



Net Positive Plus 25%.... On Less Than 4kW of PV!

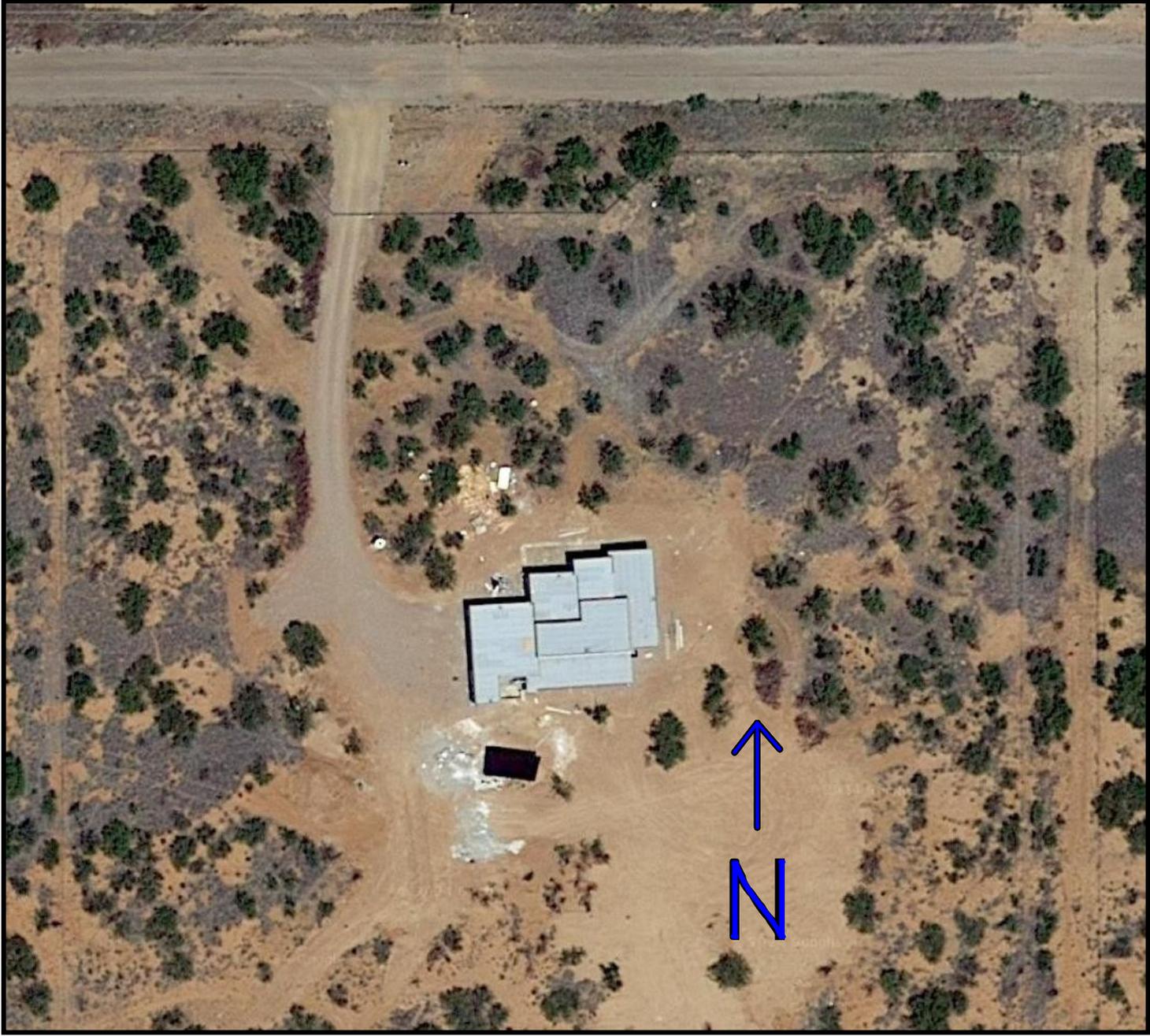


David Butler
Optimal Building Systems
Dry Climate Forum
February 5, 2024

