Journey women's center

MATERNITY HOME | TEAM: OSU | DIVISION: AH | CZ: 4A

Hope | Community | Resiliency

U.S. DEPARTMENT OF ENERGY Solar Decathlon

OSU

TEAM INTRODUCTION

Community Partners

Journey Women's Center - Amy Voth

Industry Partners

Guaranteed Watt Saver – Kelly Parker
820 Solar – Cory Baitz
Standard Panel – John Pardue
AWAD Construction
Dolese
Lee Glass and Window

Special Thanks

Homestead School - Bruce & Barbra Johnson

Instructors

Khaled Mansy, Ph.D. – Architecture
Jay Yowell, AIA – Architecture
Christian Bach, Ph.D. – M. Engineering
Hebatalla Nazmy, Ph.D. – Interior Design

Christian Brack
Architecture

Abigail Richardson
Architecture

Emily Smith
Architecture

Pouria MoghimiGhadikolaei
Mechanical Engineering

Maggie Carathers
Architecture

Jahnia Wright
Interior Design

Ian Strickland
Architecture

Jacob Gore
Architecture

Whitney Waitsman
Architecture

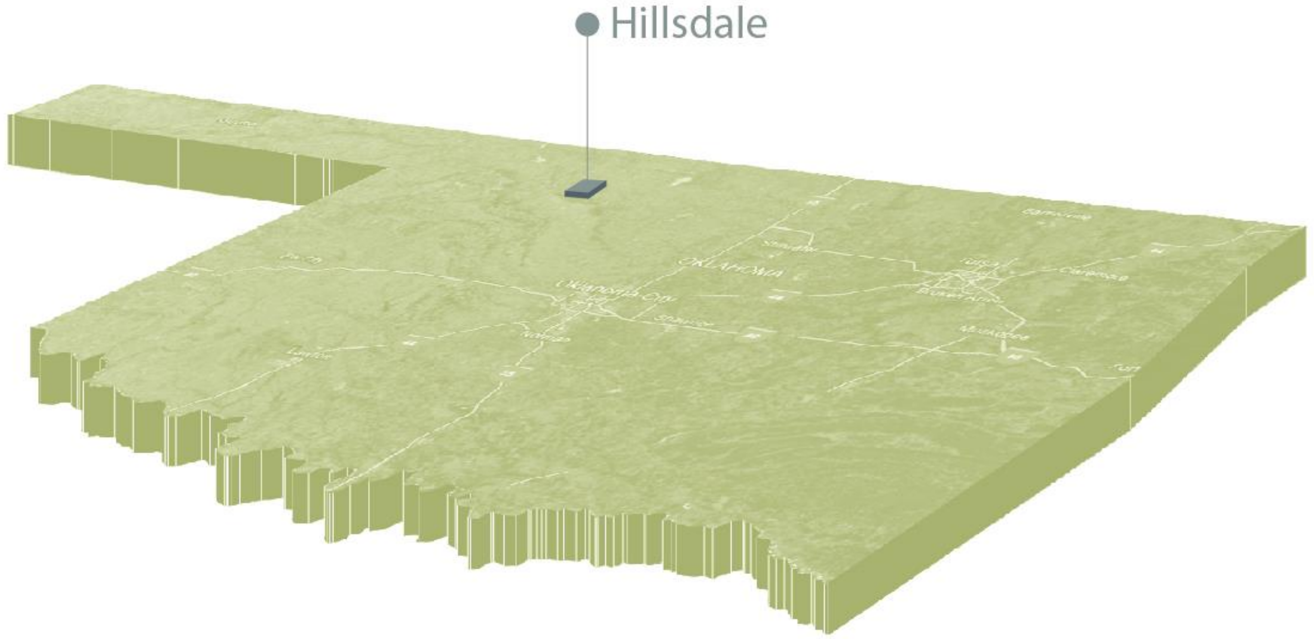
Amr Abdelmoneim
Mechanical Engineering

Lia Jenson
Interior Design

Molly Hoback
Team Lead, Architecture

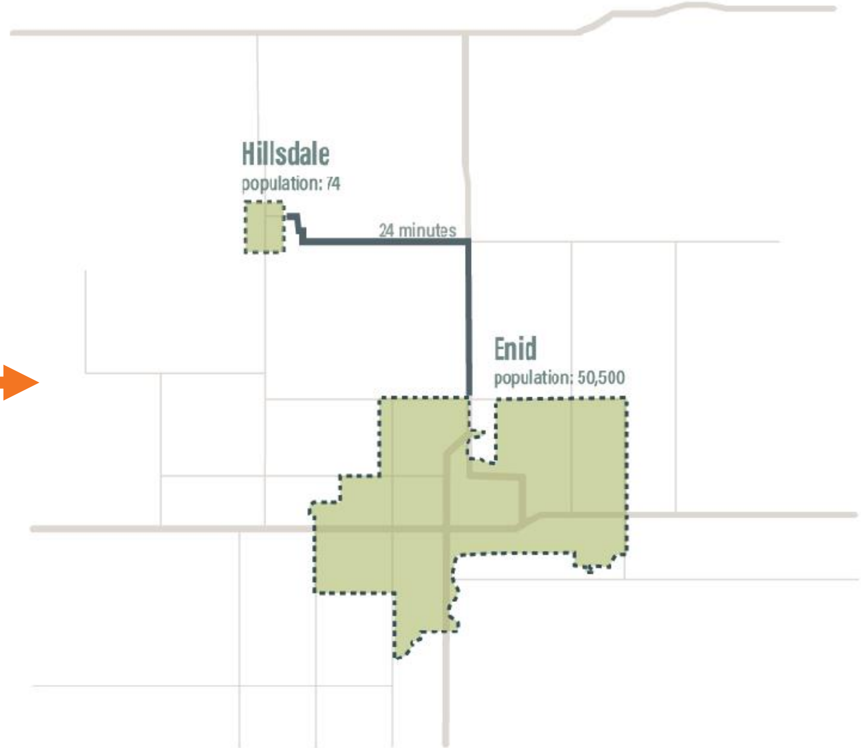
SITE CONTEXT

State of Oklahoma



The location of the Journey House resides in the State of Oklahoma. Serving a nearby community within our state has drastically impacted the significance and relationship with Oklahoma State University.

Hillsdale, OK



Journey Women's Center Headquarters is in the town of Enid, Oklahoma which is a 24-minute drive from our site of Hillsdale, Oklahoma for the Journey House.

Northview Road & Conner Street

The illustrated site focuses in on the intersection of streets in Hillsdale. Unit A and B of the Attached Housing project are displayed as well as the additional transitional Units C & D.

H C R

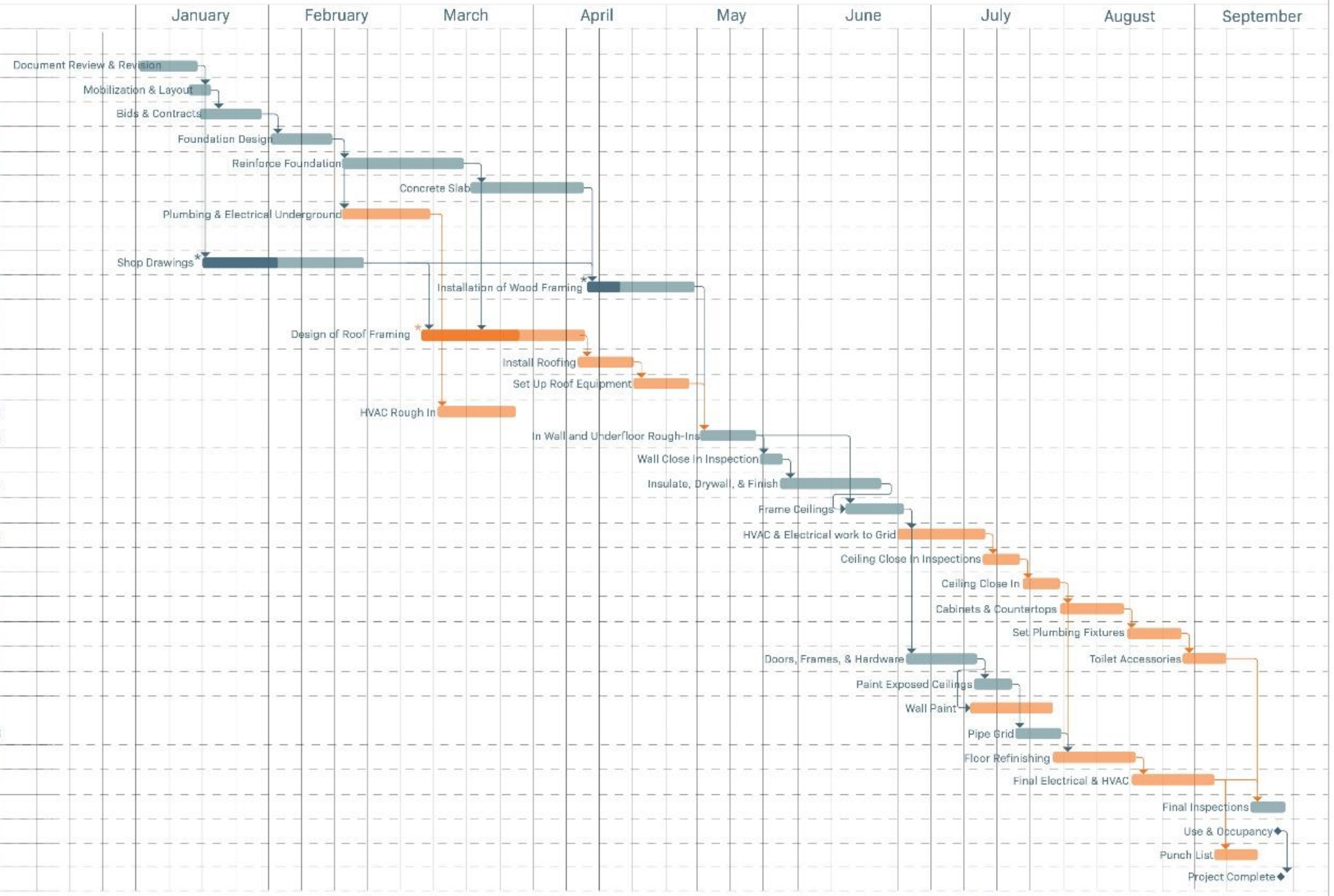
BUDGET & TIMELINE

Journey women's center

Solar Decathlon Journey Women's Center Construction Timeline

2 Construction Phase

	Task	Days
1	Document Review & Revision	12 days
2	Mobilization & Layout	3 days
3	Bid & Contracts	10 days
4	Foundation Design	10 days
5	Reinforce Foundation	20 days
6	Concrete Slab	28 days
7	Plumbing & Electrical Underground	15 days
8	**Wood Framing**	48 days
9	Shop Drawings	33 days
10	Installation of Wood Framing	15 days
11	**Roofing**	27 days
12	Design Roof Framing	30 days
13	Install Roofing	15 days
14	Set up Roof Equipment	2 days
15	HVAC Rough In	20 days
16	In-Wall and Underfloor Rough-Ins	10 days
17	Wall Close In Inspection	1 day
18	Insulate, Drywall & Finish	20 days
19	Frame Ceilings	5 days
20	HVAC & Electrical work to Grid	12 days
21	Ceiling Close In Inspection	1 day
22	Ceiling Close In	4 days
23	Cabinets & Countertops	3 days
24	Set Plumbing Fixtures	5 days
25	Toilet Accessories	5 days
26	Doors, Frames, & Hardware	7 days
27	Paint Exposed Ceilings	4 days
28	Wall Paint	12 days
29	Pipe Grid	3 days
30	Final Electrical & HVAC	8 days
31	Final Inspections	3 days
32	Use & Occupancy	3 days
33	Punch List	7 days
34	FINISH PROJECT	0 day



