

Passive House & Energy Efficiency for Resilience



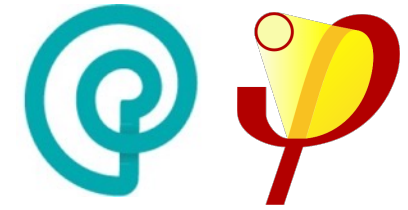
**BayREN Codes & Standards Regional Forum
September 20, 2023**

**Graham Irwin, Principal
Essential Habitat Architecture**

ESSENTIAL
HABITAT
ARCHITECTURE



What is Passive House?



- **Rigorous Building Design & Performance Standard**
- **Formalized by European Scientists ~1990**
- **Based on Super-Insulated, Passive Solar & “Low-Energy” Buildings**
- **“Quality” = How LITTLE Energy is Required for Comfort & Convenience**
- **Superior Comfort, Indoor Air Quality & Durability**
- **10’s of 1000’s Worldwide: Residential, Commercial, Institutional**



World’s 1st Passive House
Kranichstein Passive House
Darmstadt, Germany (1990)



1st Passive House in US
Smith House
Urbana, Illinois (2003)



1st Passive House in CA
Tahan Residence
Berkeley, California (2007)



1st Certified Passive House in CA
1st Certified PH Retrofit in US
O’Neill Residence
Sonoma, California (2010)

How Does Passive House Work?

- **Optimized Solar Gains**
- **Draft-Free Shell**
- **Heat Recovery Ventilation (typical)**
- **Continuous Insulation**
- **High Performance Windows & Doors**
- **Efficient Equipment, Appliances & Lighting**
- **Renewable Energy**

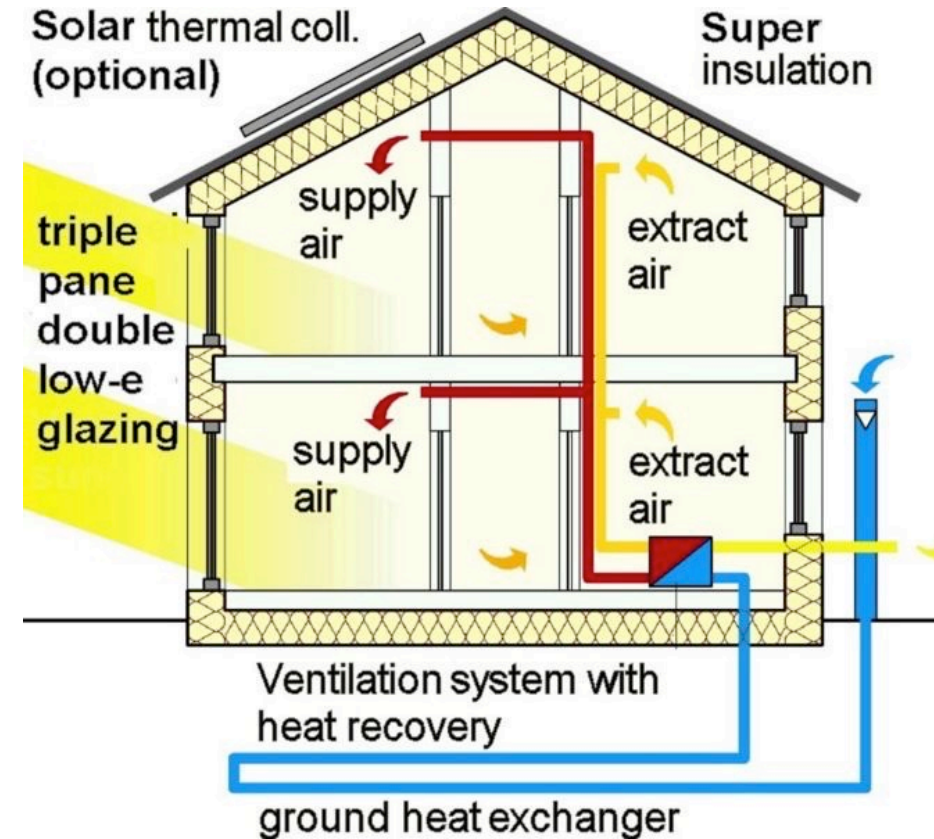


Image: Passivhaus Institut (PHI)

Passive House Benefits

1. Health

24/7 Filtered Fresh Air & Quiet, Consistent Comfort

Supplemental Filtration (HEPA) for Wildfire Smoke

Durable Shell Free of Moisture & Mold Problems

2. Wealth

Tiny Energy Bills, High Quality Construction

Immune to Changing Energy Prices & Policy

“Thermal Battery” to Store Heating & Cooling

3. Happiness

A Safe, Healthy Home for You & The Planet

A “Legacy” Building for Your Family

Quiet, Secure, Comfortable Interior – “Sanctuary” in the Modern World

4. Wisdom

Based on 40+ Years of Research & Engineering

30+ Years of Proven Performance

Efficiency is a Permanent Gift





Anchor Bay House
Guafala, CA (2014)
1st Certified PH in Mendocino County
with Matthew Copleigh



O'Neill Residence
Sonoma, CA (2019)
1st Certified Passive House in CA
1st Certified PH Retrofit in US
with Led Design Group



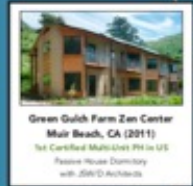
Jandak Wood Residence
Sonoma, CA (2012)
PH Residence & Guest House
with Sigurn Architecture



Casa Miraval
Napa, CA (2014)
Passive House Custom Home
with Sigurn Architecture



John Trigg Library
Ester, AK (pending)
Passive House Public Library
with USPH, Inc.



Green Gulch Farm Zen Center
Marin Beach, CA (2011)
1st Certified Multi-unit PH in US
Passive House Community
with JSDA Architects



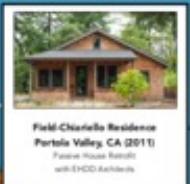
Laney College BEST Center
Oakland, CA (pending)
Passive House Classroom
with PLAD Architects



Solarb II
Durango, CO (2013)
PH Feasibility Study
Production Homes
Developer: New Town Builders



Equilibrium House I
San Francisco, CA (2013)
Passive House Spec Retrofit
with Huel Thomas Architects



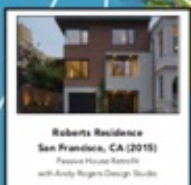
Field-Chiarolla Residence
Portola Valley, CA (2011)
Passive House Retrofit
with EHCD Architects



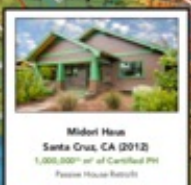
La Casa Navajo
Santa Fe, NM (2014)
Passive House Custom Home
with W&M Studio



Kaplan-Malarkey Residence
San Francisco, CA (2014)
Passive House Retrofit



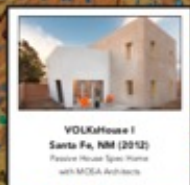
Roberts Residence
San Francisco, CA (2015)
Passive House Retrofit
with Andy Rogers Design Studio



Midori House
Santa Cruz, CA (2012)
1,000,000+ sq ft Certified PH
Passive House Retrofit



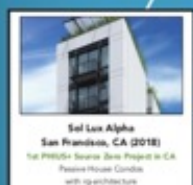
Maso Residence
Shaver Lake, CA (inbuilt)
Passive House Custom Home



VOLKHouse I
Santa Fe, NM (2012)
Passive House Spec Home
with W&M Studio



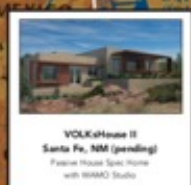
Andalusia
Clovis, NM (pending)
10 Units Affordable Passive House
with W&M Studio



Sol Lux Alpha
San Francisco, CA (2018)
1st PHUS+ Source Base Project in CA
Passive House Condo
with Sigurn Architects



Mosaic Gardens
Whittier, CA (2012)
PH Feasibility Study
Affordable Multi-Family
Developer: UMC Housing



VOLKHouse II
Santa Fe, NM (pending)
Passive House Spec Home
with W&M Studio

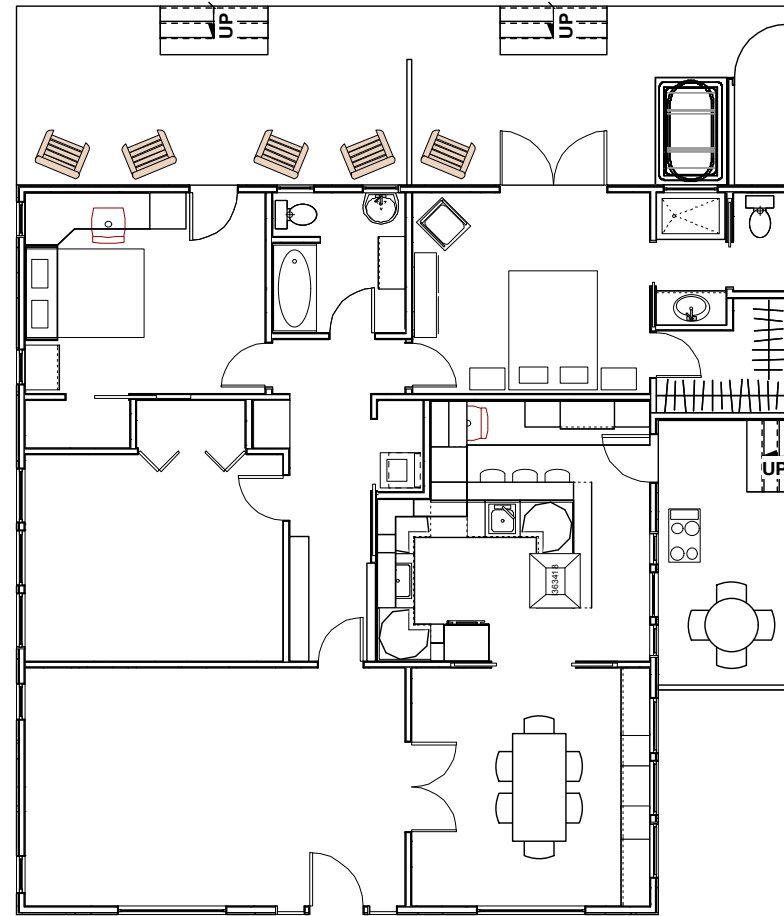
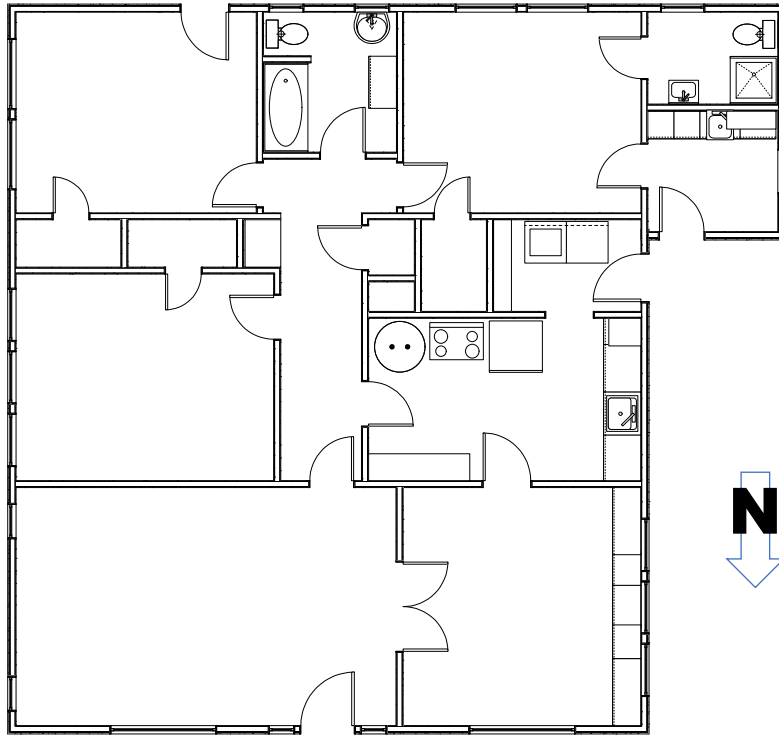
Midori Haus, Santa Cruz