Optimum Value Engineering for Comfort and Energy Efficiency

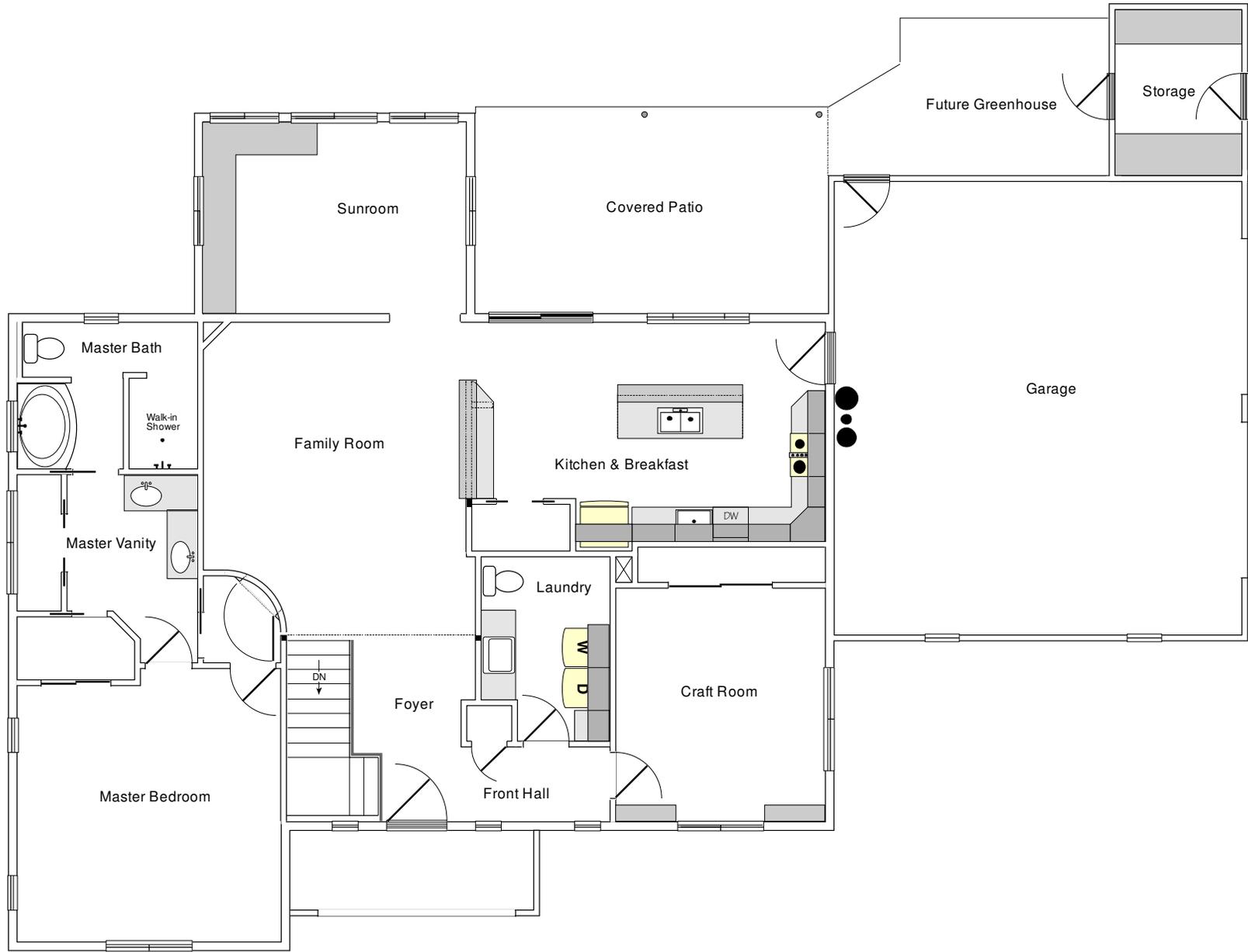
Optimum Value Engineering for Comfort and Energy Efficiency