Task | Critical | Milestone | SIPS Panels Installation Improvement * | SIPS Panels Design Improvement *

Figure 1.4: Gantt Chart Timeline for Construction Phase

Model 1

~$152.50/SF | $460,691.50

Model 5

~$180.02/SF | $545,049.57

A cost the client can afford. Land is donated. SIPs are donated. 30% rebate on PV.

Model 1

36 weeks

Model 5

30 weeks

A net saving of 6 weeks.

If we were to start construction in January of 2025, the estimated end date would land at the end of September totaling 36 weeks. However, with the integration of SIPs Panels, it would reduce the total construction time by 6 weeks.

TARGET MARKET

Journey women's center

295+ CLIENTS SERVED

195+ ULTRASOUNDS GIVEN

225+ PREGNANCY TESTS

495+ APPOINTMENTS AT NO COST

"Journey Women's Center educates, supports, and empowers women facing unplanned pregnancies with compassionate, professional care."

Services

No-Cost Limited OB Ultrasounds

Options Counseling

No Cost Pregnancy Tests

Purpose of Design

+ The maternity home will provide housing for 4 women and house parents in each unit

+ The goal of the maternity home is to provide safe housing and an encouraging environment for women

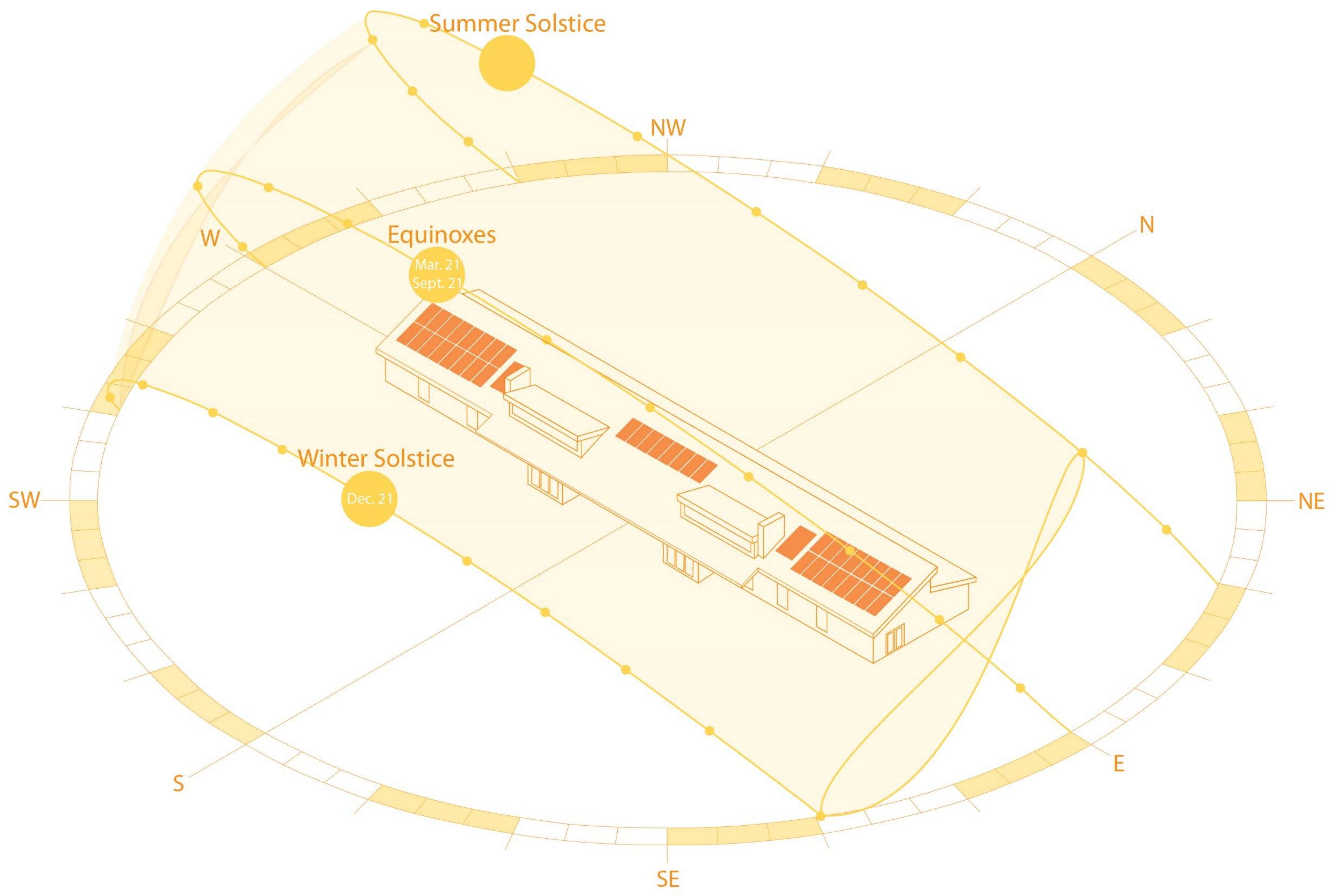
+ Women can live there during pregnancy all the way until the child is 1 year old

"Oklahoma has the second highest teen pregnancy rate in the nation."

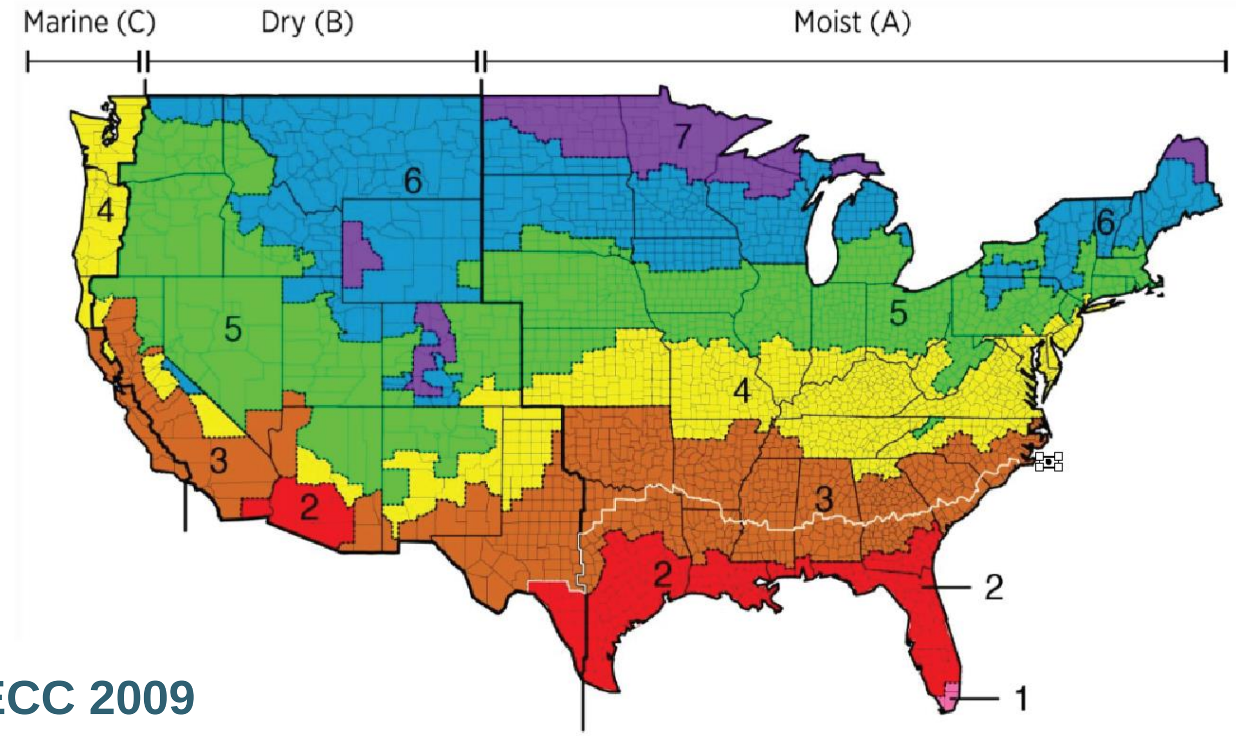
(FocusForwardOK)