Midori Haus

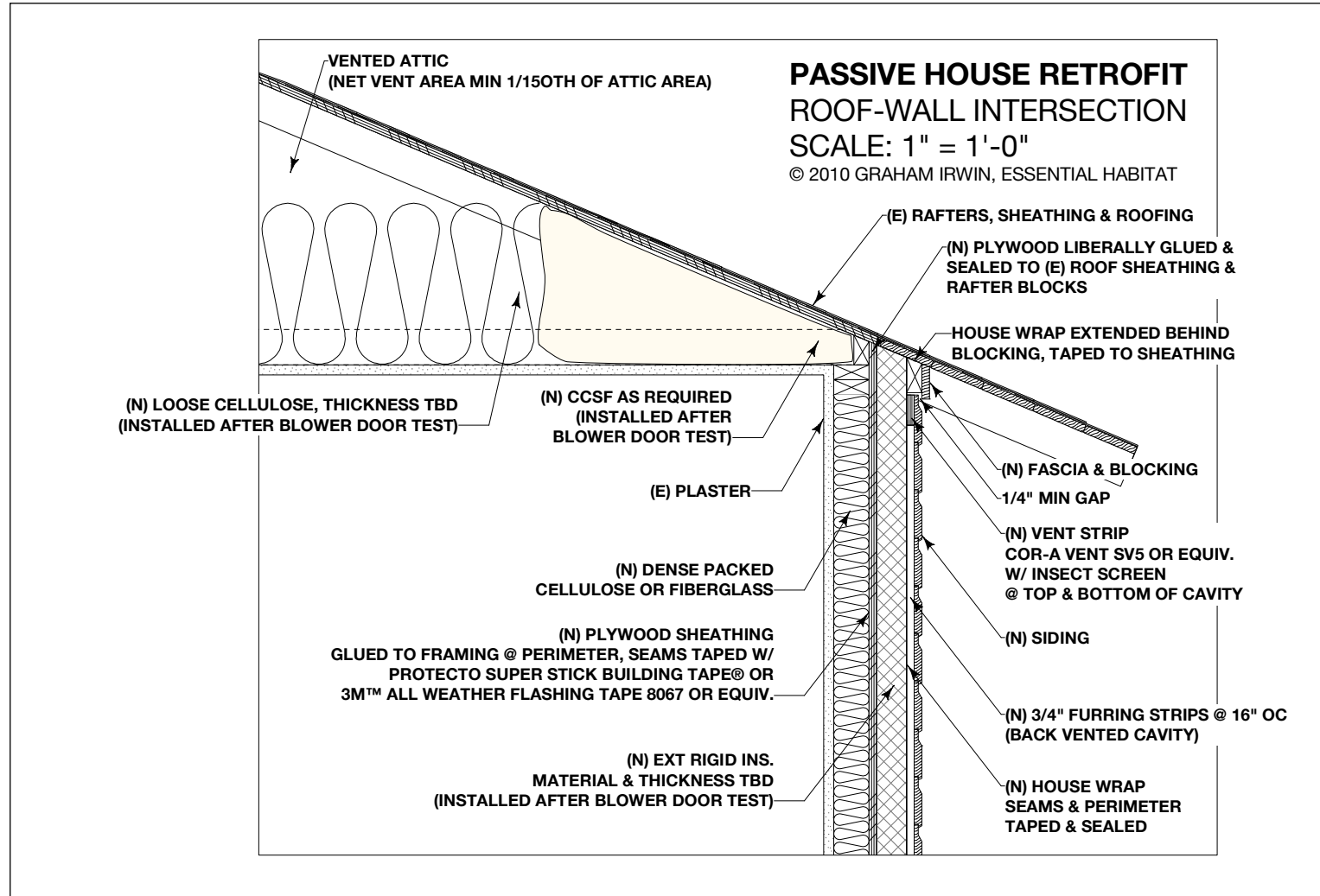
Santa Cruz

1569 ft², 3BR/2BA
Built 1922, Remodeled 2013



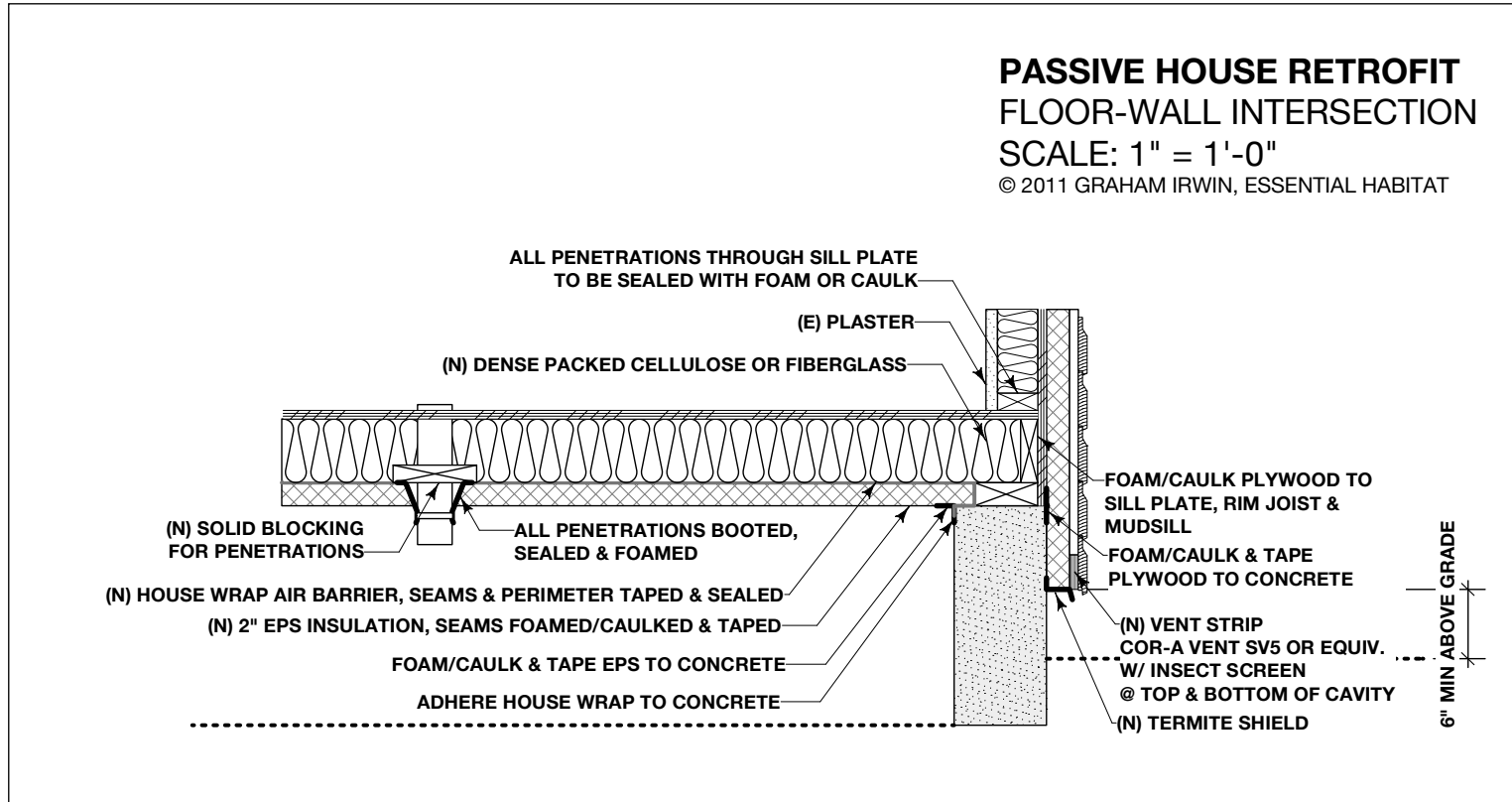
Midori Haus

Santa Cruz



Midori Haus

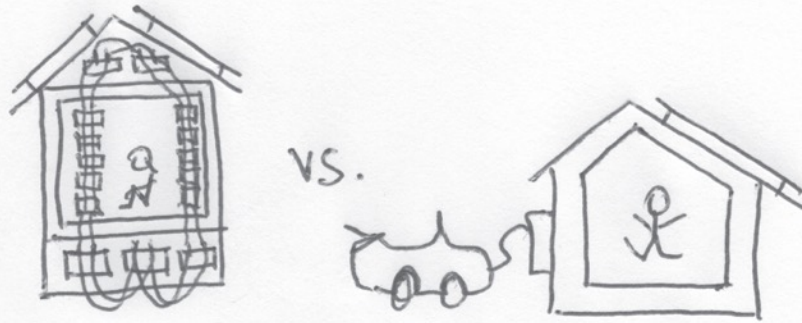
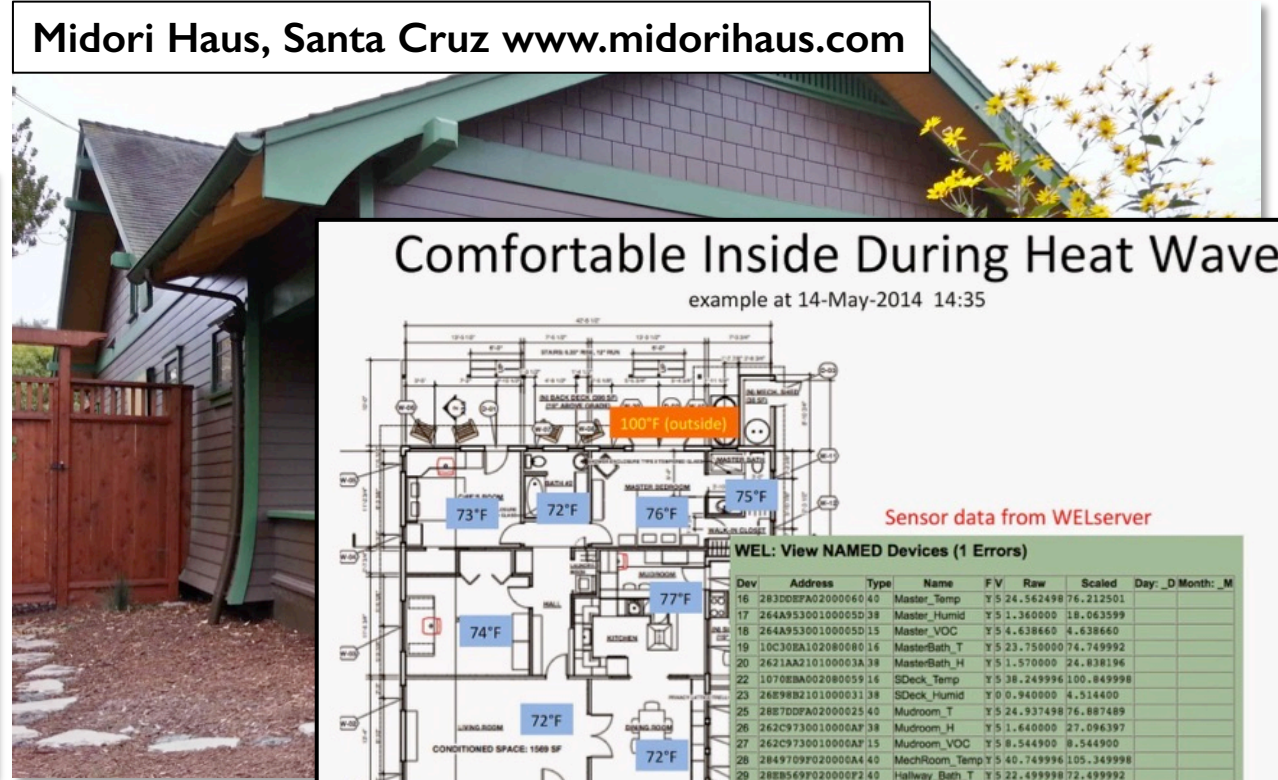
Santa Cruz



Thermal Storage

Passive House in a Heat Wave, No A/C

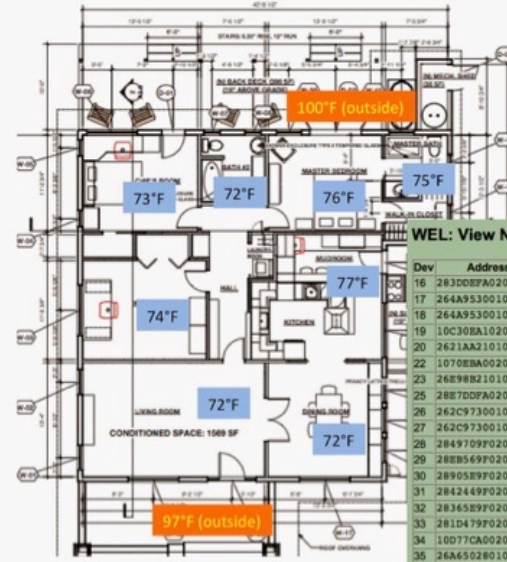
Midori Haus, Santa Cruz www.midorihaus.com



Passive House = Thermal Battery
©2015 Essential Habitat

Comfortable Inside During Heat Wave

example at 14-May-2014 14:35



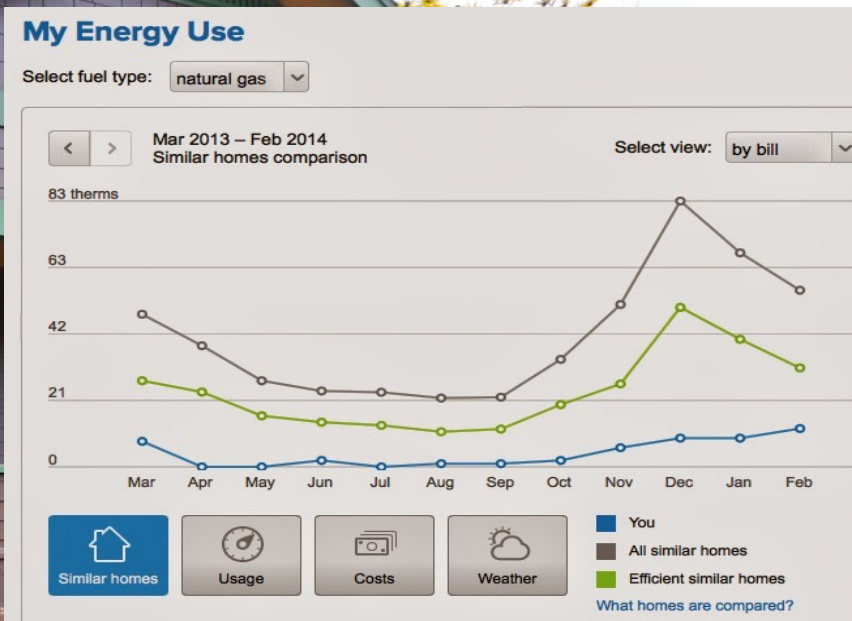
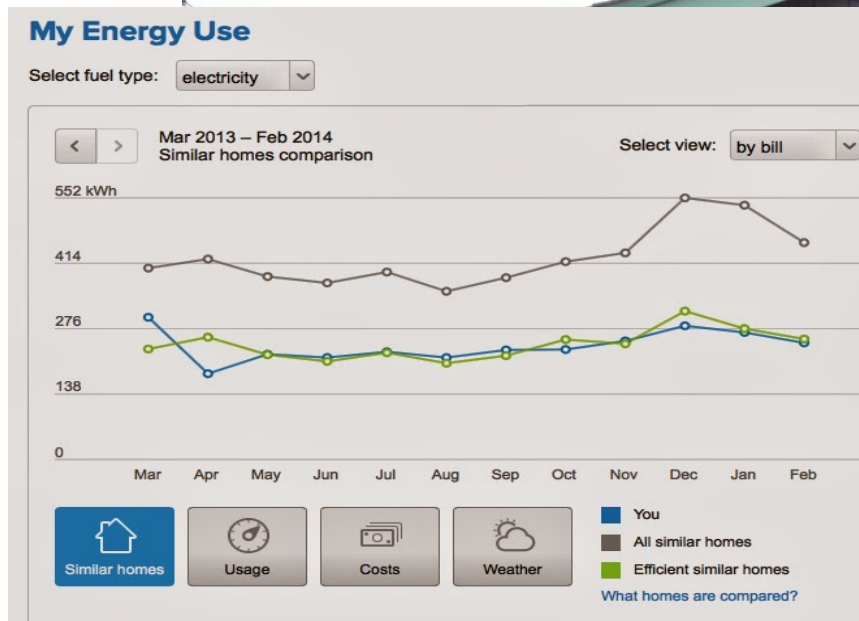
Sensor data from WELserver