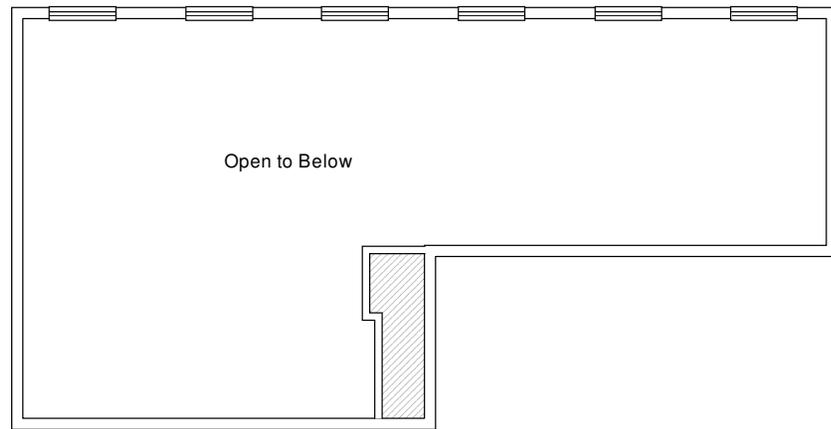
- Site selection
 - north-facing lot: ideal for most home designs

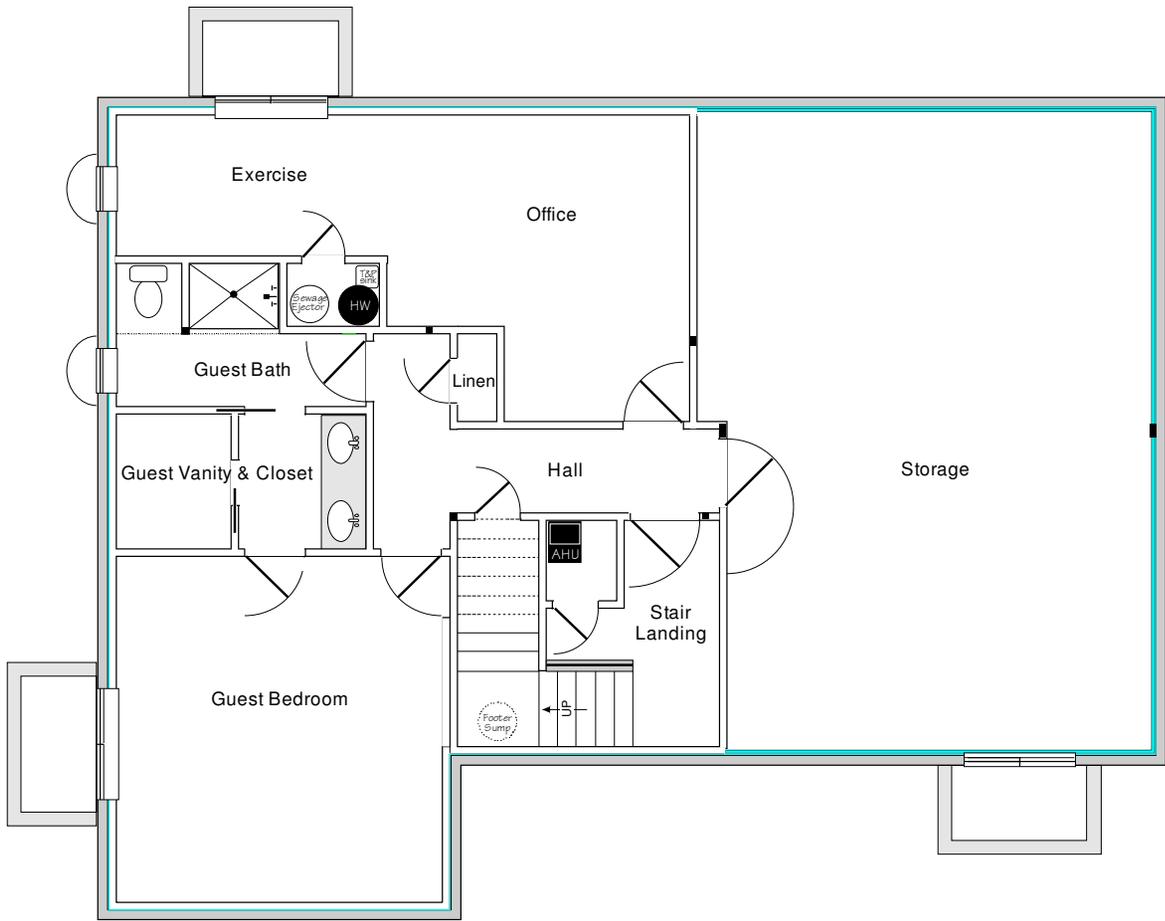


Optimum Value Engineering for Comfort and Energy Efficiency

- Site selection
 - north-facing lot: ideal for most home designs
- Passive solar design concepts
 - classic passive solar: incompatible with low-load construction...
 - except for engineered overhangs on all south-facing glass...
 - and strategic room layout







Optimum Value Engineering for Comfort and Energy Efficiency

- Site selection
 - north-facing lot: ideal for most home designs
- Passive solar design concepts
 - classic passive solar: incompatible with low-load construction...
 - except for engineered overhangs on all south-facing glass...
 - and strategic room layout
- Modeling
 - energy modeling: a design aid, not an end
 - master strengths & weaknesses of modeling tools
 - compare modeling results with actual performance data!
 - modeling results should inform, not control the design
 - heat pumps are notoriously difficult to model in new construction

Whetstone Green Enclosure Specifications

- Overall design
 - 3,300 sq.ft. conditioned floor area, 4 bedrooms, 2.5 baths
 - single level ranch over a basement (fully below grade)
 - flat roof with overhangs (unique), non-vented truss space
 - many advantages with basement design:
 - ideal location for mechanicals
 - ample storage (no attic storage with flat roof)
 - suspended ceiling provides easy access to wires, pipes & ducts
 - minimal actionable load (47% conditioned floor area below grade)

Whetstone Green Enclosure Specifications

