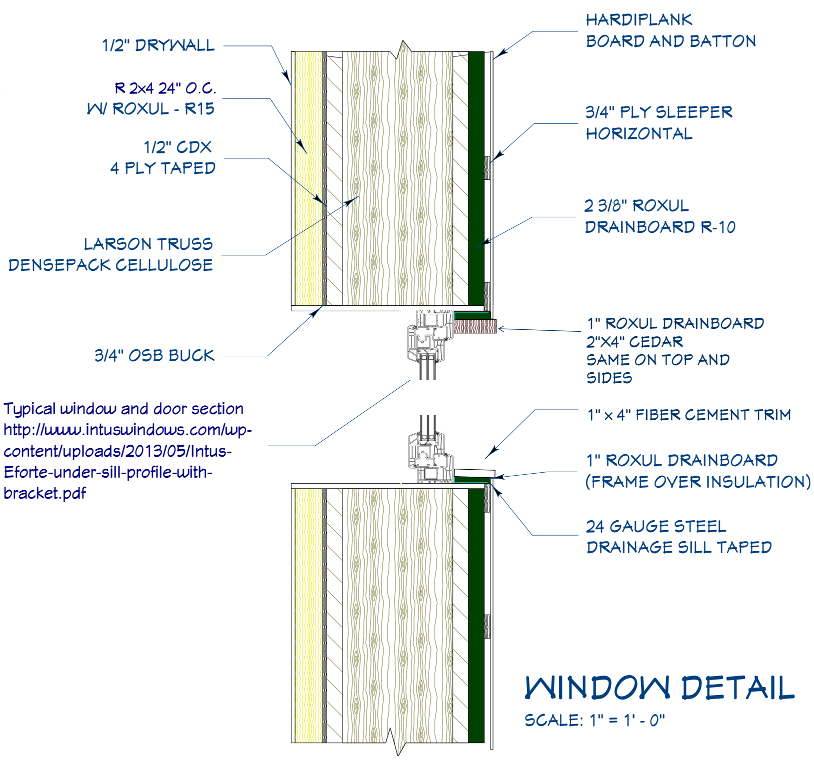
The majority of the thermal envelop utilizes I-Joists for the roof and floor and Larson Trusses for the walls. The walls were broken to 7 ft lifts 24" wide and denspacked with cellulose to 3.8 lbs cubic foot. Structural wall interiors were insulated with Mineral wool batt.

Floors were denspacked from the interior to 3.0 lbs cubic foot, and the roof was denspacked through the membrane to the same density. A plywood deck and 2x4 lift provided additional capacity to insulate with mineral wool batt. The OSB roof sheathing and metal roof is back ventilated.

R-Value of roof assembly from top to bottom: 2x4 mineral wool batt R21, 14" I-joist dense pack cellulose R53.2, 3" service cavity R11.4