WEL: View NAMED Devices (1 Errors)

Dev	Address	Type	Name	F.V	Raw	Scaled	Day_D Month: _M
16	283DDFA0200006040	Master_Temp	Y5 24.562498	76.212501			
17	264A95300100005D38	Master_Humid	Y5 1.360000	18.063599			
18	264A95300100005D15	Master_VOC	Y5 4.638660	4.638660			
19	10C30EA10208008016	MasterBath_T	Y5 23.750000	74.749992			
20	2621AA210100003A38	MasterBath_H	Y5 1.570000	24.838196			
22	1070E8A0208005916	SDeck_Temp	Y5 38.249996	100.849998			
23	26E98B210100003138	SDeck_Humid	Y0 0.940000	4.514400			
25	28E7DDFA0200002540	Mudroom_T	Y5 24.937498	76.887489			
26	262C9730010000A738	Mudroom_H	Y5 1.640000	27.096397			
27	262C9730010000A715	Mudroom_VOC	Y5 8.544900	8.544900			
28	2849709F020000A440	MechRoom_Temp	Y5 40.749996	105.349998			
29	28E8569F020000F240	Hallway_Bath_T	Y5 22.499998	72.499992			
30	28905B9F020000A0C40	Dining_Room_T	Y5 22.499998	72.499992			
31	2842449F020000C740	Front_Porch_T	Y5 35.874996	96.574989			
32	28365B9F020000A240	Chie's_Room_T	Y5 22.749998	72.949989			
33	281D479F0200008340	Living_Room_T	Y5 22.374998	72.275001			
34	10D77CA0208006416	Kurt's_Room_T	Y5 23.062498	73.512489			
35	26A65028010000DD38	Kurt's_Room_H	Y5 1.490000	22.257393			

1-Wire Status = Devices Found

Seasonal Demand



2869 kWh Elec. + 50 Therms (1,465 kWh) Nat. Gas = 4,334 kWh (before PV!)

Before Retrofit 21,928 kWh/yr, Similar CA Home 19,596 kWh/yr

MCM ReEnvisioned, Sunnyvale



BEFORE (2019, Constructed 1955):
1,193 SF (3 BR/1³/₄ BA)

MCM ReEnvisioned, Sunnyvale



AFTER (2022):
1,767 SF (3 BR/2½ BA)



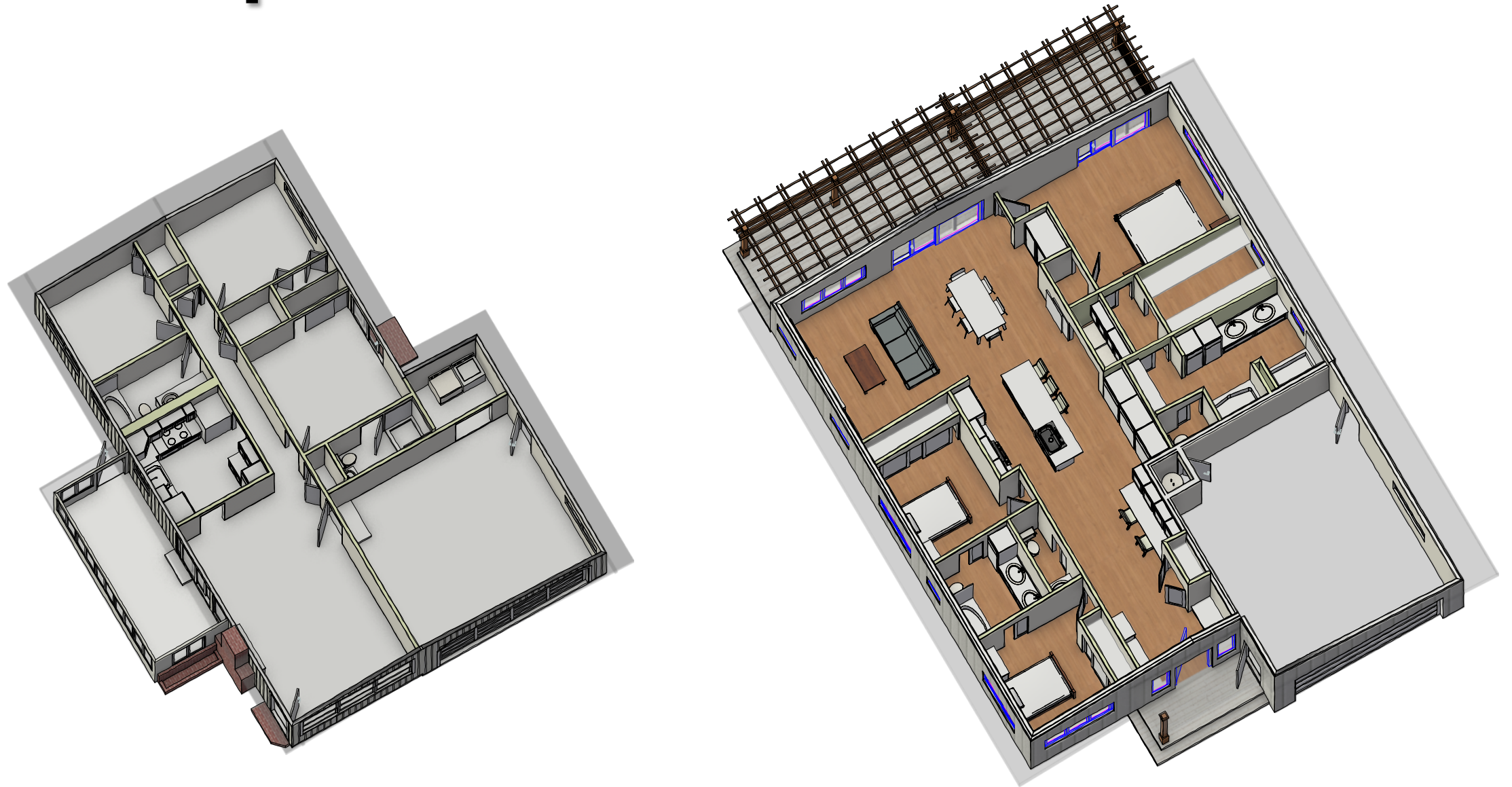
MCM ReEnvisioned, Sunnyvale



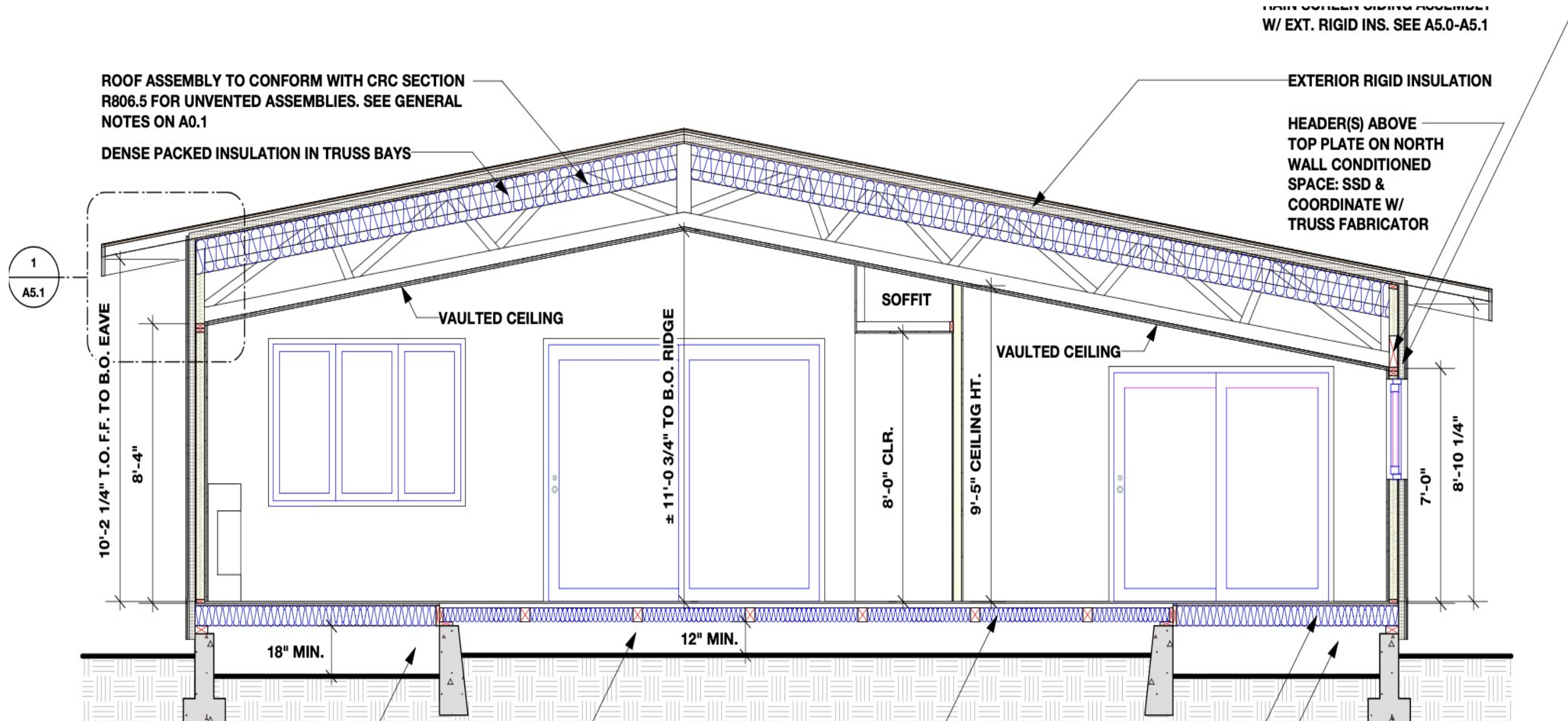
MCM ReEnvisioned, Sunnyvale



Floorplan Before & After



3. DETAILS: FLOOR



3. DETAILS: FLOOR

ROOF ASSEMBLY TO CONFORM WITH CRC SECTION R806.5 FOR UNVENTED ASSEMBLIES. SEE GENERAL NOTES ON A0.1

DENSE PACKED INSULATION IN TRUSS BAYS

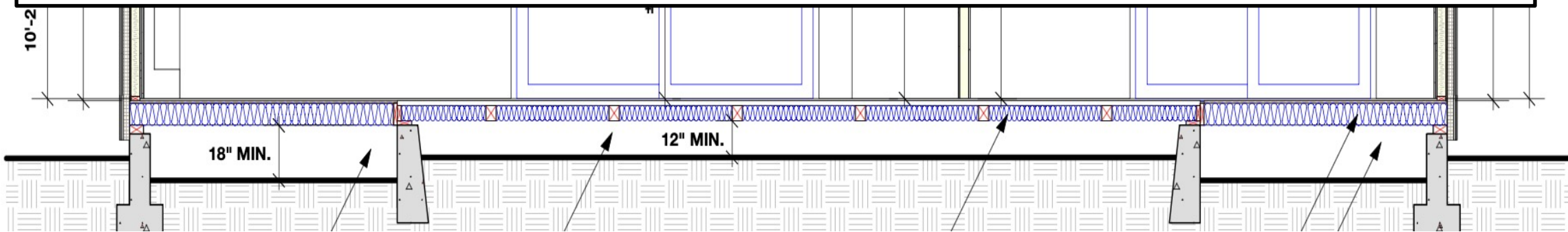
FRAMING MEMBER SIDING ASSEMBLY W/ EXT. RIGID INS. SEE A5.0-A5.1

EXTERIOR RIGID INSULATION

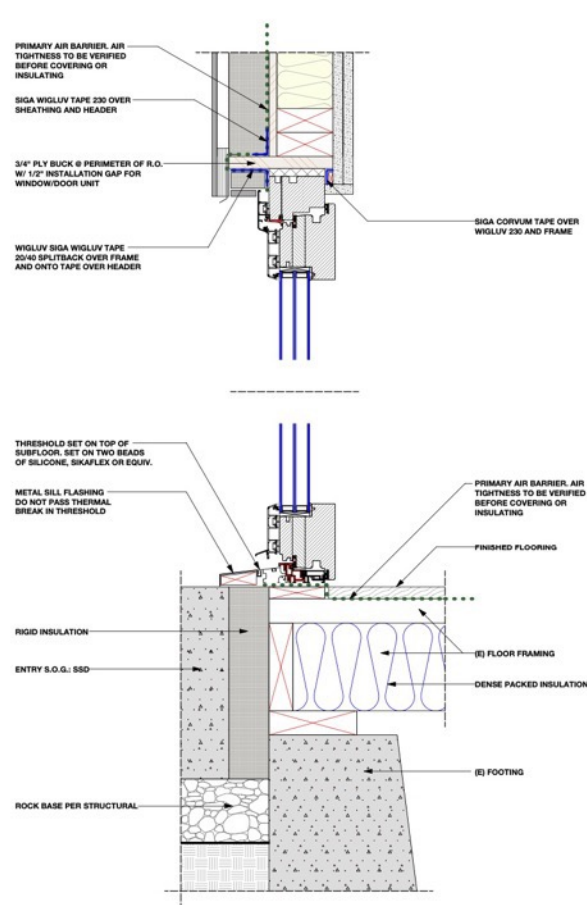
HEADER(S) ABOVE TOP PLATE ON NORTH WALL CONDITIONED SPACE: SSD &

Clean Crawl Space: 1/10th Typical Vent Openings
Air Sealing (Plywood Deck)
7¼" Insulation
Water Supply Pipes in Joist Bays