- Overall design
 - 3,300 sq.ft. conditioned floor area, 4 bedrooms, 2.5 baths
 - single level ranch over a basement (fully below grade)
 - flat roof with overhangs (unique), non-vented truss space
 - many advantages with basement design:
 - ideal location for mechanicals
 - ample storage (no attic storage with flat roof)
 - suspended ceiling provides easy access to wires, pipes & ducts
 - minimal actionable load (47% conditioned floor area below grade)
- Enclosure, lighting & appliance specifications
 - 2x6 above-grade walls 24-oc, R-23 BIBS + R-4 exterior EPS
 - 2x4 below-grade walls 24-oc, R-13 batts + R-6 continuous EPS
 - 6" ocSPF in floor truss band (~R-22), 9" ocSPF on roof deck (~R-33)
 - vinyl windows with 0.28 u-factor, 0.19 SHGC
 - air tightness tested out @ 0.52 ACH50
 - EnergyStar appliances, conventional electric smoothtop range
 - strategically located electric water heater, structured plumbing
 - LED lighting throughout

Blown-in Blanket System™ (BIBS)



Open-cell spray polyurethane foam (ocSPF)



Below-grade walls: R-13 + R-2 continuous EPS
6" ocSPF in truss band (R-22)



Exterior below-grade walls Ames BlueMax™ liquid rubber + R-4 EPS



Exterior above-grade wall insulation: R-4 EPS



High reflectance & emissivity roof coating
Henry 687 – 3 yr SR 0.80, TE 0.90



Whetstone Green Modeling Results

- Outdoor design conditions for nearby Sierra Vista:
 - Summer 93F, Winter 28F
 - 1,710 CDD, 2,370 HDD (Fort Huachuca)
- Indoor design conditions
 - Summer 78F daytime, 73F nighttime (Master BR zone only)
 - Winter 69F daytime, 66F nighttime
 - Note: basement zone rarely has actionable heat or cooling call