LOCAL CLIMATE

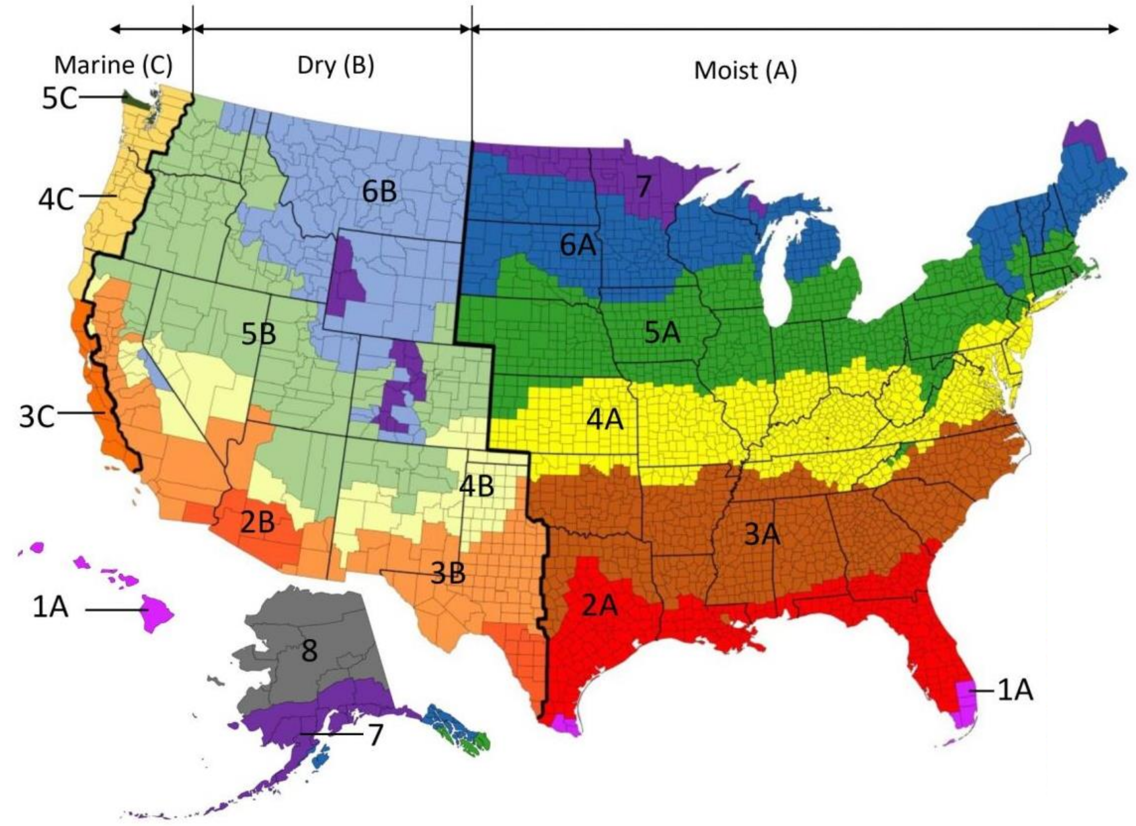
Sun Path Diagram



Climate Zone Maps



IECC 2009

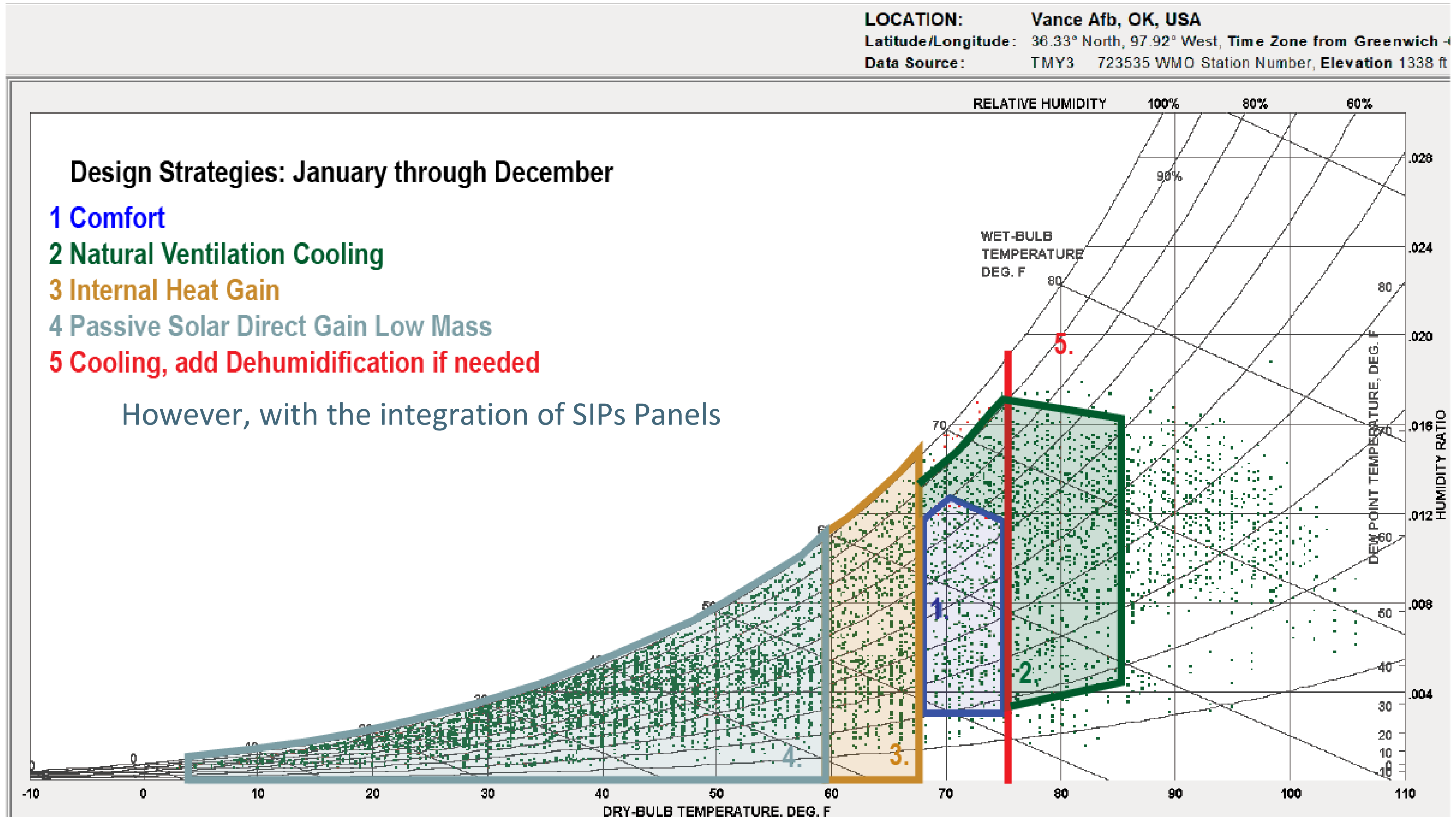


IECC 2021

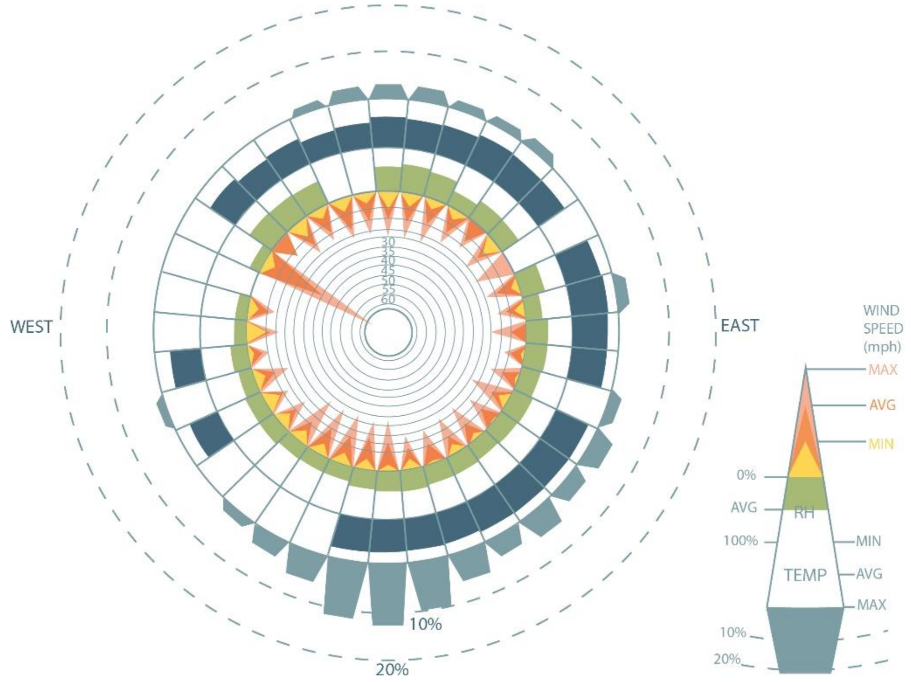
LOCAL CLIMATE

Journey women's center

Psychrometric Chart - Hourly



Psychrometric Chart - Hourly



Temperature Range

According to IECC 2021, Hillsdale, Oklahoma is located within Climate Zone 4A. Temperature range helped us in the design of passive solar heating, and the wind wheel helped us to design the natural ventilation and the fan-assisted ventilation. Our climate provides a **high potential** for passive heating and cooling. Additionally, resources such as the Psychrometric chart provided guidance in our desired condition of the air. The utilization of the Sun Path Solar Diagram allowed us to develop the necessary overhangs and window openings.

BUILDING CODES & STANDARDS

Journey women's center

Building Codes	IECC 2009	IECC 2021+ZERH	PHIUS	Model 5
Energy Code IECC 2009, IECC 2021, RESNET 301 (2019) Envelope Values	**R-1** Slab & Perimeter	**R-10** Slab & Perimeter	**R-13** Slab & Perimeter	**R-14** Slab & Perimeter
Building Code IBC 2018 (R-2), IRC 2009, IRC 2021 Building Classification & Req's	**R-15** Wall	**R-32** Wall	**R-35** Wall	**R-43** Wall
Mechanical Standard ASHRAE 62.2 (2019), 90.2 (2018), 228 (2019), 55.2 (2017), 227P (2023), ACCA Manual S & J System Sizing & Ventilation	**R-32** Roof	**R-60** Roof	**R-62** Roof	**R-65** Roof
Standards & Programs DOE ZERH, Phius, WELL Envelope Values & Best Practices	**U: 0.50** **SHGC: 0.30** Glass	**U: 0.30** **SHGC: 0.40** Glass	**U: 0.19** **SHGC: 0.40** Glass	**U: 0.20** **SHGC: 0.37** Glass

DESIGN GOALS

Hope

Community

Resiliency

DESIGN GOALS

Journey women's center

Hope

+ **24/7 Care**
+ **Biophilic design**
+ **Natural light / shadow-free daylighting**
+ Positive environment for healing & gaining life skills
+ Open views to outside
+ Rural living
+ Community greenhouse

DESIGN GOALS

Journey women's center

Community + Design Justice

+ **Local support**
+ **Cluster design**
+ Funds from Enid/Hillsdale
+ Site donated by community member
+ Outdoor living
+ Open plan and shared bathrooms