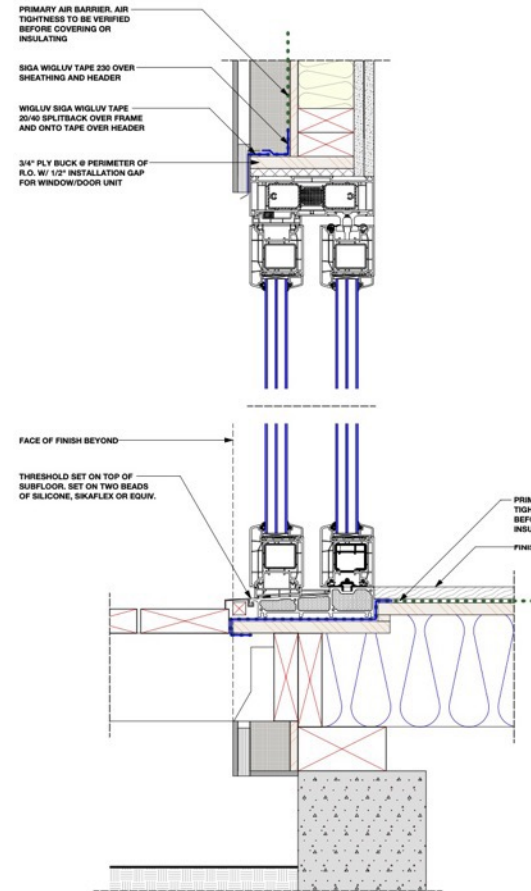
1
A5.1



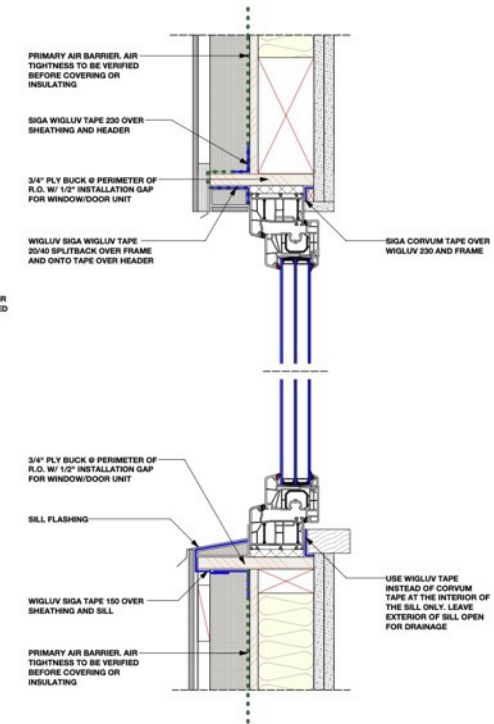
3. DETAILS: WALLS



1 IN-SWING ENTRY DOOR HEAD & THRESHOLD
Scale: 3" = 1'-0"



2 LIFT SLIDE DOOR HEAD & THRESHOLD
Scale: 3" = 1'-0"



3 WINDOW HEAD & SILL TYP.
Scale: 3" = 1'-0"

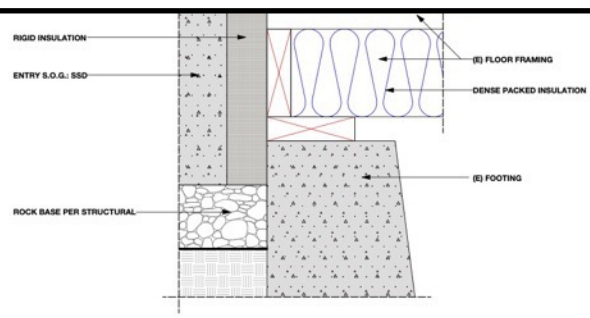
3. DETAILS: WALLS



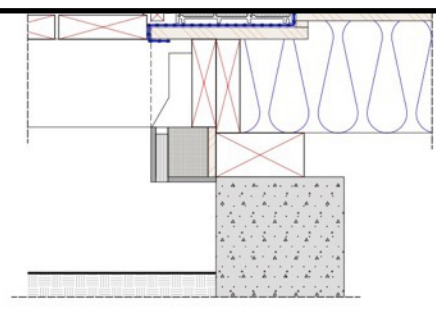
3 1/2" Cellulose + 2 1/2" Surplus Polyiso

Air Sealing (Zip Sheathing)

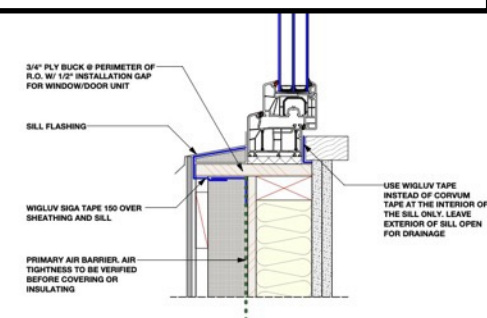
Doors & Windows: Zola Thermo uPVC (R7), Triple Pane