Whetstone Green Modeling Results

- Outdoor design conditions for nearby Sierra Vista:
 - Summer 93F, Winter 28F
 - 1,710 CDD, 2,370 HDD (Fort Huachuca)
- Indoor design conditions
 - Summer 78F daytime, 73F nighttime (Master BR zone only)
 - Winter 69F daytime, 66F nighttime
 - Note: basement zone rarely has actionable heat or cooling call
 - 2 retired occupants
- Design loads @ 93F, 28F
 - Cooling 7,676 Btuh, Heating 14,593 Btuh
- Design loads @ 100F, 17F
 - Cooling 9,480 Btuh, Heating 18,608 Btuh
 - For high performance homes, MJ overstates design heat loads by up to 100%, depending on climate...
 - MJ intentionally ignores internal loads, solar heat gains and thermal mass. These factors loom large in low-energy homes!

Whetstone Green Modeling Results

- Outdoor design conditions for nearby Sierra Vista:
 - Summer 93F, Winter 28F
 - 1,710 CDD, 2,370 HDD (Fort Huachuca)
- Indoor design conditions
 - Summer 78F daytime, 73F nighttime (Master BR zone only)
 - Winter 69F daytime, 66F nighttime
 - Note: basement zone rarely has actionable heat or cooling call
 - 2 retired occupants
- Design loads @ 93F, 28F
 - Cooling 7,676 Btuh, Heating 14,593 Btuh
- Design loads @ 100F, 17F
 - Cooling 9,480 Btuh, Heating 18,608 Btuh
 - For high performance homes, MJ overstates design heat loads by up to 100%, depending on climate...
 - MJ intentionally ignores internal loads, solar heat gains and thermal mass. These factors loom large in low-energy homes!
- Energy Model
 - 6,900 kWh/year (all-electric except outdoor grill)

Whetstone Green Mechanical Specifications

- 1-ton heat pump
 - Carrier 18VS 5-stage heat pump (25VNA813)
 - variable fan coil (FE4ANF002)
 - 3 kW supplemental heat kit (10k Btuh)
 - Infinity zone control (4 zones, load diversity)
 - AHRI Ratings
 - cooling capacity: 13,000 Btuh @ 95F
 - seasonal cooling efficiency: 17 SEER
 - heating capacity: 17,000 @ 47F, 11,200 @ 17F
 - heating efficiency: ???