DESIGN GOALS

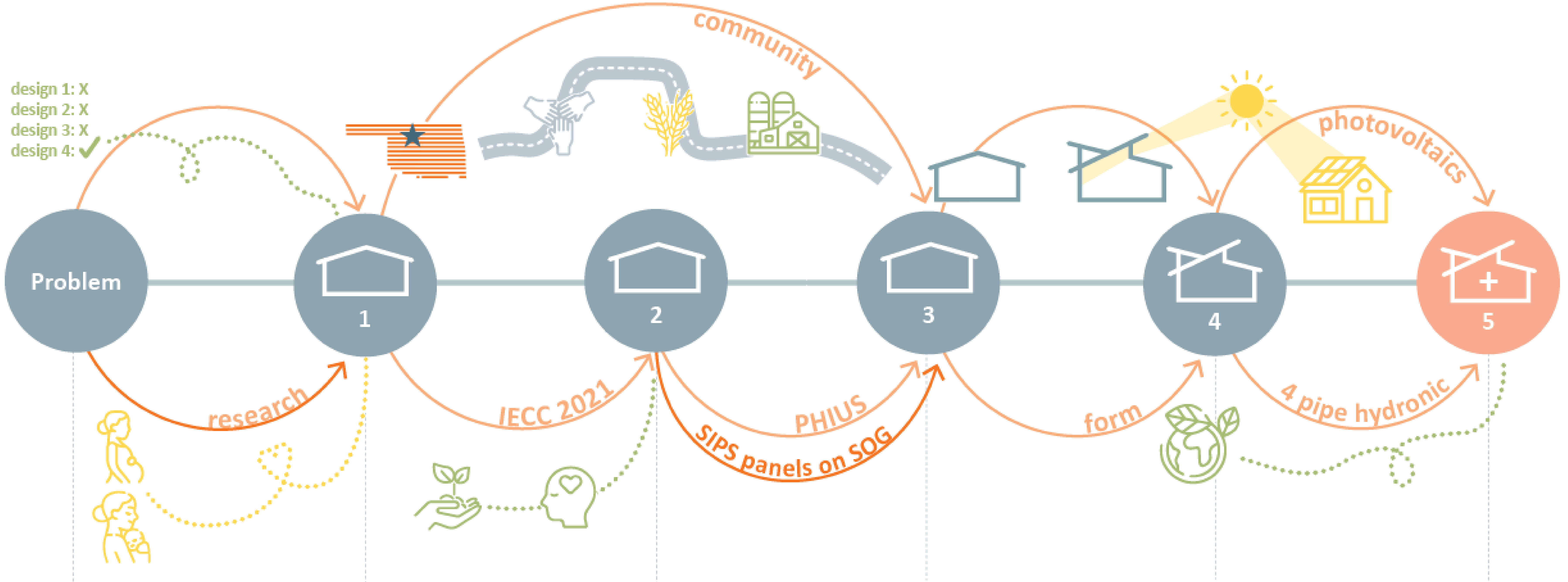
Journey women's center

Resiliency + Sustainability + Climate Action

+ **Sustainable materials**
+ **Passive systems**
+ **PV & Battery storage**

+ Natural ventilation
+ Solar water heating with 80-gallon tank & backup electric coil/heating
+ FEMA-Approved above-ground storm shelter, easily accessible & close to exterior wall
+ Vegetable garden
+ Future community wind power

DESIGN METHODOLOGY

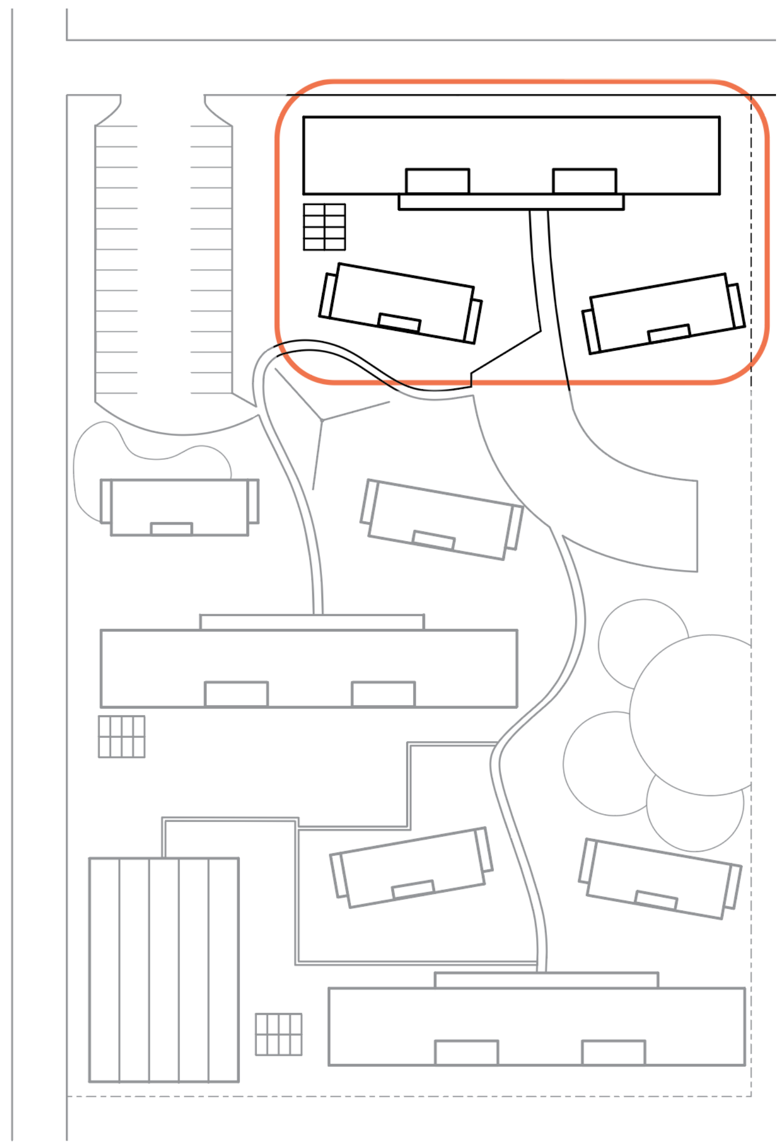


structure:	Wood Framing on SOG	SIPS panels on SOG	
mechanical:	Ducted Furnace + AC	Ductless Mini-Splits + DOAS	4 Pipe Hydronic + ERV
energy:	Ekotrope		Energy Plus