1 IN-SWING ENTRY DOOR HEAD & THRESHOLD
Scale: 3" = 1'-0"

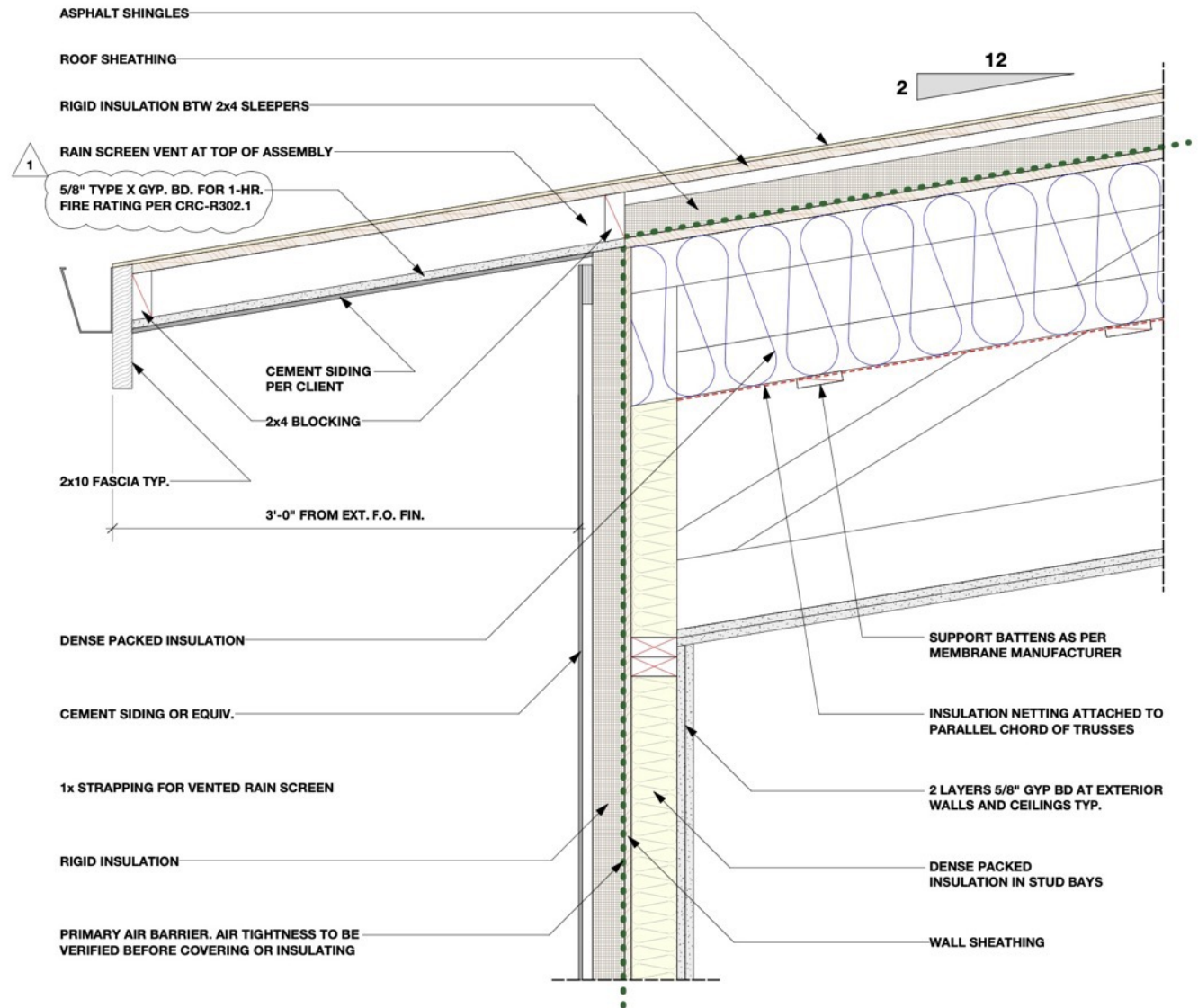


2 LIFT SLIDE DOOR HEAD & THRESHOLD
Scale: 3" = 1'-0"

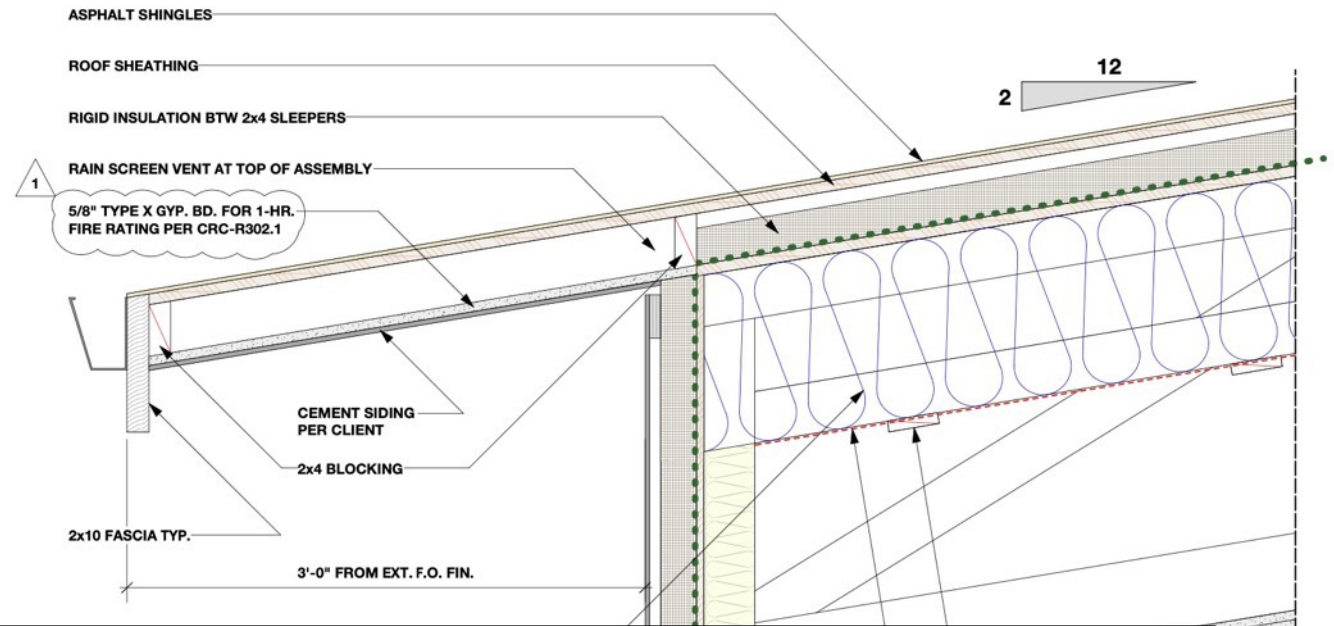


3 WINDOW HEAD & SILL TYP.
Scale: 3" = 1'-0"

3. DETAILS: ROOF

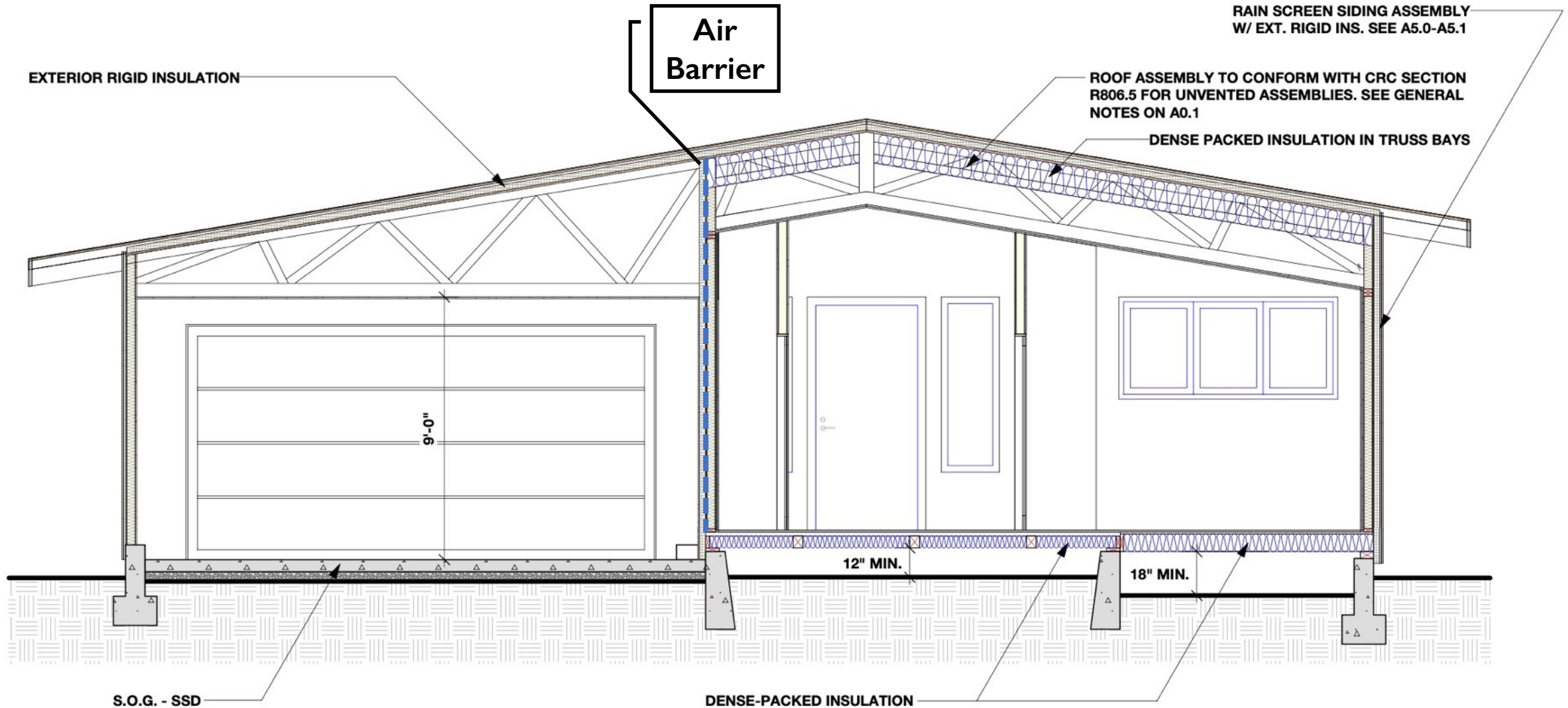


3. DETAILS: ROOF



“Milburn Truss”: Parallel Chord for Insulation Net Air Sealing (Zip Sheathing), Overhangs Above 12” Cellulose + 2½” Surplus Polyiso ‘Cool’ (Reflective) Roofing

3. DETAILS: GARAGE ROOF





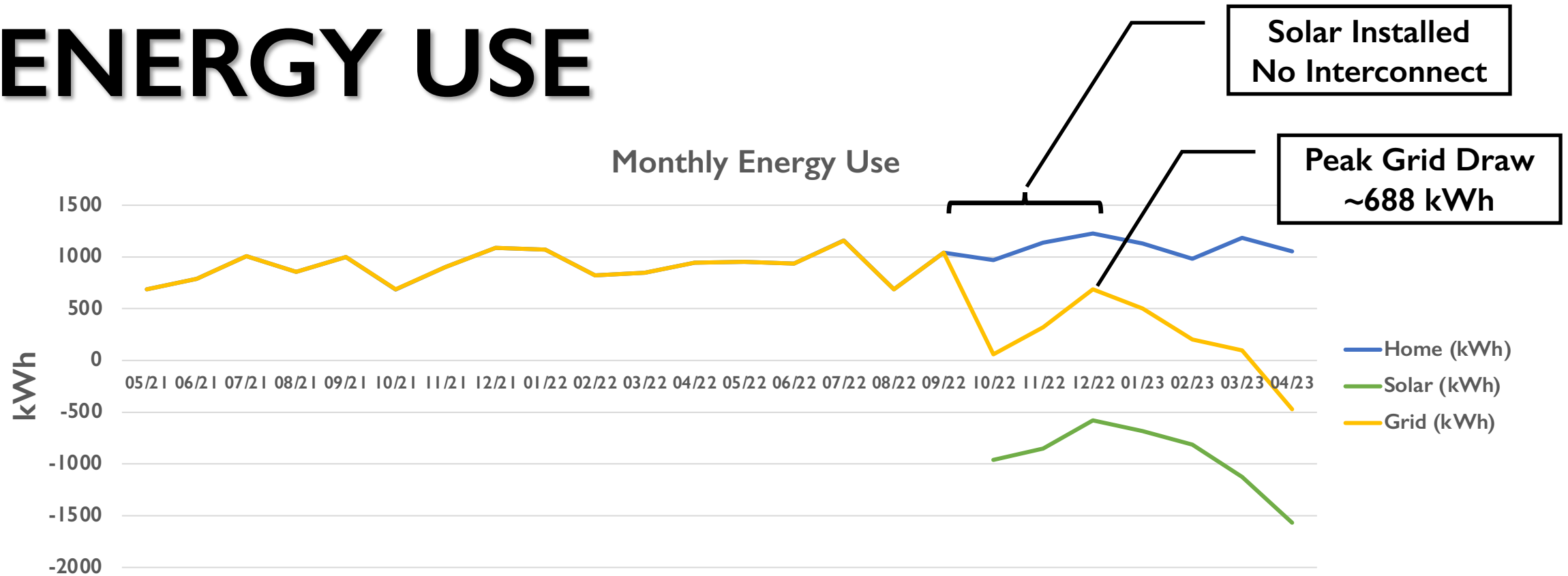
3. DETAILS: SHADING

36'' Eaves

Low-g Glazing

Seasonal Pergola Shade (West)

ENERGY USE



Before Remodel: \$150/month (55-95°F House, No Cars)

After Remodel, Before Solar: \$180/month (Perfect Comfort, Two Electric Cars @ ~340 kWh/month)

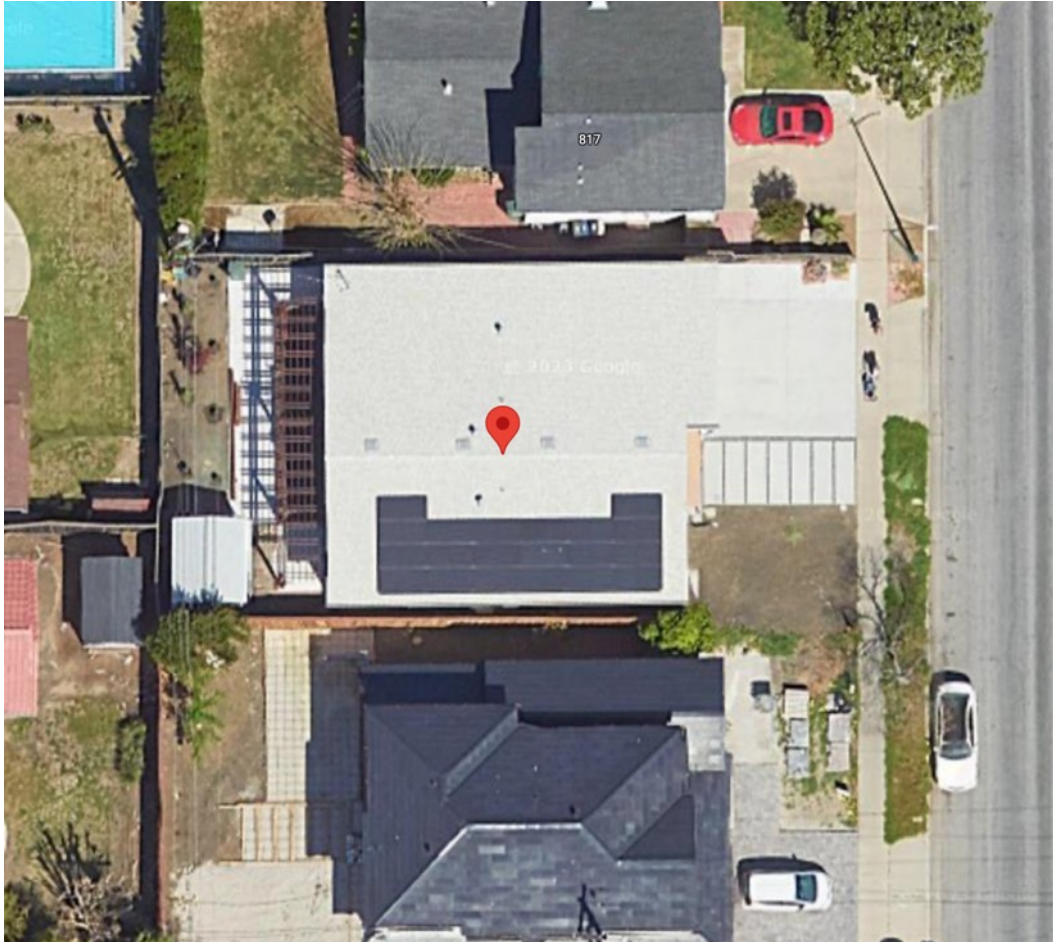
With Solar, Jan-Mar 2023: ~\$9/month + \$11 Connection Fee (Perfect Comfort, Two Electric Cars)

With Solar, Apr 2023: -\$67.48

Typical CA Home: 1,667 kWh/month, Typical CA Car: 1,630 kWh/month = 3,297 kWh/month

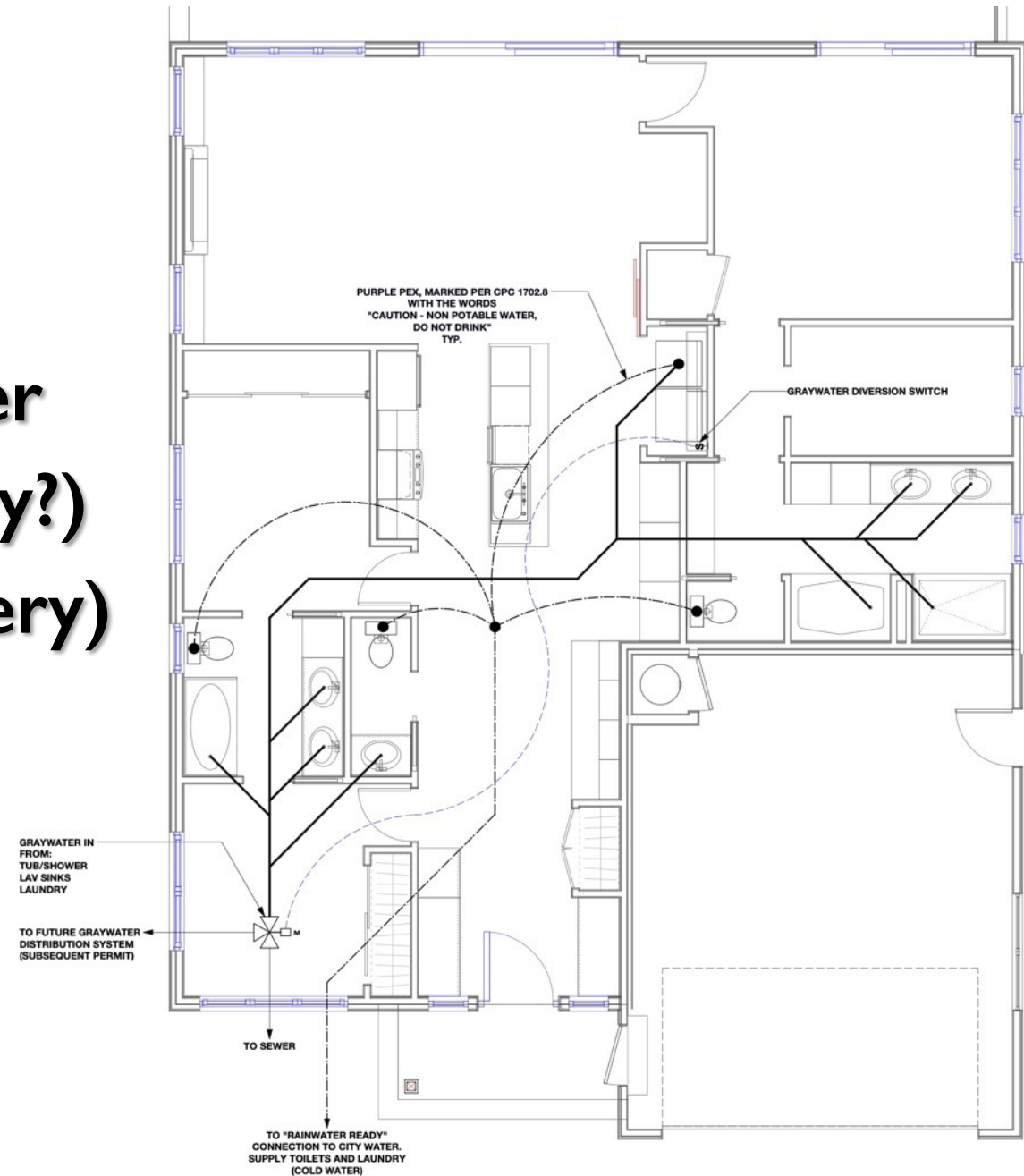
SOLAR SYSTEM

8.5kW PV + 2 Tesla Powerwalls



WATER

SANCO2 Heat Pump Water Heater
Drainwater Heat Recovery (1 Story?)
Structured Plumbing (DHW Delivery)
Rainwater Ready (Indoor Use)
Low Water, Permeable Landscape
Graywater Ready (Outdoor Use)