R-Value floor: 16 I-joists dense pack cellulose R60.8

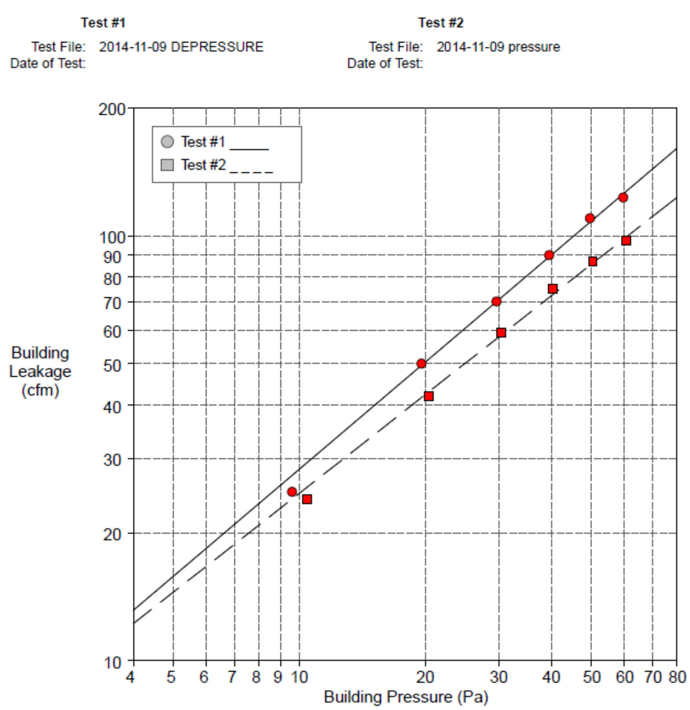
7.4 Window details



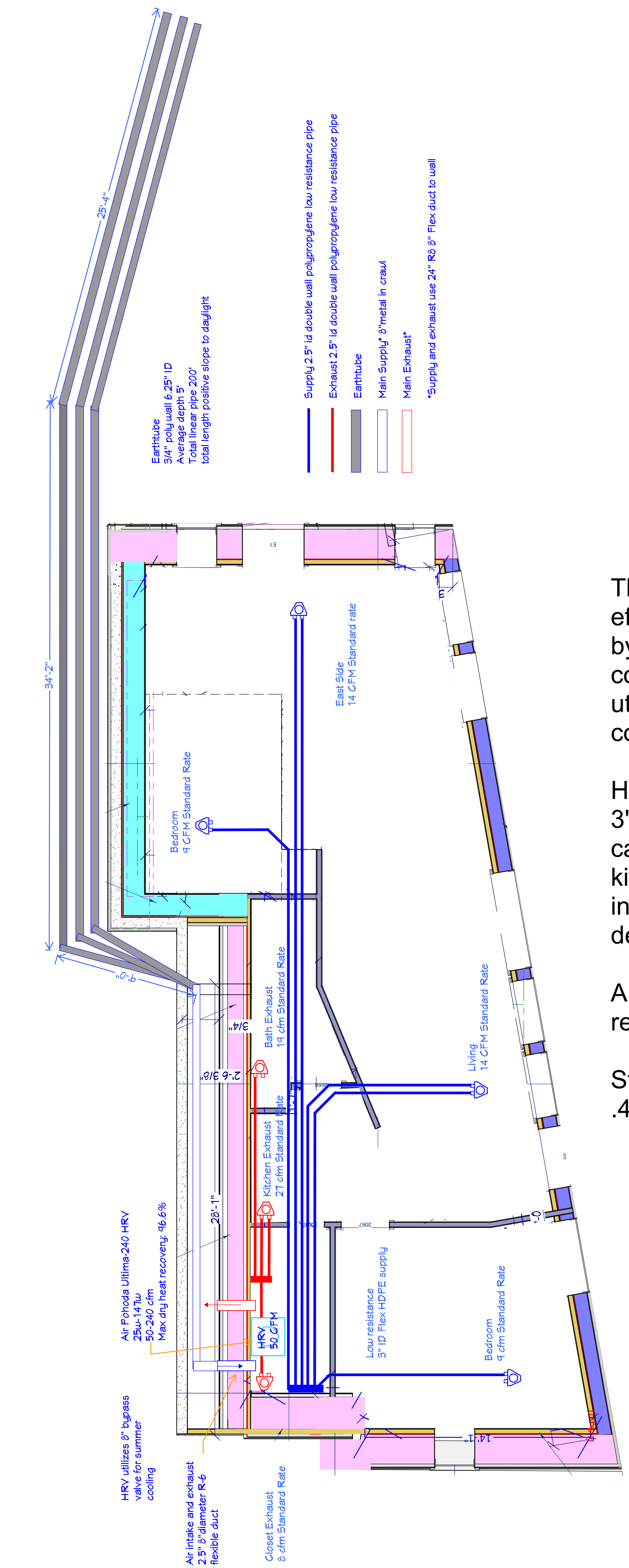
Intus E-forte tripple pane with argon fill glass and door units have Uf 0.167, Ug of 0.09 and SHGC of 0.49. Tempered glass was utilized for fire protection. Frames taped on exterior to window buck and over insulted with mineral wool board and cedar. A minimal use of tilt and turn windows, placed at the corner of the building, allow for hi/low passive cooling ventilation.