OVERVIEW

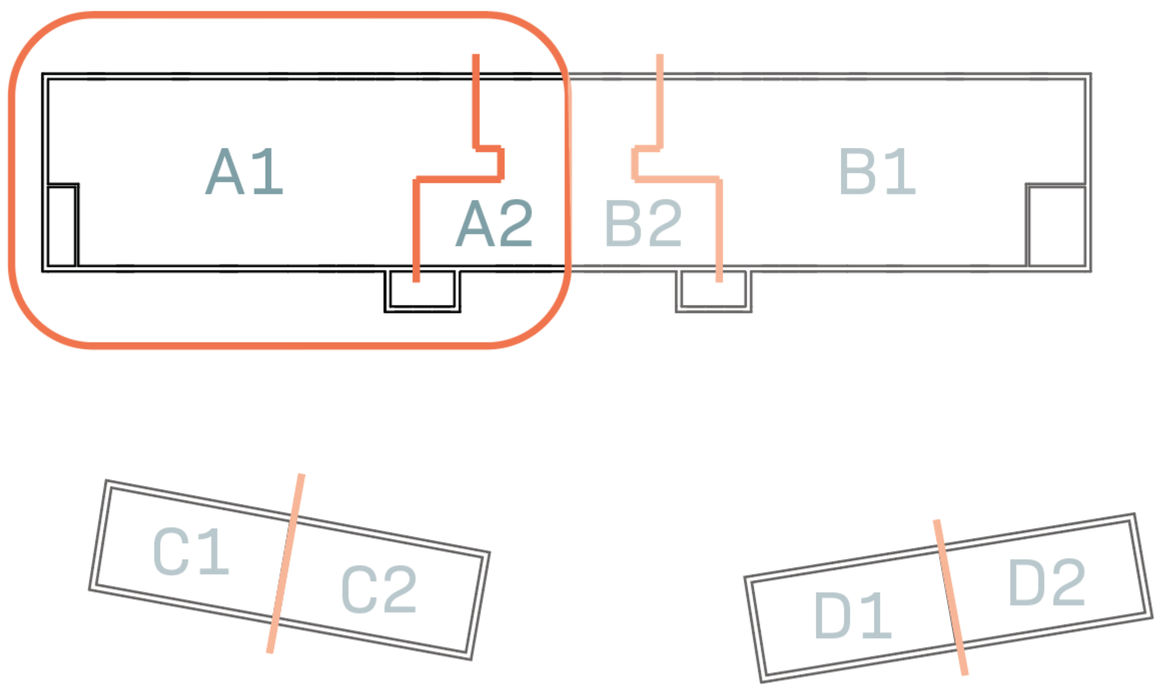
Phase 3

A Compound of 3 Clusters



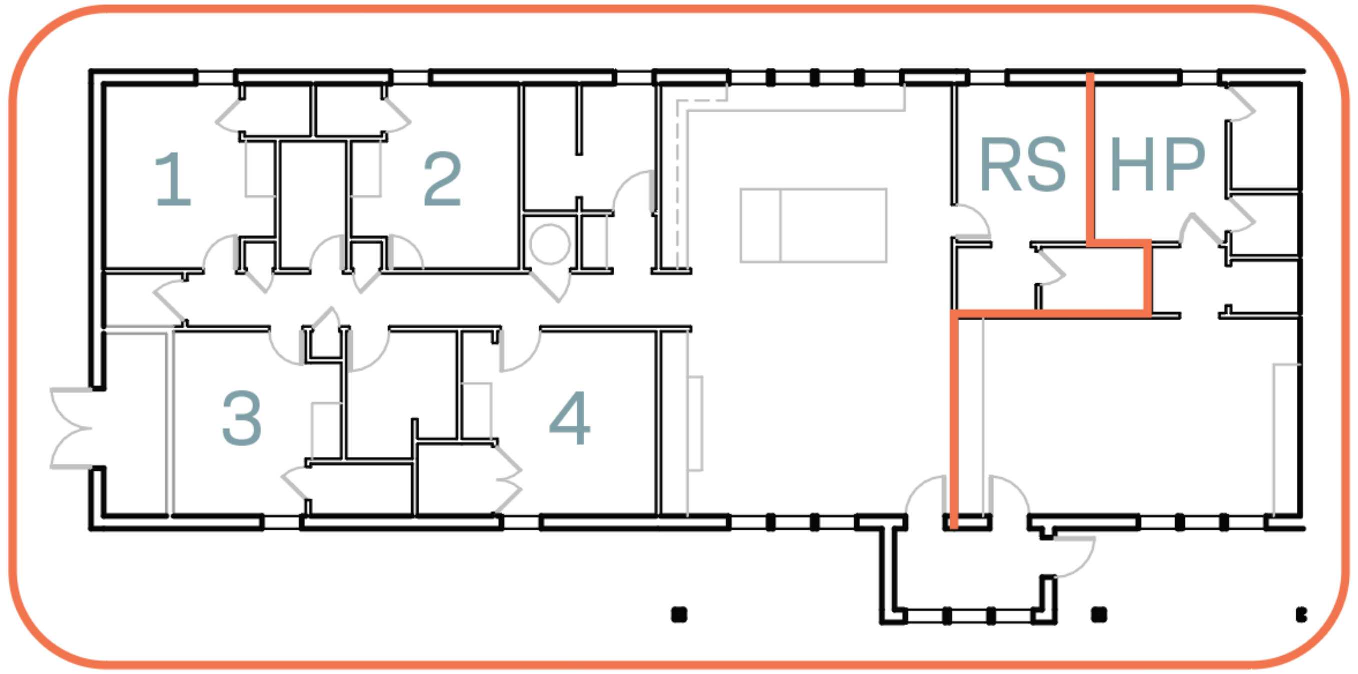
Phase 2

The North Cluster:
Units A + B = Maternity Homes
Units C + D = Transitional Units



Phase 1

4 Dwelling Units: A1 + A2 + B1 + B2



4 Units 2 Maternity Units 2 Support Units	**5,980 SF** 12 Bedrooms 8 Bathrooms	**Climate Zone: 4A**	**Site EUI Before PV: 9.64** kBtu/SF/yr	**Site EUI After PV: -2.81** kBtu/SF/yr	**HERS Before PV: A1 = 26 A2 = 27**	**HERS After PV: A1 = -1 A2 = -3**	**Annual Savings: $1,248**

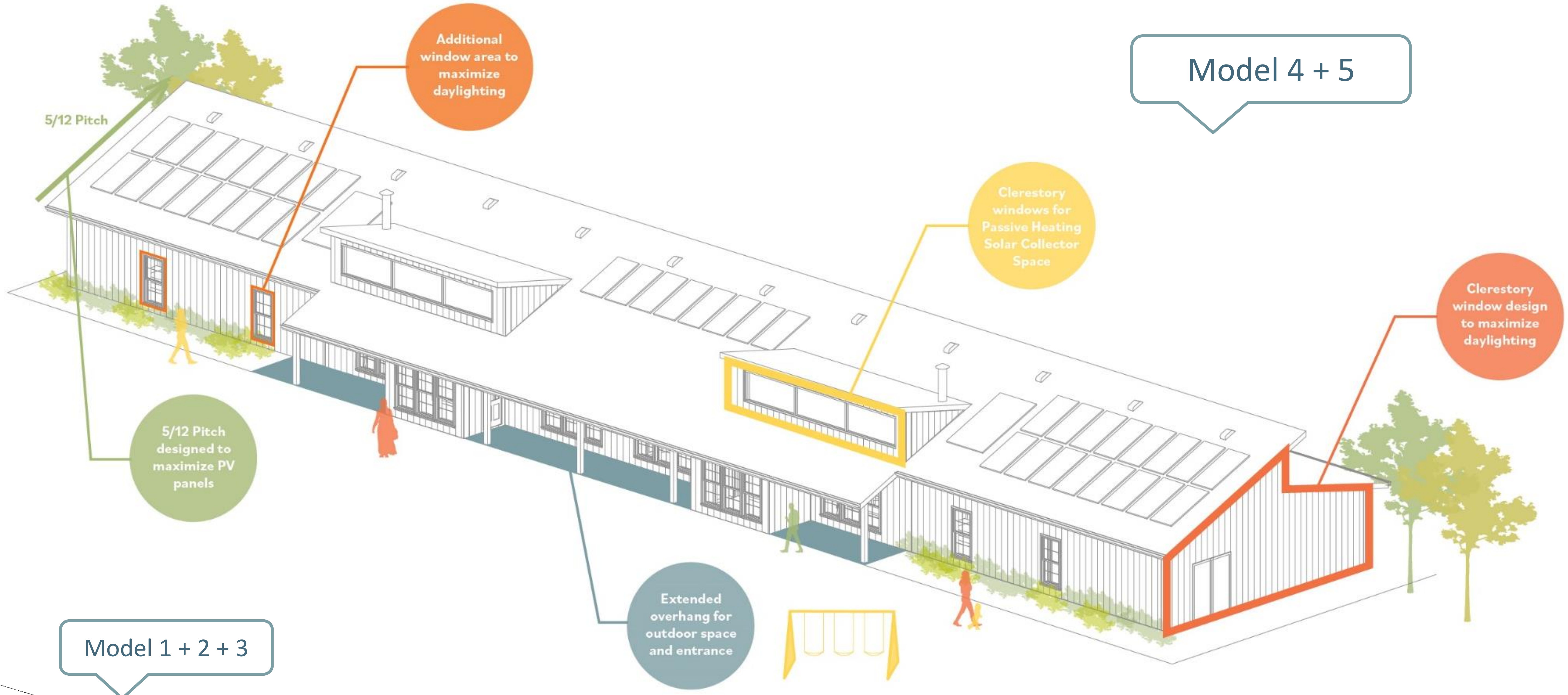
CONTESTS DISCUSSION

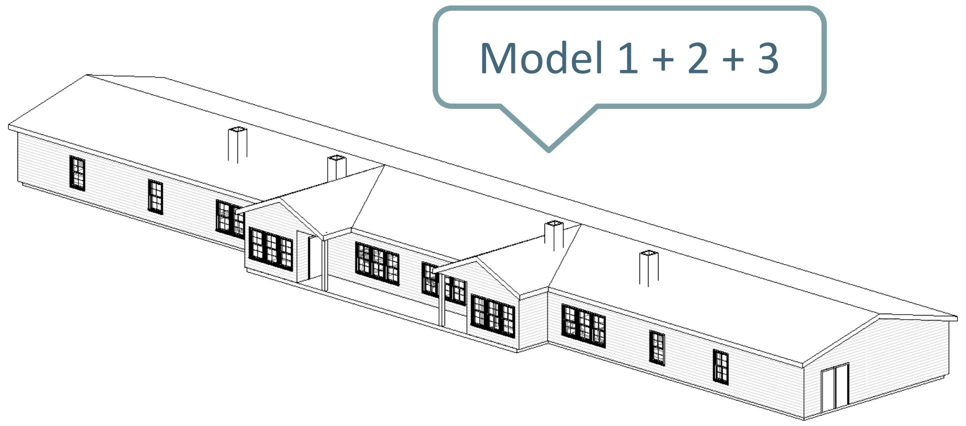
- Architecture
- Engineering
- Envelope
- Efficiency
- Grid-Interactivity
- Life-Cycle
- Health
- Market
- Community

Journey women's center

Architecture
Engineering
Envelope
Efficiency
Grid-Interactivity
Life-Cycle
Health
Market
Community