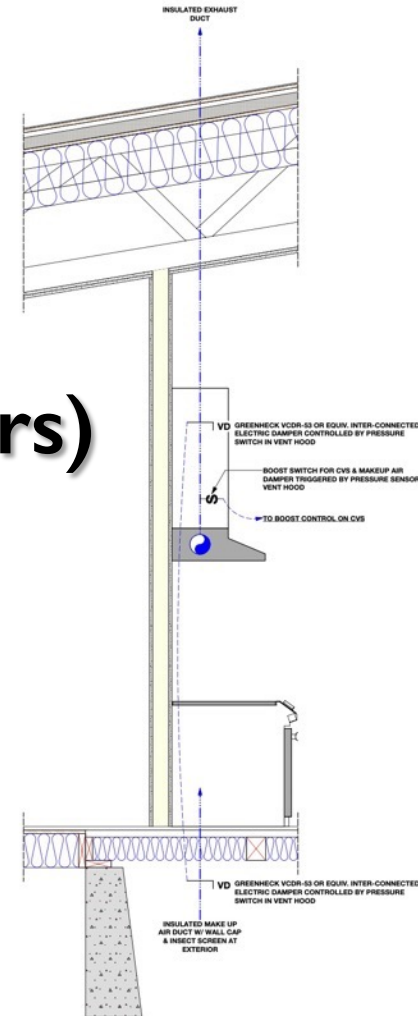


AIR QUALITY

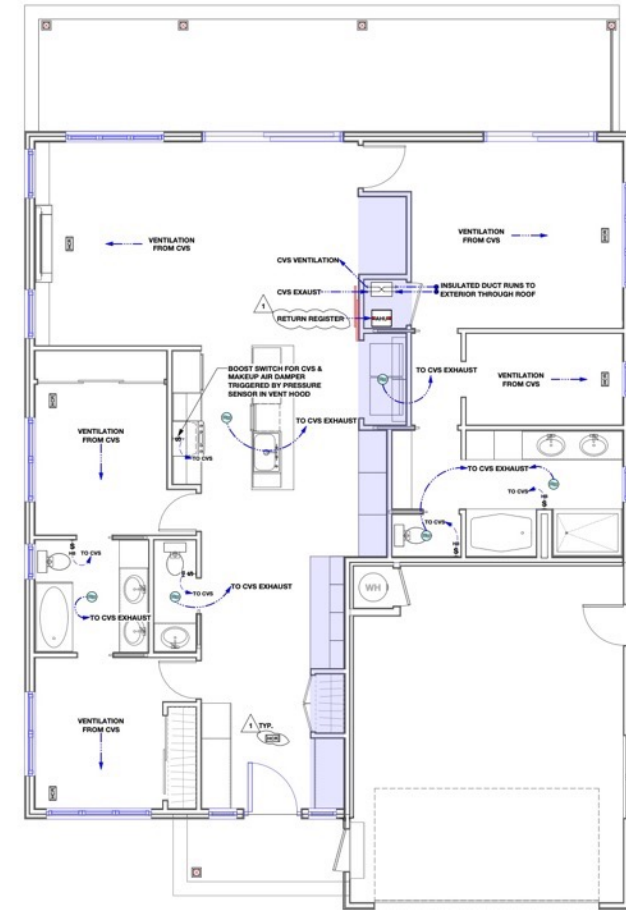
Zehnder ComfoAir 160 HRV
Vented Range Hood (with Dampers)
HEPA Filter @ HRV for Wildfires



7-Month-Old HRV Filters vs. New



2 RANGE HOOD VENT DETAIL
Scale: 1" = 1'-0"



1 MECHANICAL PLAN
Scale: 1/4" = 1'-0"

- VERTICAL/HORIZONTAL 1/2" R10 CONCEALED AIR HANDLER OR EQUIV.
- CENTRALIZED VENTILATION UNIT
- EXHAUST OUTLET TO CENTRAL VENTILATION SYSTEM
- HUMIDISTAT AND TIMED BOOST SWITCH FOR CENTRAL VENTILATION SYSTEM
- DUCT PATH
- HEATING / COOLING REGISTER

QUALITY OF LIFE & JOY



“The design really encapsulates everything we were hoping to enjoy, and the Passive House benefits have really been as great as you said they would be.” - John & Adrienne

Agnieszka Jakubowicz Photography

Study: CA Code → Passive House

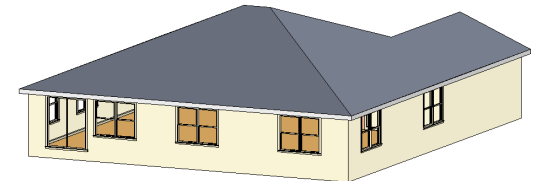
2013 California Code vs. Passive House

1. Analysis of California Code-Minimum Construction in Passive House Planning Package (PHPP 8.4) by Climate Zone.
2. Step by Step Analysis of Cost Effective Upgrades to Reach Passive House Performance.

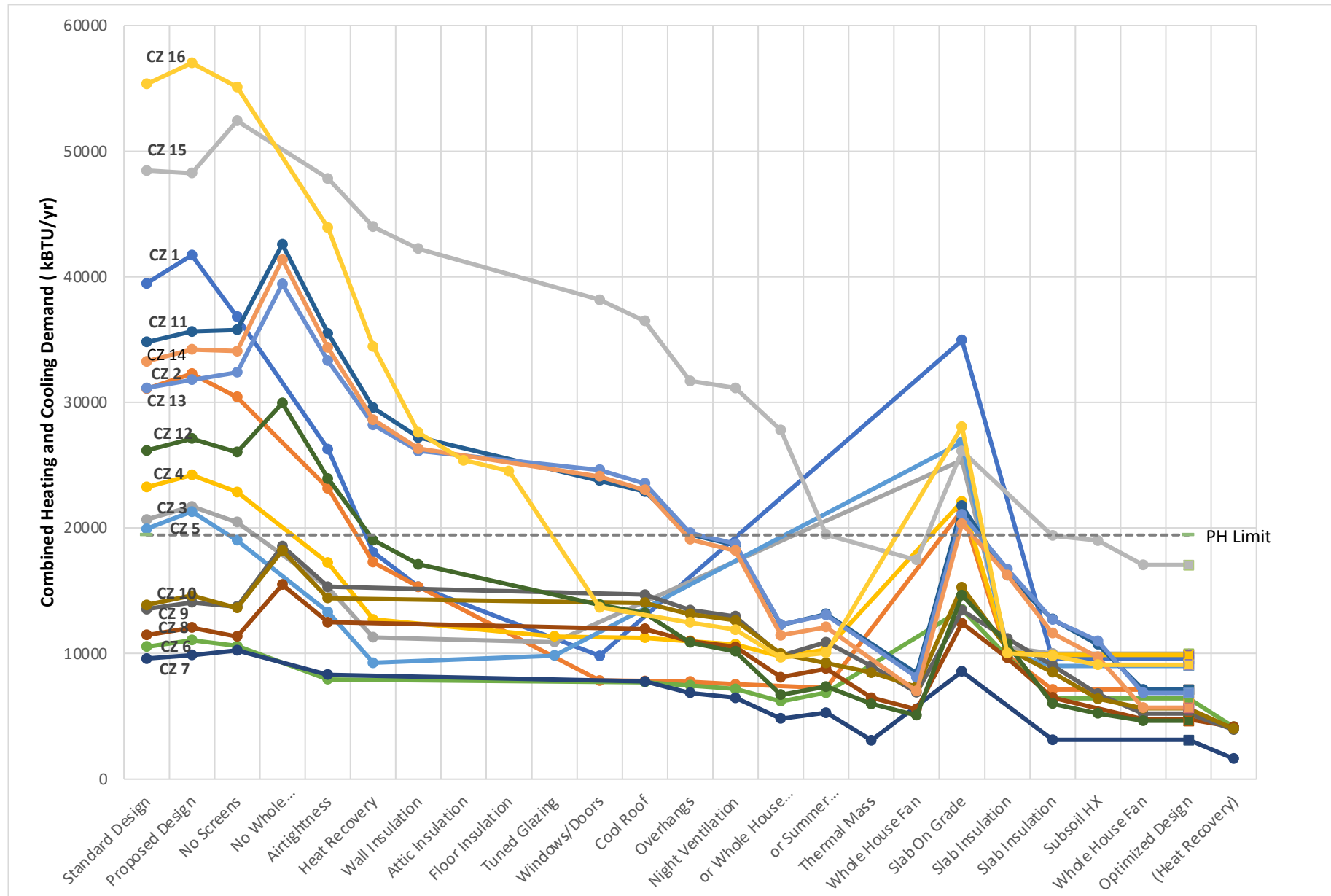
Figure A-1: One Story Prototype Front View