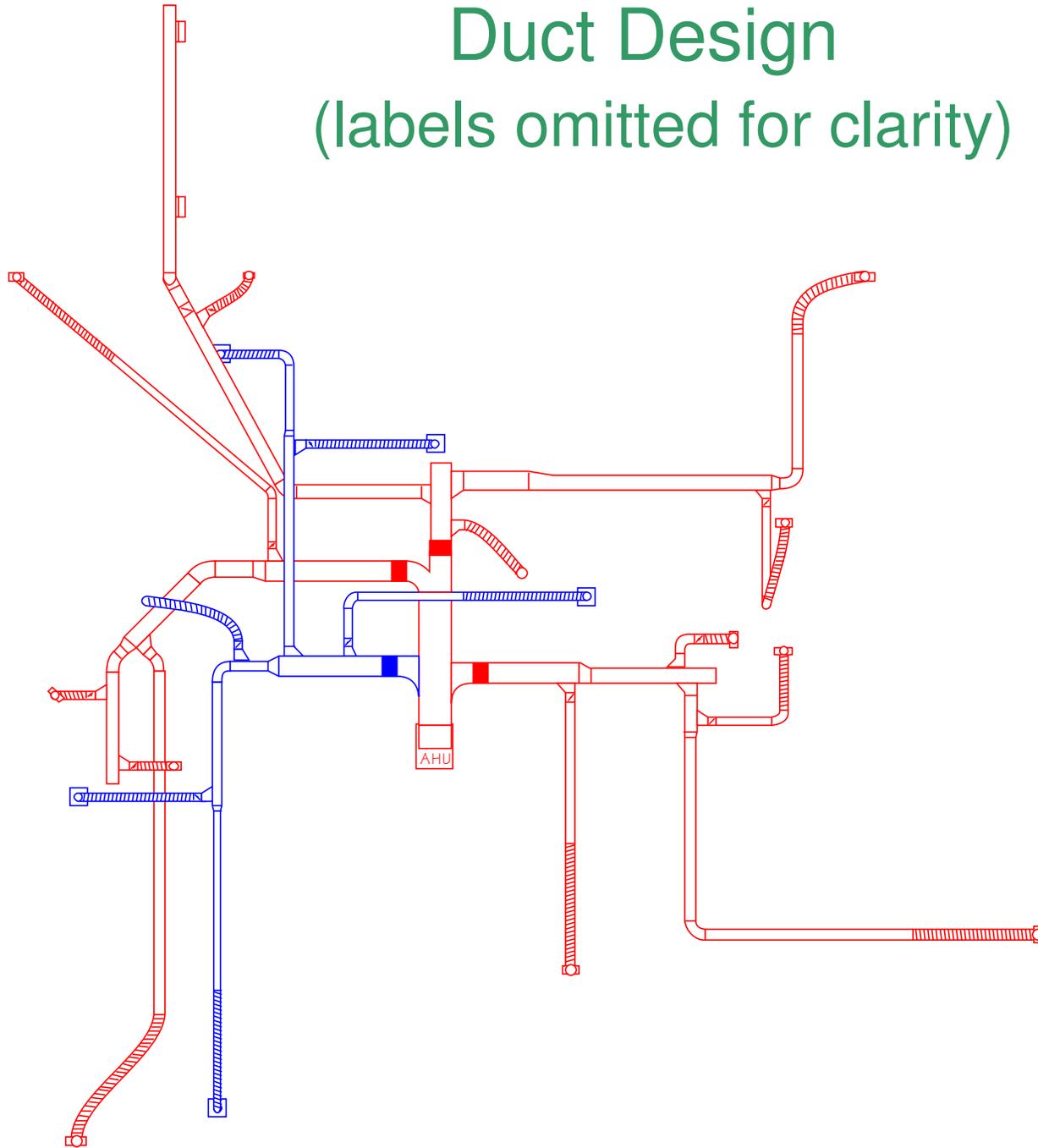
Mechanical equipment



Whetstone Green Mechanical Specifications

- 1-ton heat pump
 - Carrier 18VS 5-stage heat pump (25VNA813)
 - variable fan coil (FE4ANF002)
 - 3 kW supplemental heat kit (10k Btuh capacity)
 - Infinity zone control (4 zones, load diversity)
 - AHRI Ratings
 - cooling capacity: 13,000 Btuh @ 95F
 - seasonal cooling efficiency: 17 SEER
 - heating capacity: 17,000 @ 47F, 11,200 @ 17F
 - heating efficiency: ???
- Ducts fully inside conditioned space
 - supply ducts routed through floor trusses
 - ductless return – ideal for basement homes
 - Duct Blaster[®] test – ‘4th ring club’ candidate

Duct Design (labels omitted for clarity)



Whetstone Green Mechanical Specifications

- 1-ton heat pump
 - Carrier 18VS 5-stage heat pump (25VNA813)
 - variable fan coil (FE4ANF002)
 - 3 kW supplemental heat kit (10k Btuh capacity)
 - Infinity zone control (4 zones, load diversity)
 - AHRI Ratings
 - cooling capacity: 13,000 Btuh @ 95F
 - seasonal cooling efficiency: 17 SEER
 - heating capacity: 17,000 @ 47F, 11,200 @ 17F
 - heating efficiency: ???
- Ducts fully inside conditioned space
 - supply ducts routed through floor trusses
 - ductless return – ideal for basement homes
 - Duct Blaster[®] test – ‘4th ring club’ candidate
- Built-in space heaters
 - 134W embedded floor heat at desk seating area
 - 300W convection radiator in Master Bath

Embedded floor heat at desk (40" x 40")



Whetstone Green Ventilation Specifications

- Master bedroom economizer
 - Fantech PrioAir 6EC (ECM motor with PWM or 0-10mA input)
 - EWC URD MA-ND5 motorized damper
 - ‘free’ cooling, ideal for arid climate with high daily temp. swings
 - computerized control (single-board CPU, ODT & IDT sensors)
 - provides roughly a 20% reduction in annual cooling load
 - whole-house CO2 dilution via AHU ‘continuous fan’ @ low speed
 - **TBD:** add CO2 input to CPU to minimize ‘unfavorable’ ventilation