Final Design Architectural Improvements



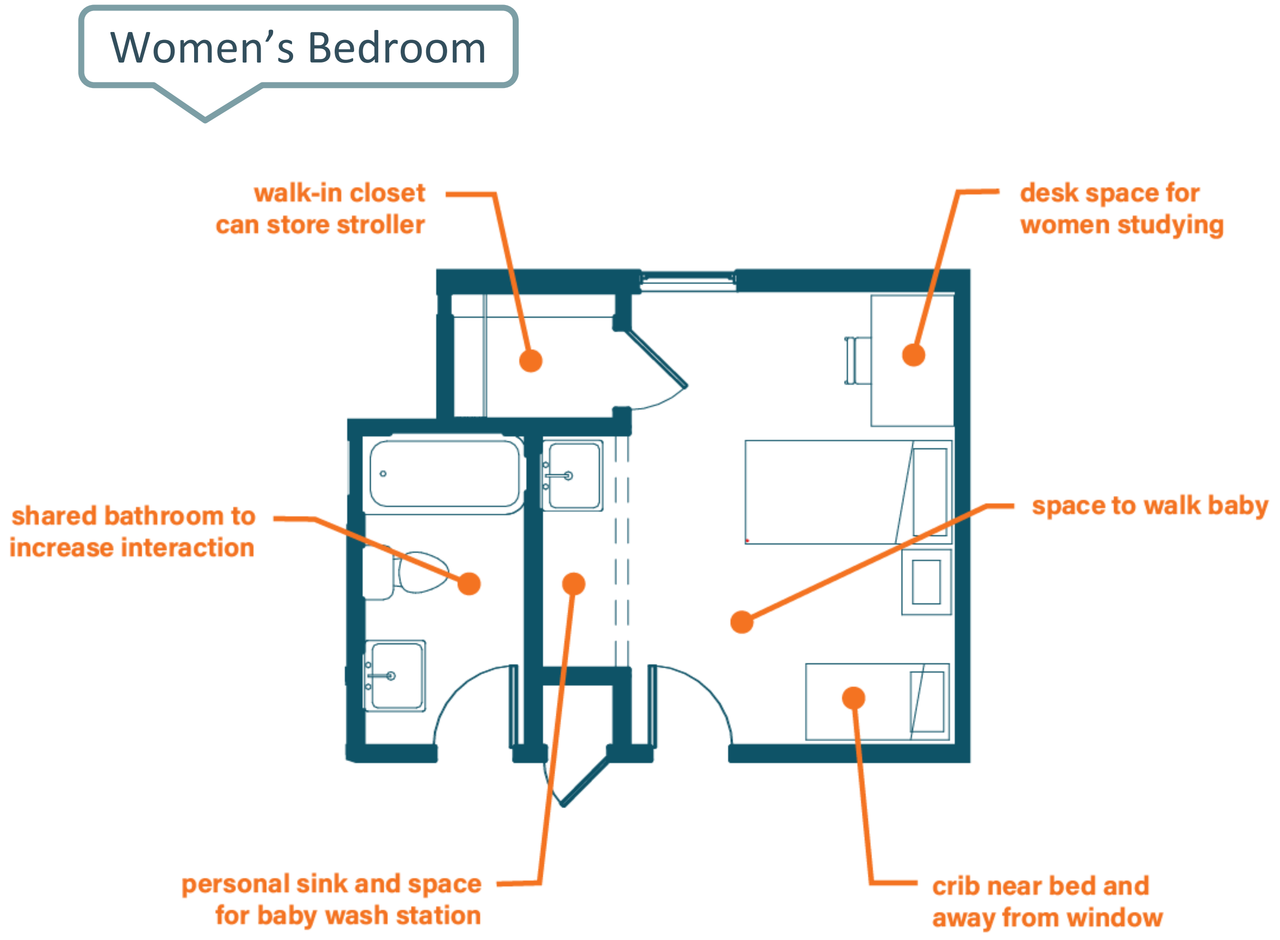


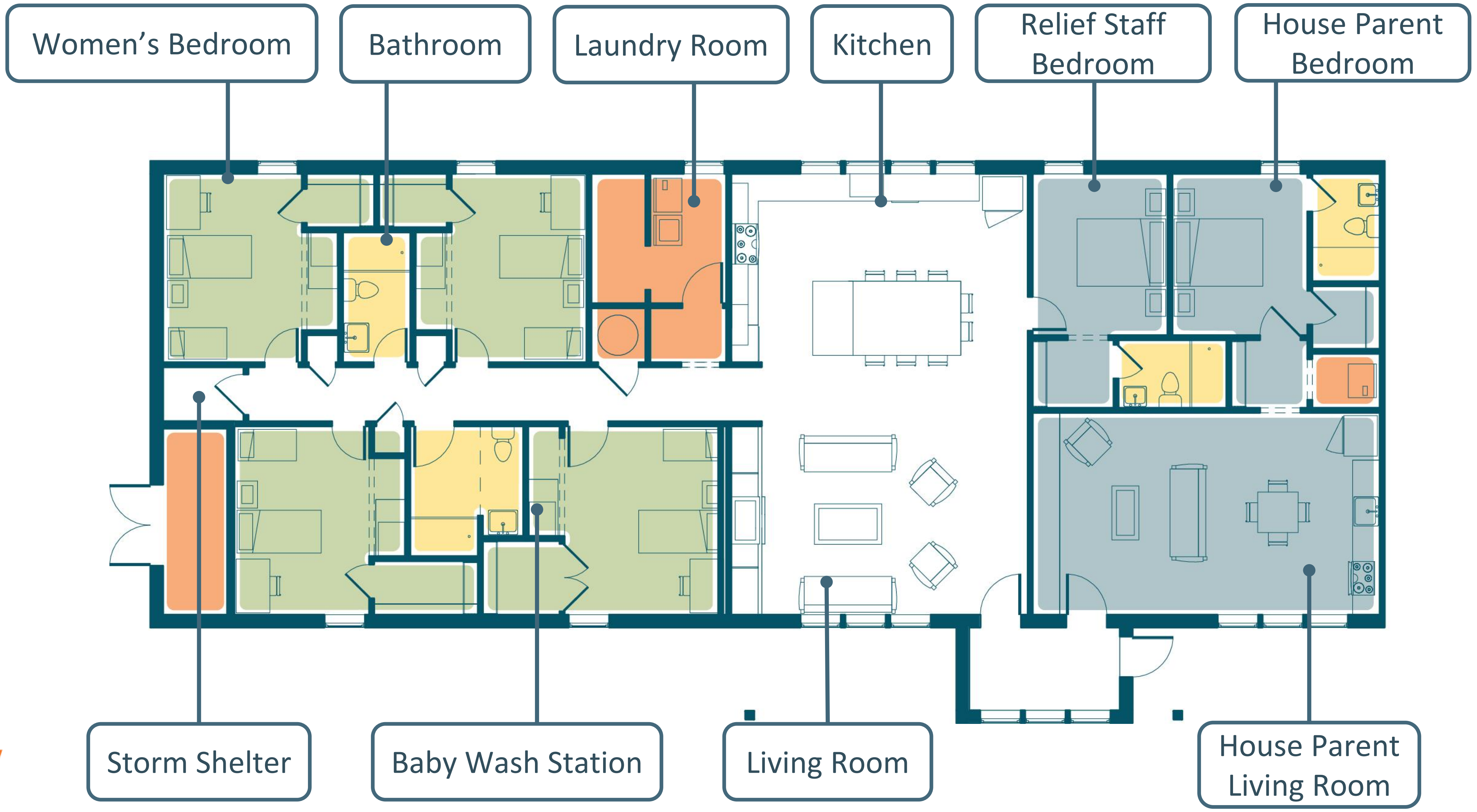
The architectural design improvements were motivated by a need to further improve the daylighting within the living space for the women as well as contribute to our passive heating design techniques. The site provides an opportunity to connect with the outside environment.

Journey women's center

Final Design Architectural Improvements

Unit A: Square Footage	+/- 2,955 sf
Women's Bedroom	+/- 145 sf
Kitchen and Living Room	+/- 740 sf



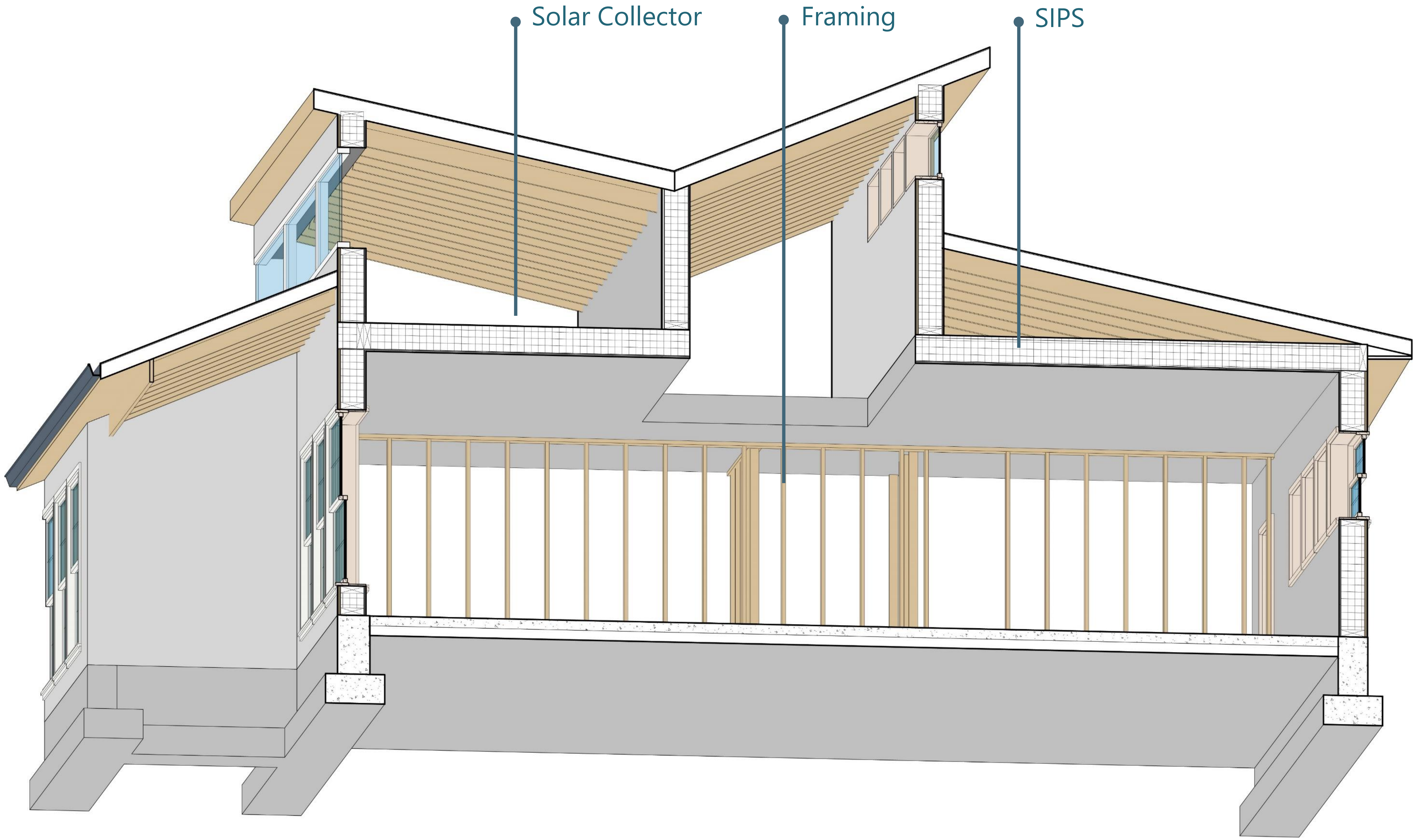


The architectural floor plan revolved around the goal of community. A deep desire for interactions between the mothers was an area that is highlighted through the shared bathrooms, living room, and kitchen space. Resiliency architecture is expressed through the operable windows, storm shelter, and fireplace. The spatial layout of every woman's bedroom is catered to provide a beneficial and functional floor plan for the woman and child.