7.5 Airtight Construction Details

The air sealing system composed of CDX plywood taped with Pro Clima Vana tape for the wall and floor system. The ceiling and North wall utilized Pro Clima Intello wrap. "Seats" were installed before foundation I joists and Roof joist. Siga Primur was applied at foundation connections to adapt to any movement over time. House blower door tested average .45 ACH 50 pascals with 105 cfm.



7.6 HRV Distribution

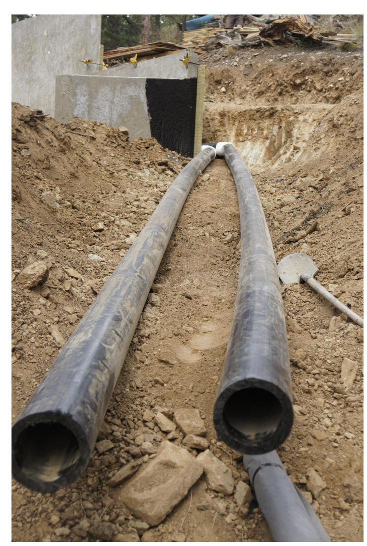


The HRV Air Pohoda Ultima240 is labeled at 92% efficient but de-rated in the PHPP to 75%. It is supplied by three 6" earthtubes which eliminate defrosting and condition the interior in summer. The re-purposed water utility tubes run at a negative slope to eliminate any condensation moisture pooling.

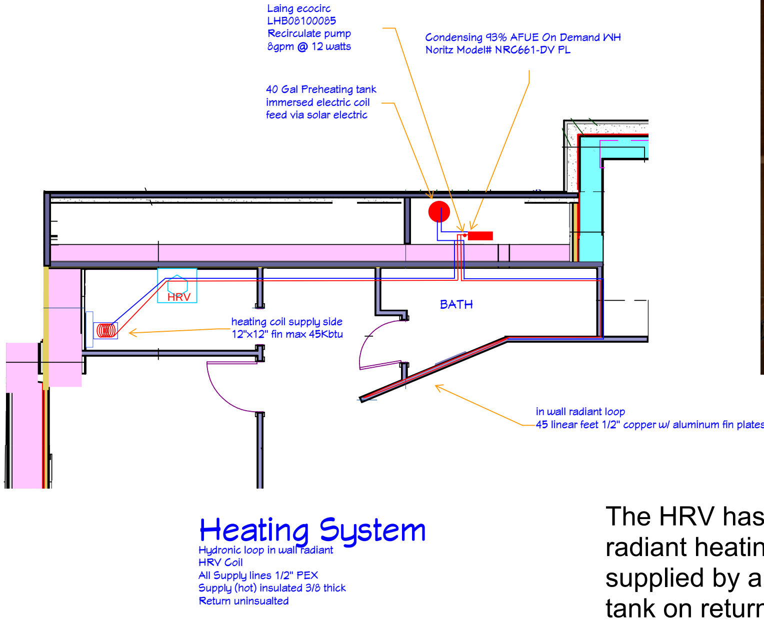
Home run supply tubing pressurizes the perimeter. The 3" flexible supply tubing is run through the ceiling service cavity to the building perimeter. The closet, bath and kitchen are clustered on the depressurization side. The interior then acts as a large plenum with a core depressurization to avoid airborne contaminates.

A bypass duct allows ground tube pre-cooled air to help reduce over heating in the summer and swing seasons.

Standard rate air supply 52 cfm, electrical consumption .46 cf/watt



7.8 Heating System



The HRV has a post heating coil on the supply side. A second in wall radiant heating system sits between the bath and living space. Heat is supplied by a 94% AFUE condensing on demand water heater with buffer tank on return side.