Economizer



Whetstone Green Solar Specifications

- 3840 Watt capacity
 - ground mount array out of necessity, 30° tilt, 184° azimuth
 - 12 LG 320W panels (2018)
 - 12 Enphase IQ 6+ micro-inverters
 - Enphase IQ Combiner
 - modeled solar production 7,600 kWh/yr (110% of modeled load)



Whetstone Green Performance Data

- Heat pump performance at peak cooling loads
 - initially omitted high reflectance roof coating to gauge impact
 - first summer (2019), indoor temp slipped 1° when ODT > 101°
 - nighttime cool-down for Master BR (73°) took too long
 - after coatings applied, heat pump can now hold 78° up to 105° !

Whetstone Green Performance Data

- Heat pump performance at peak cooling loads
 - initially omitted high reflectance roof coating to gauge impact
 - first summer (2019), indoor temp slipped 1° when ODT > 101°
 - nighttime cool-down for Master BR (73°) took too long
 - after coatings applied, heat pump can now hold 78° up to 105° !
- Supplemental heat consumption
 - heat pump auxiliary strips – average 44 kWh/yr
 - desk embedded floor heat, Master Bath radiator – avg. 30 kWh/yr

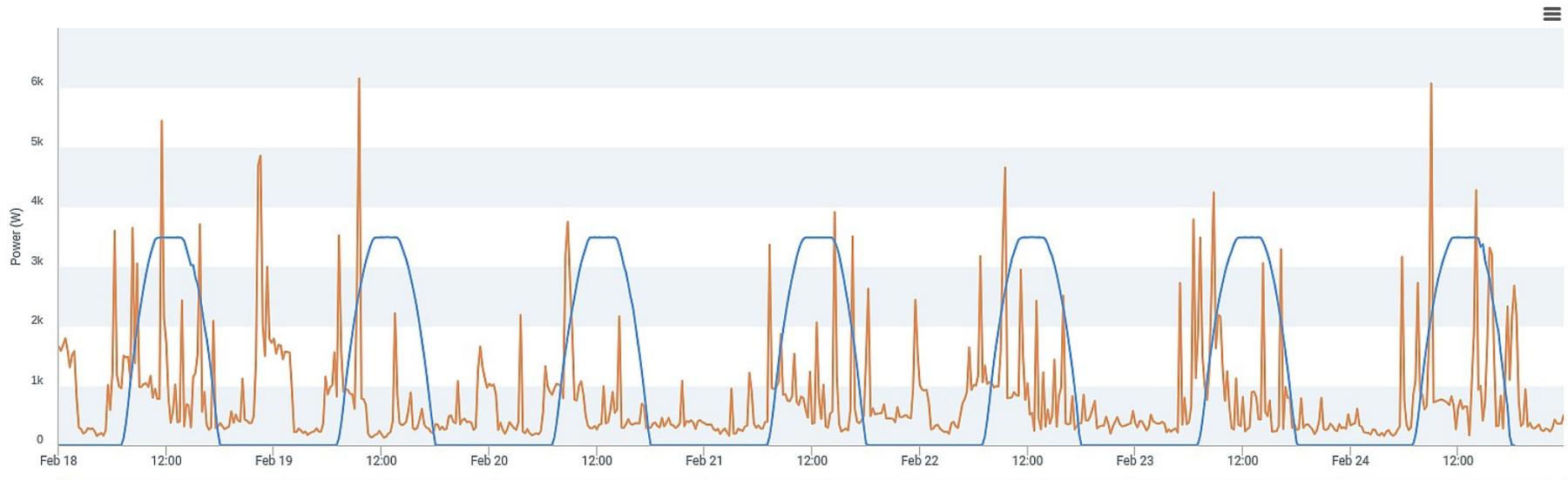
Whetstone Green Performance Data

- Heat pump performance at peak cooling loads
 - initially omitted high reflectance roof coating to gauge impact
 - first summer (2019), indoor temp slipped 1° when ODT > 101°
 - nighttime cool-down for Master BR (73°) took too long