ENGINEERING / STRUCTURE

Architecture
Engineering
Envelope
Efficiency
Grid-Interactivity
Life-Cycle
Health
Market
Community

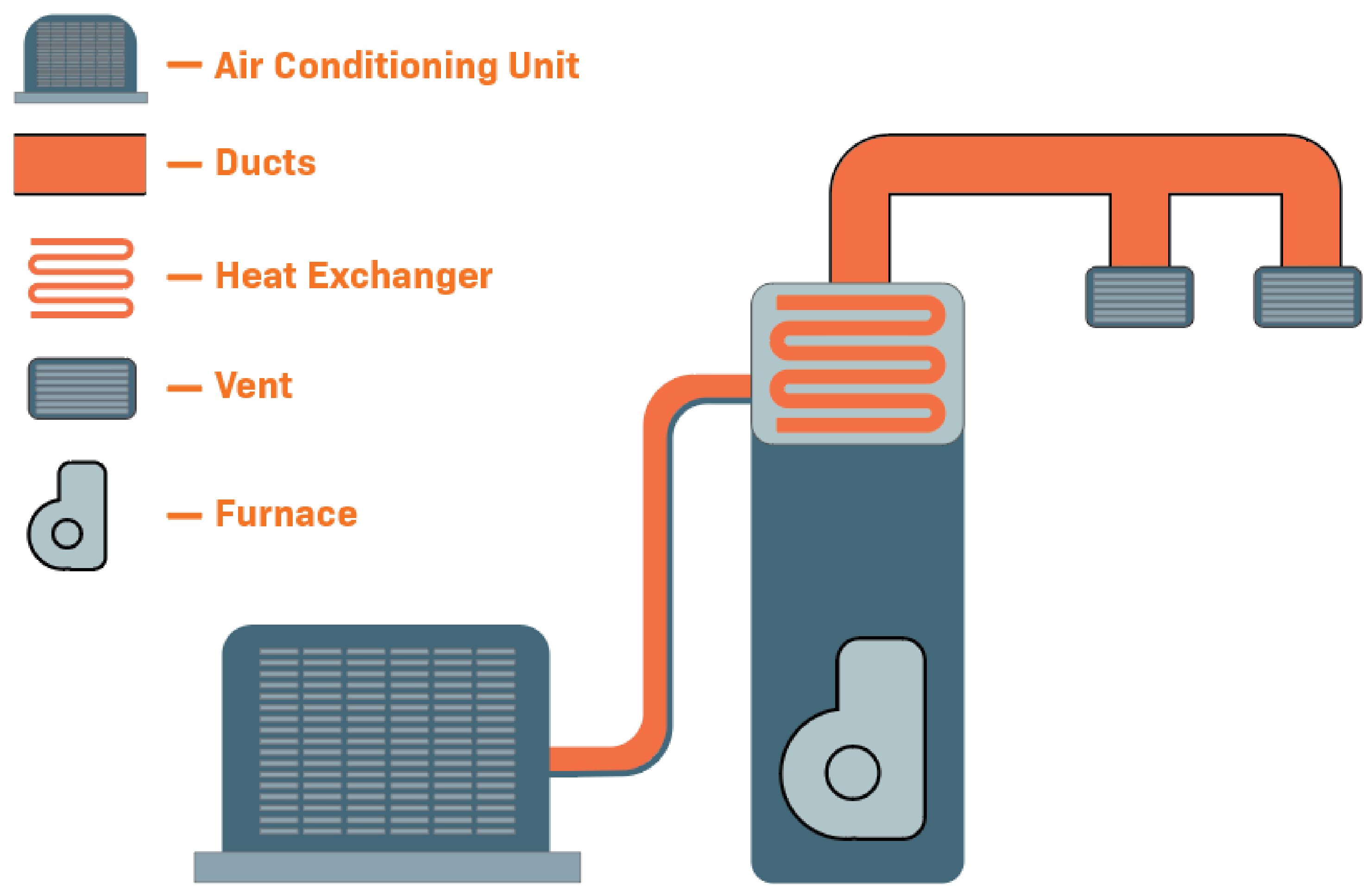
+ SIPs reduce construction time
+ Resilient in the wind
+ Withstands weight of solar heating water tubes/tanks
+ Reduction in construction waste
+ Slab on grade simplifies construction and provides easy access to the building (using a locally-available low-carbon concrete mix)



ENGINEERING / HVAC / MODELS 1, 2, 3 & 4

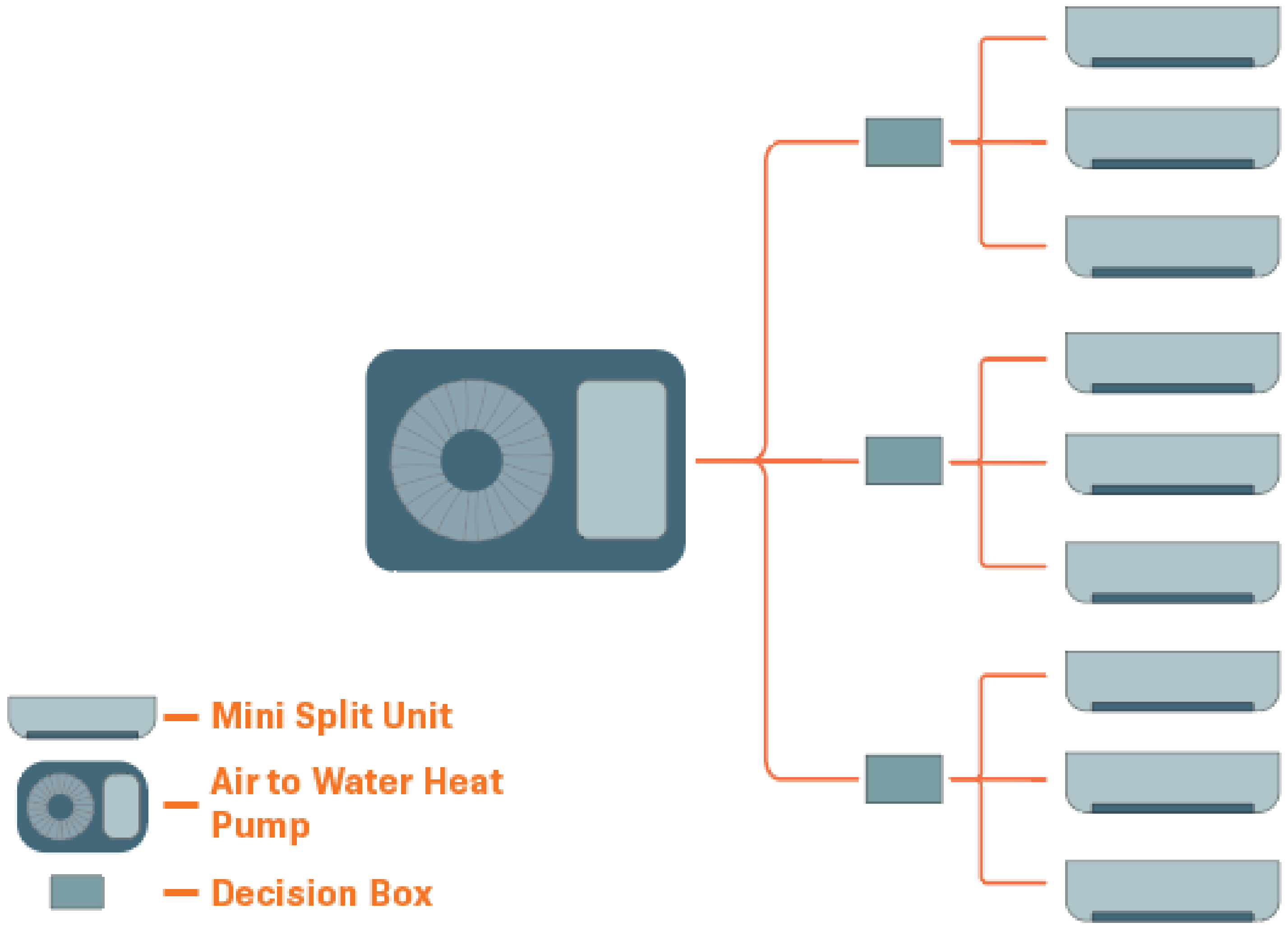
Journey women's center

Baseline / Central Air Conditioning System



+ **Models 1 & 2**
+ Two systems for units A1 & A2
+ Basic, traditional setup for Oklahoma homes
+ One thermostat per dwelling unit
+ Low efficiency, SEER = 13 & HSPF = 7.7

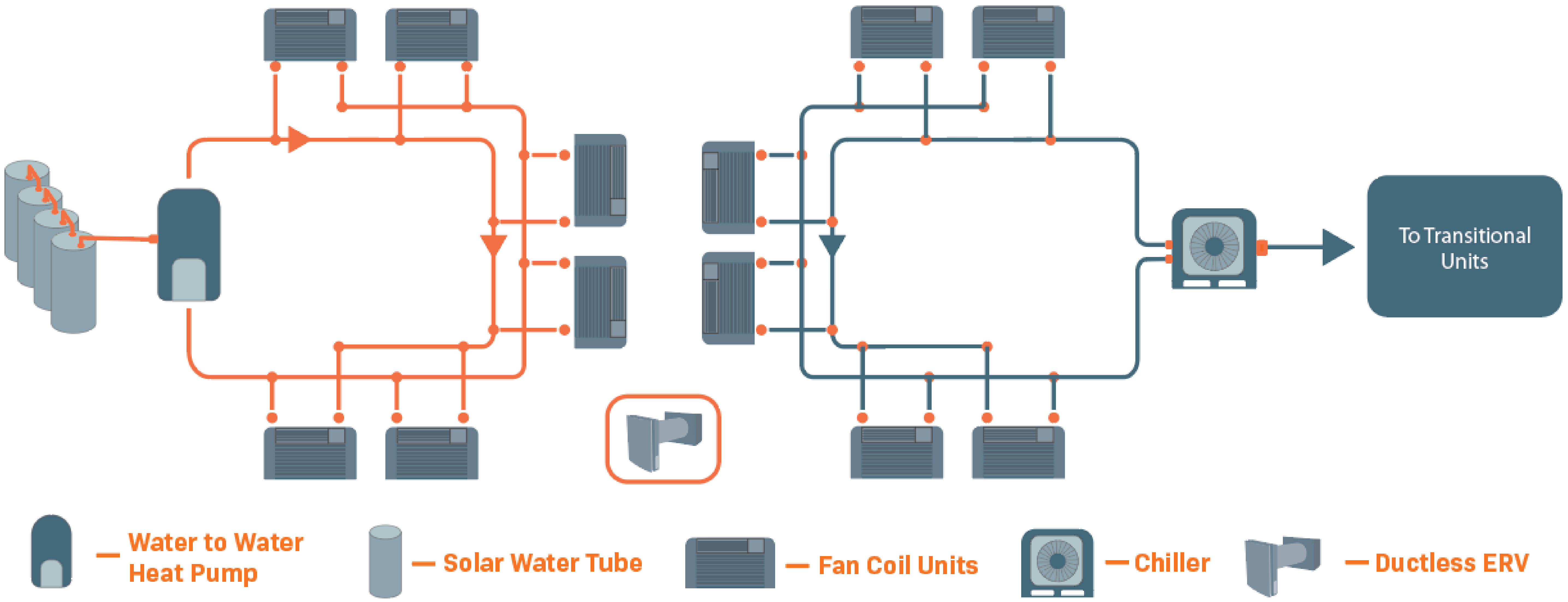
Final / Multi-Zone Mini Split System



+ **Models 3 & 4**
+ Three distribution boxes + nine thermostats
+ Individual control for occupants
+ High efficiency, SEER = 18.35 & HSPF = 15.8
+ Most Expensive
+ Ventilation through DOAS or ductless ERV