Figure A-2: One Story Prototype Back View

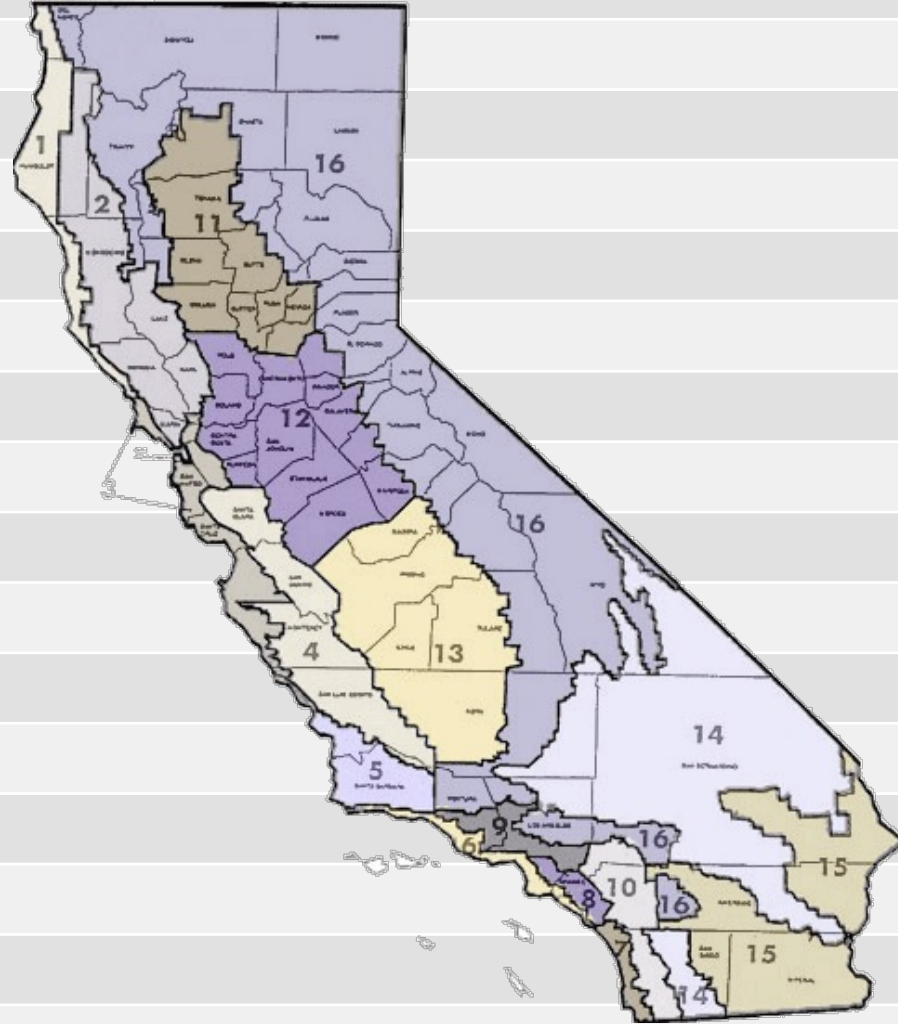


Results: CA Code → Passive House



Heating & Cooling Savings vs. 2013 T24

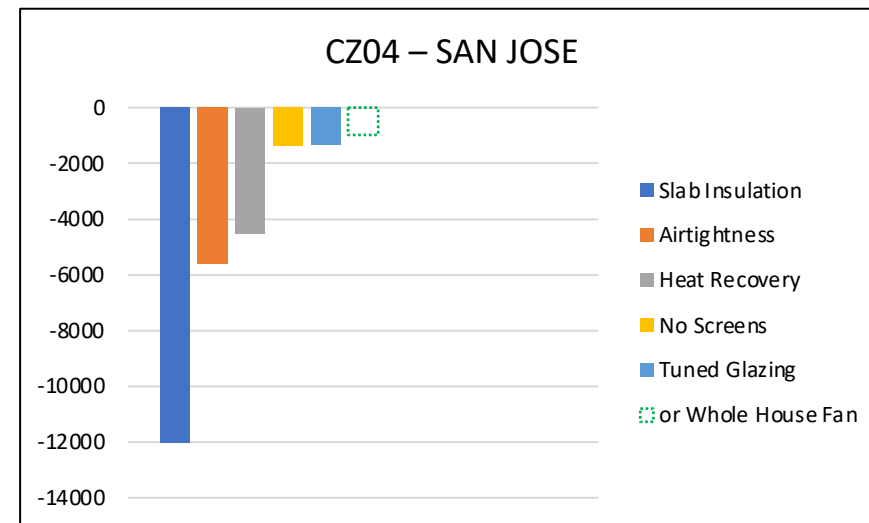
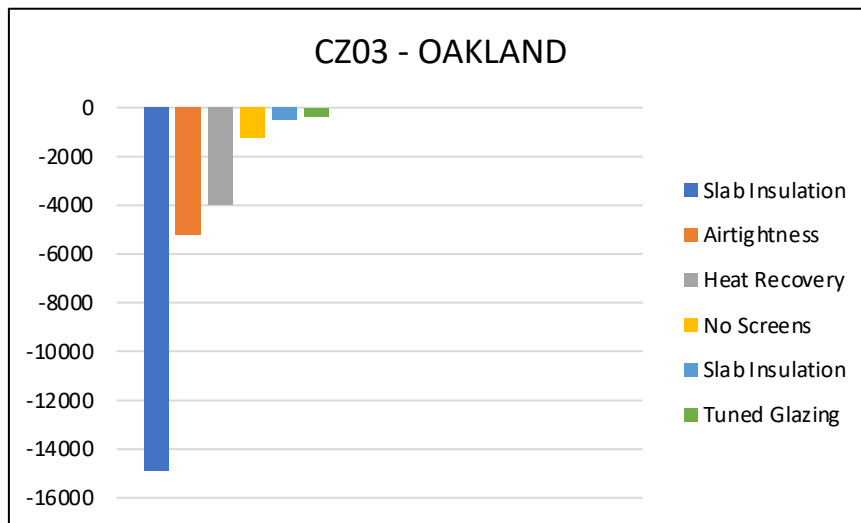
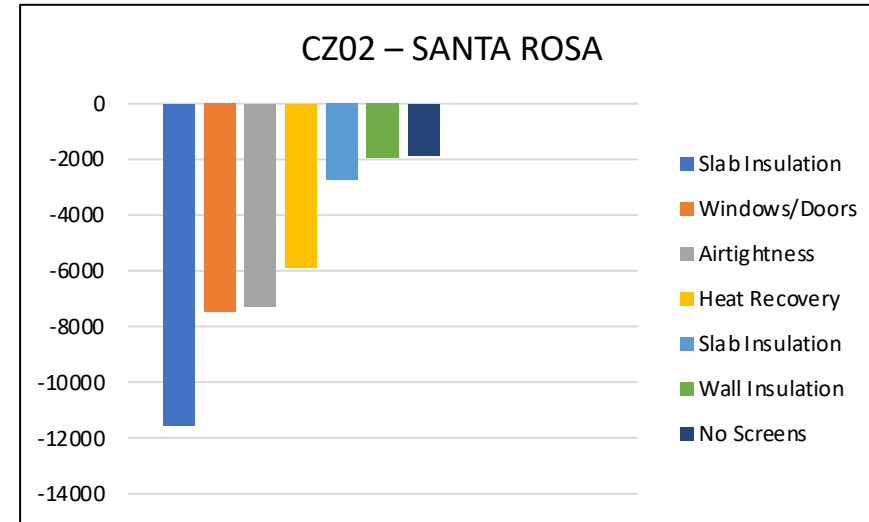
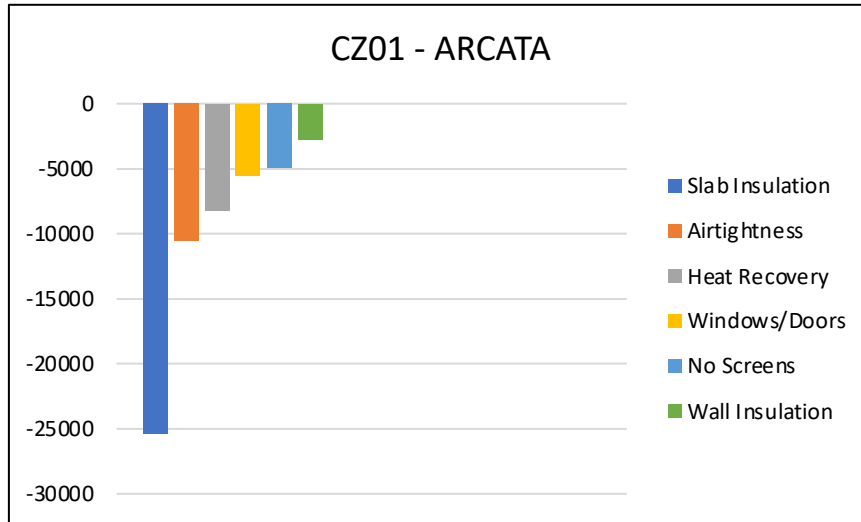
Location	# Passive Houses = 1 Code House, (🏠) = w/ Optional Heat Recovery
01 Arcata	🏠🏠🏠🏠
02 Santa Rosa	🏠🏠🏠🏠
03 Oakland	🏠🏠
04 San Jose	🏠🏠
05 Santa Maria	🏠🏠
06 Torrance	🏠🏠(🏠)
07 San Diego	🏠🏠🏠(🏠🏠🏠)
08 Fullerton	🏠🏠🏠(🏠)
09 Burbank	🏠🏠🏠(🏠)
10 Riverside	🏠🏠(🏠)
11 Red Bluff	🏠🏠🏠🏠🏠
12 Sacramento	🏠🏠🏠🏠🏠🏠
13 Fresno	🏠🏠🏠🏠🏠
14 Palmdale	🏠🏠🏠🏠🏠🏠
15 Palm Springs	🏠🏠🏠
16 Blue Canyon	🏠🏠🏠🏠🏠🏠



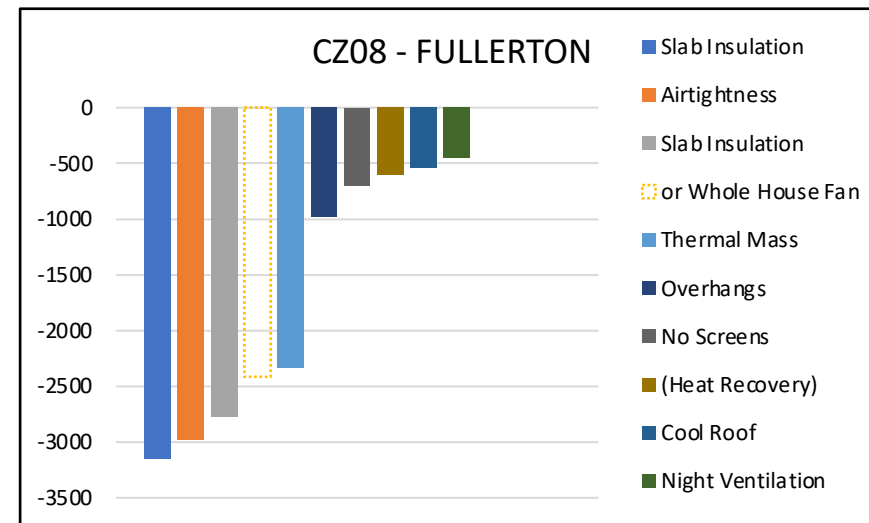
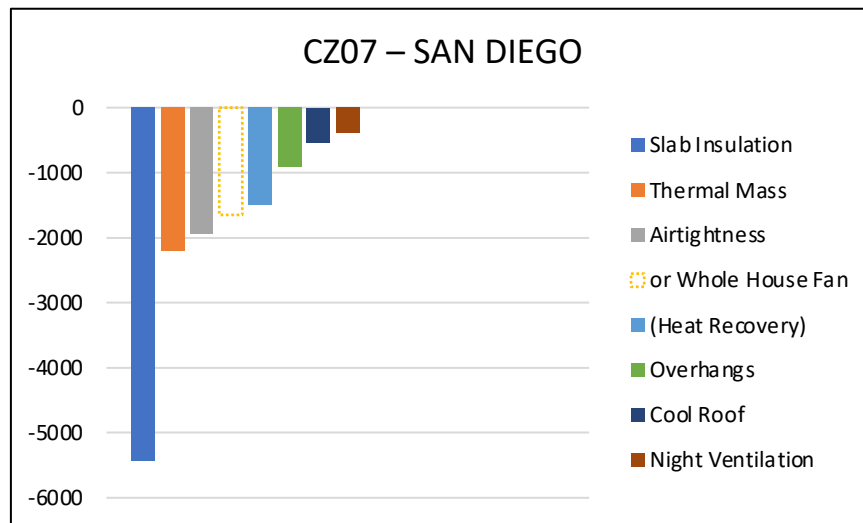
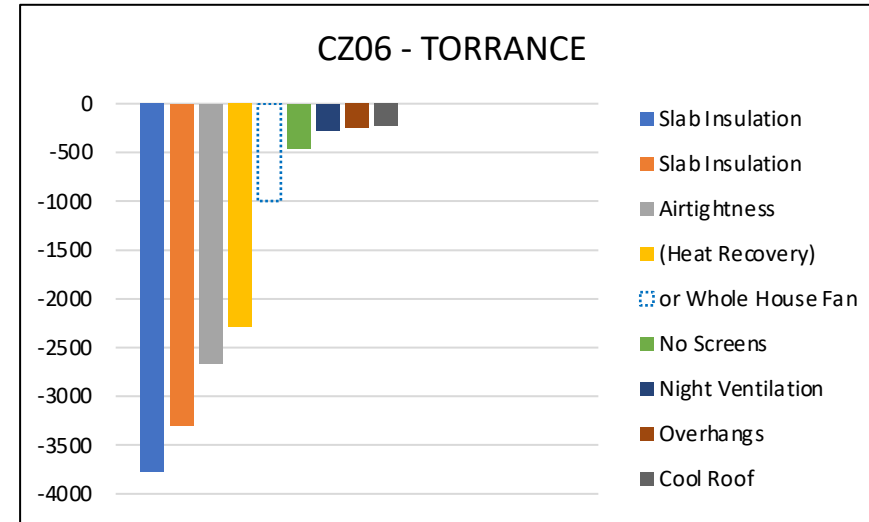
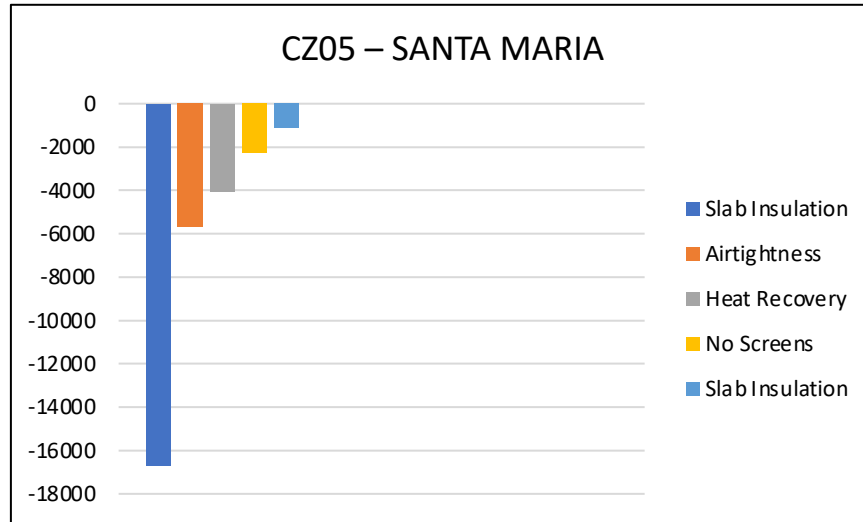
Optimized Building Shell

Location	Roof	Walls	Raised Floor	Slab	Windows	Air-Tightness
01 Arcata	Code	R21 _{cavity} +R4	Code	R14	U 0.14 0.35 SHGC	0.6 ACH ₅₀
02 Santa Rosa	↓	↓	↓	↓	↓	↓
03 Oakland	↓	Code	↓	R13	Code 0.50 South	↓
04 San Jose	↓	↓	↓	↓	↓	↓
05 Santa Maria	↓	↓	↓	R12	↓	↓
06 Torrance	↓	↓	↓	R10	Code	↓
07 San Diego	↓	↓	↓	R18	↓	↓
08 Fullerton	↓	↓	↓	R19	↓	↓
09 Burbank	↓	↓	↓	↓	↓	↓
10 Riverside	↓	↓	↓	↓	↓	↓
11 Red Bluff	↓	R21 _{cavity} +R4	↓	R14	U 0.14 0.35 SHGC	↓
12 Sacramento	↓	↓	↓	R19	↓	↓
13 Fresno	↓	↓	↓	R13	↓	↓
14 Palmdale	↓	↓	↓	R12	↓	↓
15 Palm Springs	↓	↓	↓	R16	↓	↓
16 Blue Canyon	R62	R21 _{cavity} +R20	R19 _{cavity} +R4	R18	↓	↓