 - after coatings applied, heat pump can now hold 78° up to 105° !
- Supplemental heat consumption
 - heat pump auxiliary strips – average 44 kWh/yr
 - desk embedded floor heat, Master Bath radiator – avg. 30 kWh/yr
- Whole-house consumption
 - modeled: 6,900 kWh/yr
 - actual: 6,280 kWh/yr – first two years (7/1/19 to 6/30/21)
6,725 kWh/yr – most recent two years (2/1/22 to 1/31/24)

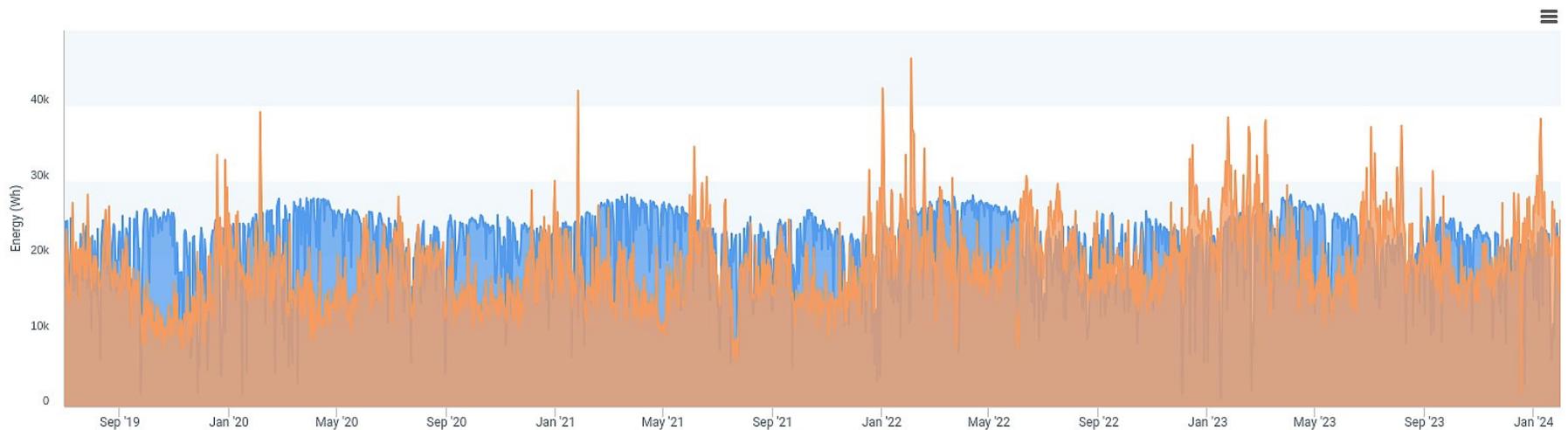
Whetstone Green Performance Data

- Heat pump performance at peak cooling loads
 - initially omitted high reflectance roof coating to gauge impact
 - first summer (2019), indoor temp slipped 1° when ODT > 101°
 - nighttime cool-down for Master BR (73°) took too long
 - after coatings applied, heat pump can now hold 78° up to 105° !
- Supplemental heat consumption
 - heat pump auxiliary strips – average 44 kWh/yr
 - desk embedded floor heat, Master Bath radiator – avg. 30 kWh/yr
- Whole-house consumption
 - modeled: 6,900 kWh/yr
 - actual: 6,280 kWh/yr – first two years (7/1/19 to 6/30/21)
6,725 kWh/yr – most recent two years (2/1/22 to 1/31/24)
- Solar performance
 - modeled: 7,600 kWh/yr (1,980 kWh/kW, 110% of modeled load)
 - actual: 7,910 kWh/yr – first two years, 126% of actual
7,790 kWh/yr – most recent two years, 116% of actual

Enphase Winter Power Graph



Enphase Lifetime Energy Graph



Thank you for listening!



Questions?