Phase change material is also incorporated in the wall to reduce overheating from solar gains.

8 PHPP Report

City, State, Zip:	Masonville, CO 80541
Country:	USA
Building type:	House
Climate:	CO, Denver — Altitude of building site (feet above sea level): 6654
Home owner / Client:	Andrew Michler
Street Address:	13465 Woodchuck Drive
City, State, Zip:	Masonville, CO 80541
Architecture:	Andrew Michler
Street Address:	PO Box 244, Masonville, CO
City, State, Zip:	Masonville, Colorado, 80541
Mechanical system:	Air Pohoda
Street Address:	
City, State, Zip:	

Year of construction:	2012-2014	Interior temperature winter:	68.0	°F	Enclosed volume V_e ft³:	18850
No. of dwelling units:	1	Interior temperature summer:	77.0	°F	Mechanical cooling:	
No. of occupants:	3.4	Internal heat sources winter:	0.67	BTU/h.ft²		
Spec. capacity:	23 BTU/F per ft² TFA	Ditto summer:	0.67	BTU/h.ft²		

Specific building demands with reference to the treated floor area

					Requirements	Fulfilled?*
	Treated floor area	1275	ft²			
Space heating	Heating demand	3.12	kBTU/(ft²yr)	66% of	4.75 kBTU/(ft²yr)	yes
	Heating load	4.62	BTU/(hr.ft²)	146% 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)	0.6	%		-	-
Primary energy	Heating, cooling, dehumidification, DHW, auxiliary electricity, lighting, electrical appliances	31.6	kBTU/(ft²yr)	83% of	38.0 kBTU/(ft²yr)	yes
	DHW, space heating and auxiliary electricity	18.4	kBTU/(ft²yr)		-	-
	Specific primary energy reduction through solar electricity	35.2	kBTU/(ft²yr)		-	-
Airtightness	Pressurization test result n_{50}	0.5	1/h		0.6 1/h	yes

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

Passive House?	yes

*note climate data and HRV not optimized.

Climate data is 1600 feet adjusted up from data set. Recommend using set at closer elevation to account for inversion layer at project altitude.

HRV not PHI certified, labeled at 92% efficiency, set at lowest CFM rate, earth-tubes not utilized in PHPP

9 Construction Costs

$220 Square foot usable area
$170 Square foot building area
$250,000 total project

11 Date of construction 2012-2015

12 The wedge shape is derived from two objectives. The south face is turned to optimize solar gain and maintain two mature Ponderosa trees which provide exterior shading. The north roof extends to the ground to emulate the formation of local hogback mountains. The East side evokes a cabin with raw logs and wood finish. A parametric interior creates visually rich spaces.

The project utilized natural or low impact material to maintain health and low embodied energy. This includes foam free construction.

13 Building services are simplified based on the low heat demand and open floor plan. Air distribution designed by Air Pohoda, heating mechanicals designed by Andrew Michler.

14 PHPP modeling by Andrew Michler, design development Andrew Michler and John Parr. Project certification and verification Passive House Academy.

15 Building structural was heavy influenced by utilizing a foam free system. The foundation plan went through multiple iterations and material analysis. The exterior grade matches the interior. To maintain an age-in-place floor plan special accommodations with the stem wall were made to eliminate thermal bridging.

16 The thermal envelope has been completed for 1.5 years. The solar gain is excellent in winter with temperatures typically ranging from 75 to 65 degrees F with the heating system turned off. On warm fall days solar gain can make the interior rise to 80 degrees F. Some additional exterior active shading will be utilized to maintain swing season heating and glare control. Summer has no overheating issues, with additional help from the earth tube and night flushing.

17 Colorado University is conducting an extensive Indoor Air Quality evaluation with base line no occupancy post construction and during habitation. Results published in 2016.

Project is chronicled in two books and multiple websites.

Project details http://baosol.com/martak/