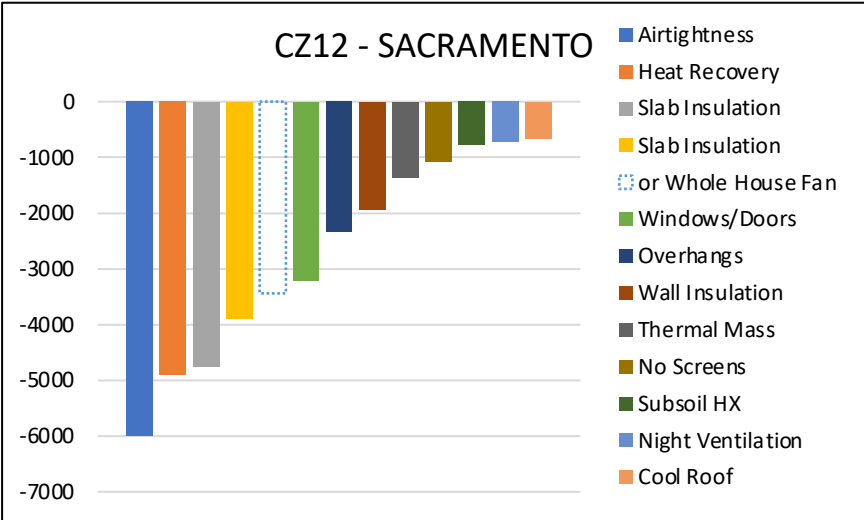
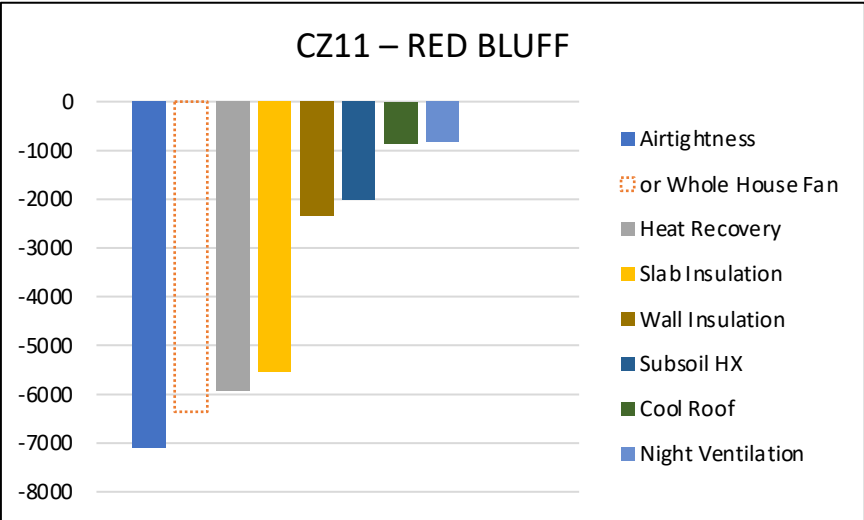
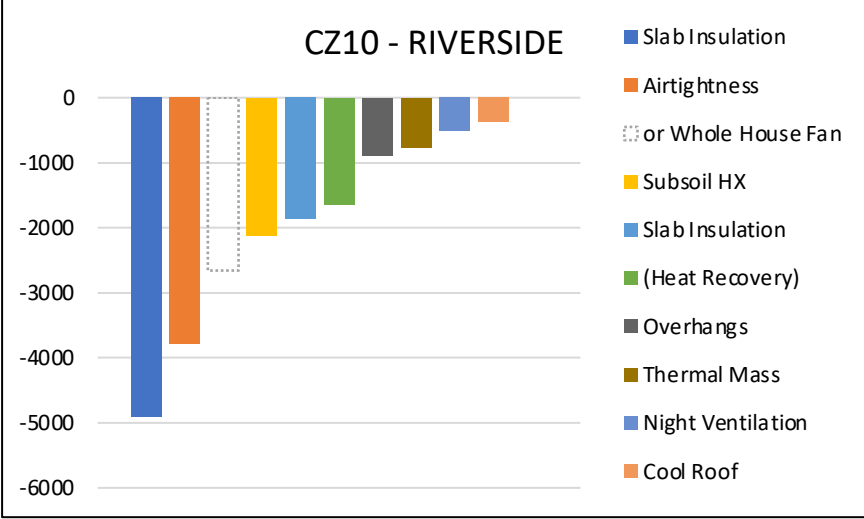
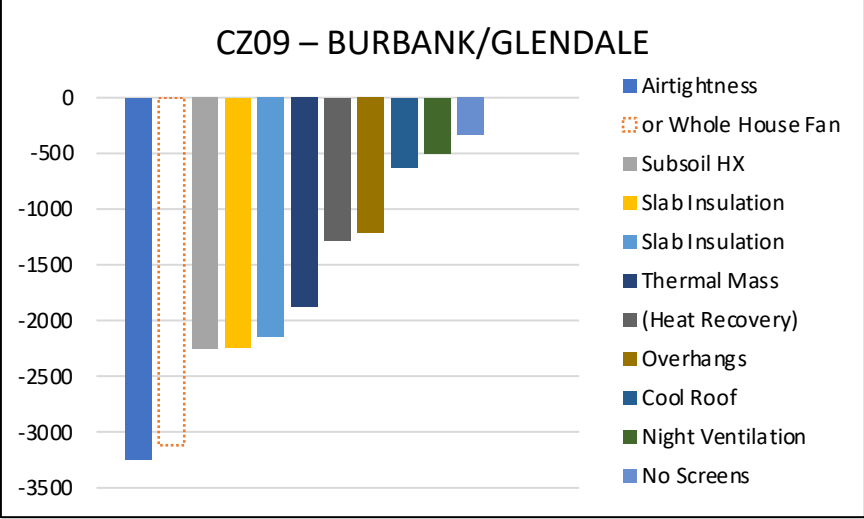
Most Effective Upgrades by Location



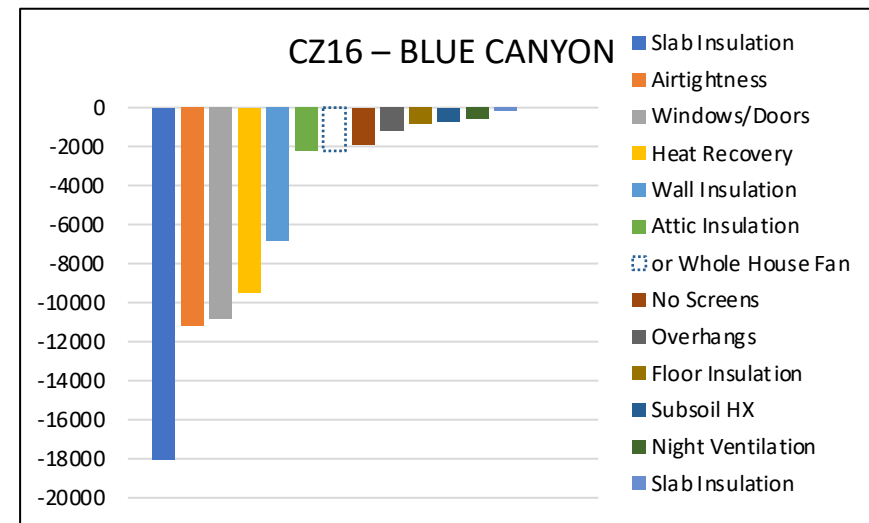
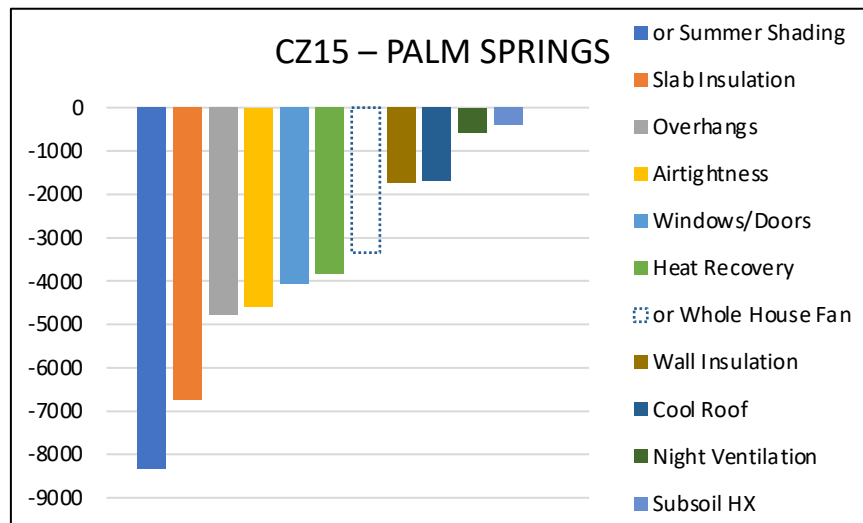
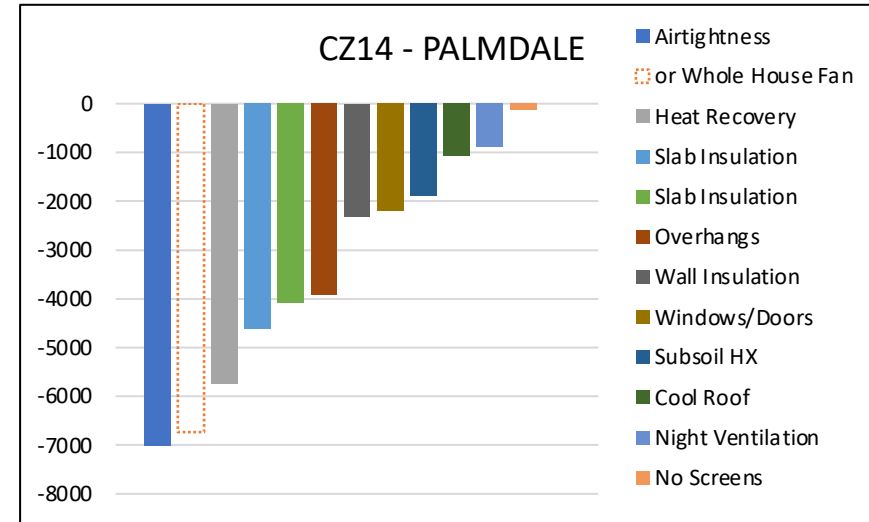
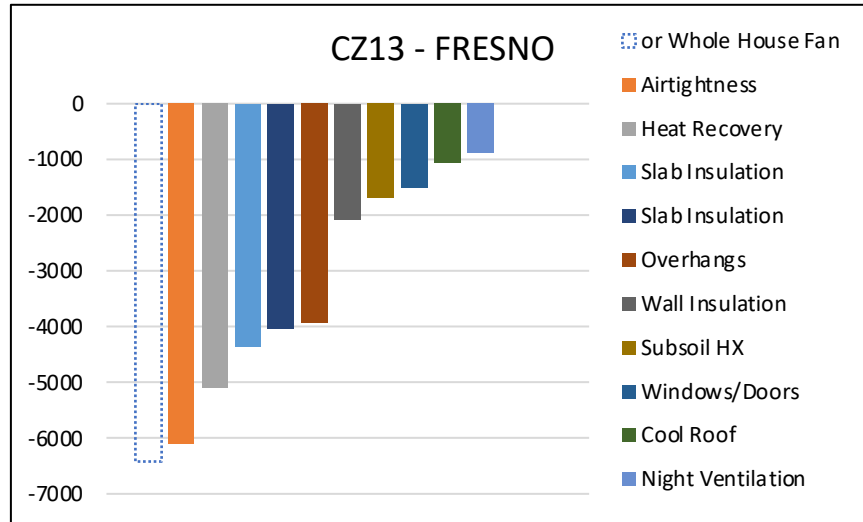
Most Effective Upgrades by Location



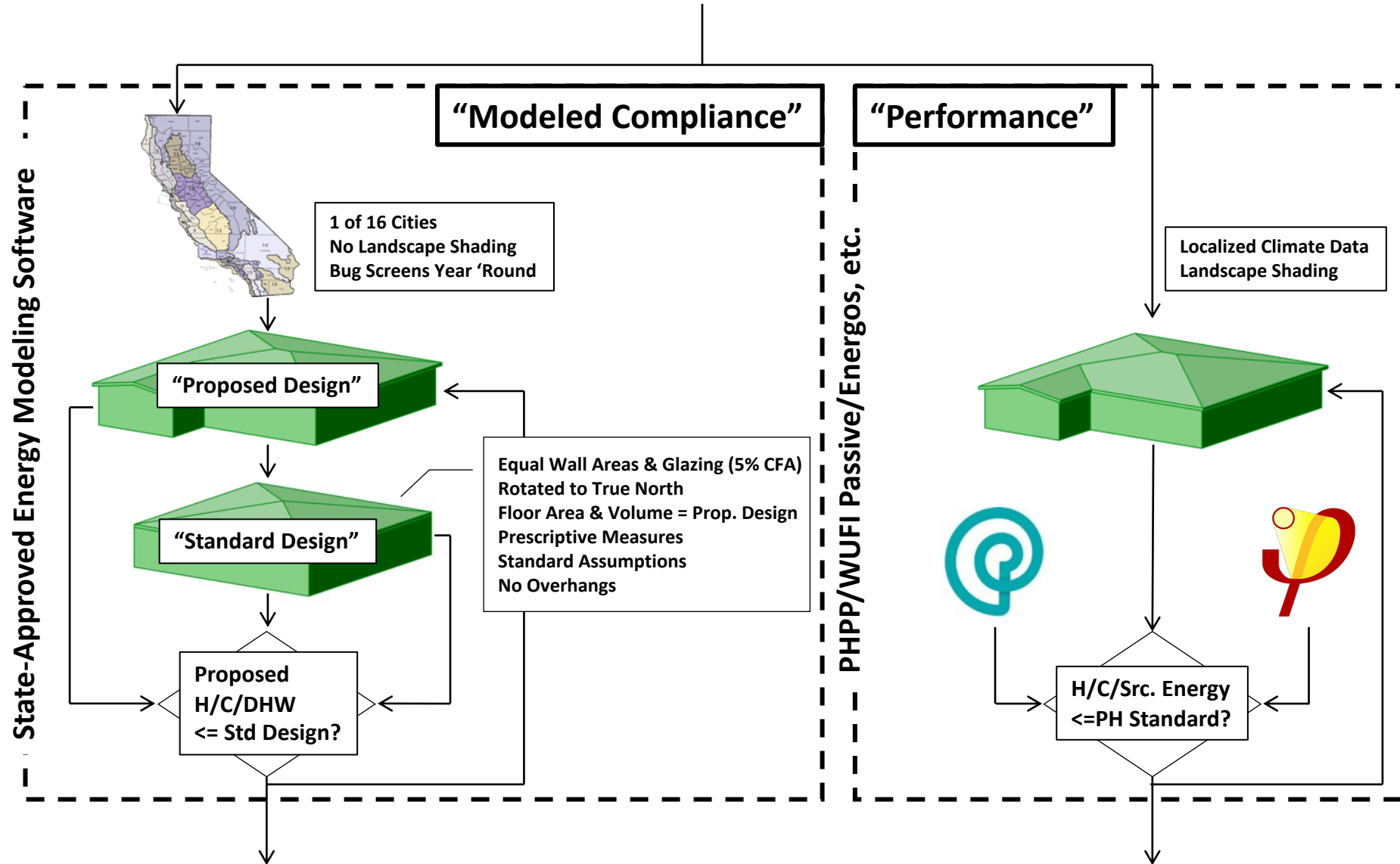
Most Effective Upgrades by Location



Most Effective Upgrades by Location



Title 24 vs. PH Energy Modeling



Performance vs. Modeled Compliance

2012 GMC Yukon Denali 1500 (15 MPG)



2012 Honda Civic HF (33 MPG)



2012 Yukon Denali 1500 Hybrid (21 MPG)



2012 Honda Civic Hybrid (44 MPG)



40% (6 MPG) Improvement

33% (11 MPG) Improvement

Reference: www.fueleconomy.gov, US DOE

Performance is an absolute standard, compliance is relative.

Thank you! Questions?



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