ENGINEERING / HVAC / MODEL 5

Final + / 4 Pipe Fan Coil system + Passive Solar Heating System + Ductless ERV



+ **Model 5**
+ Individual control (9 zones)
+ Simultaneous heating and cooling
+ High efficiency hydronic system
+ Full integration with passive solar heating
+ Backup electric heater

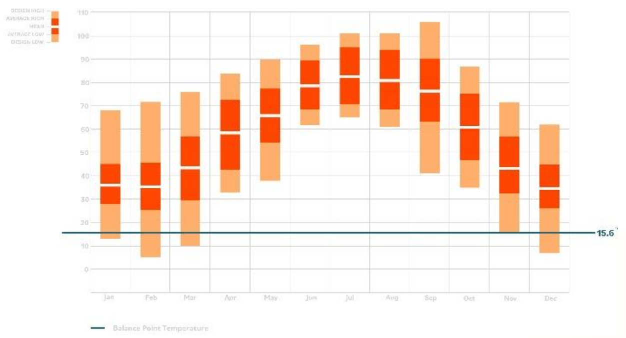
+ District cooling with air-cooled chiller serving one cluster
+ No refrigerant within house
+ High efficiency heat pumps
+ Ventilation through ductless ERV per room
+ Ductless ERV controls relative humidity
+ High efficiency, SEER = 19.92 & HSPF = 15.4

ENGINEERING / PASSIVE SYSTEMS

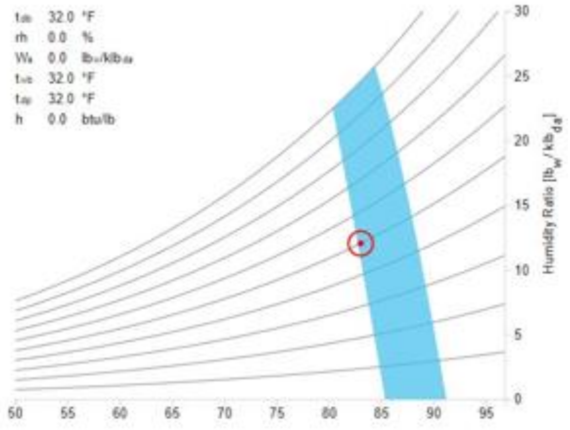
Journey women's center

Passive Solar Heating + Passive Cooling + Daylighting

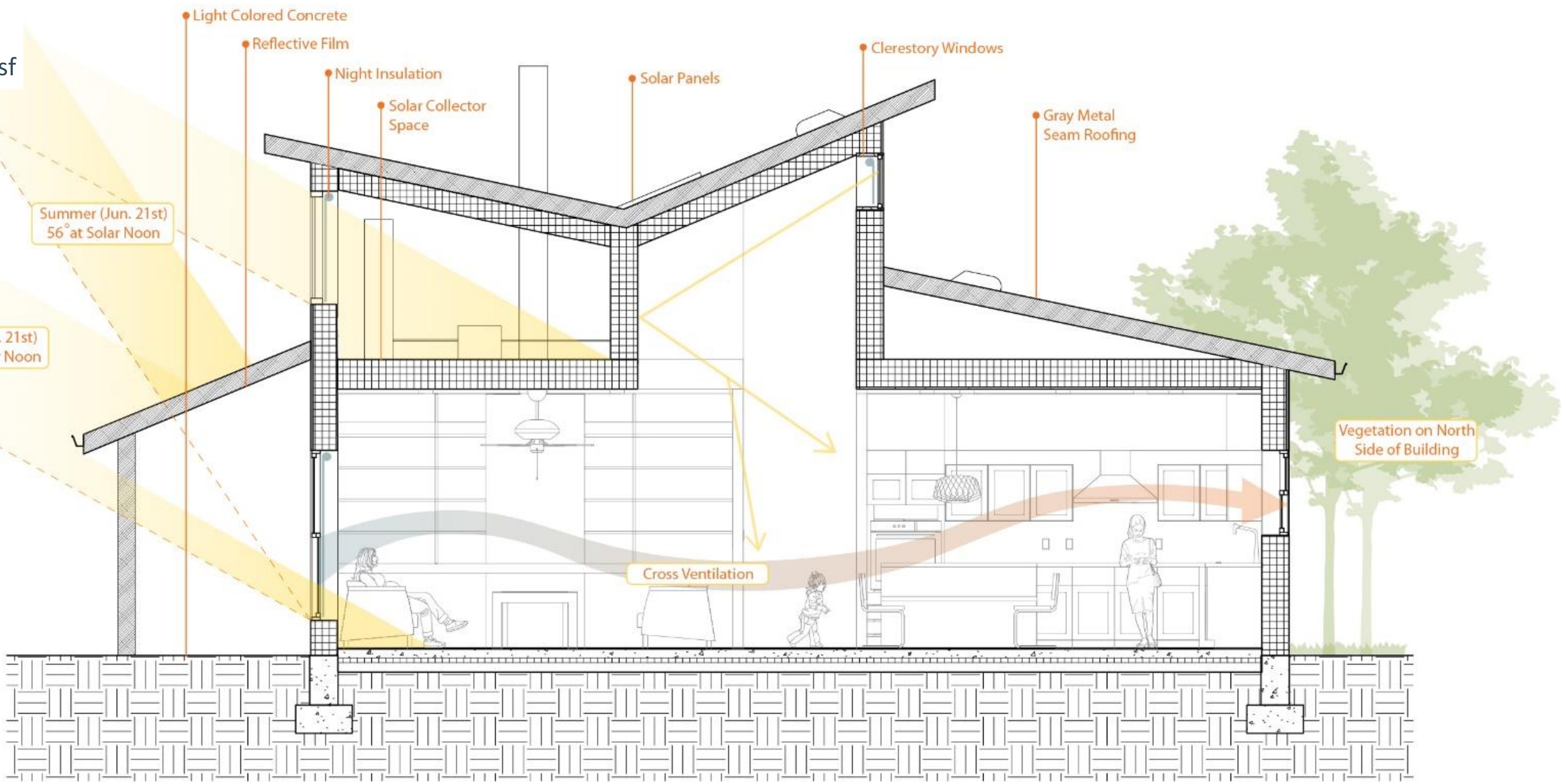
Area of South Windows	144 sf
Area of Exterior South Wall	813 sf
Area of all other Windows	120 sf
Area of all other Exterior Walls	1,764 sf



Balance Point Temperature with Passive Heating (15.6)

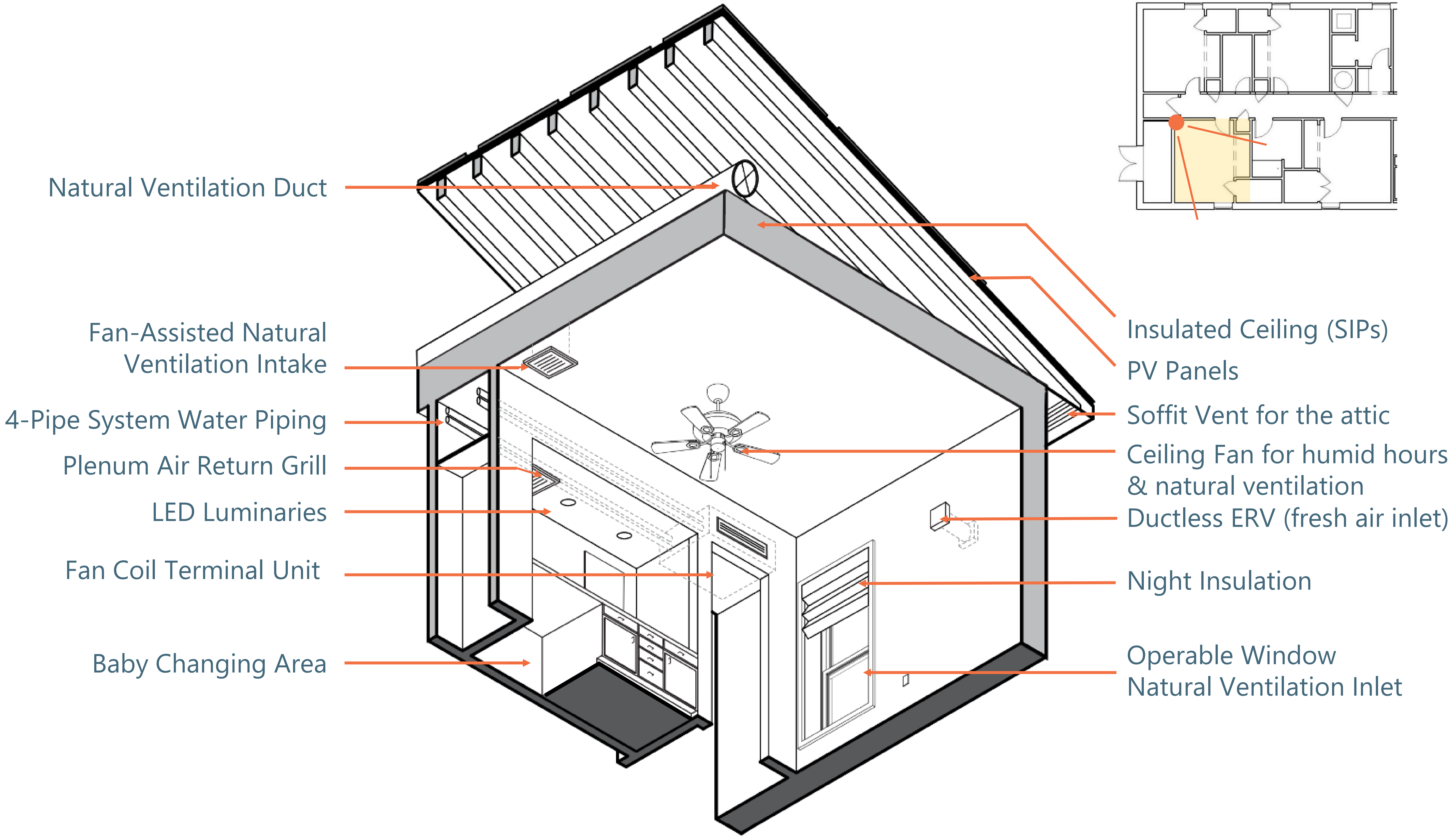


Comfort with Natural Ventilation (83)



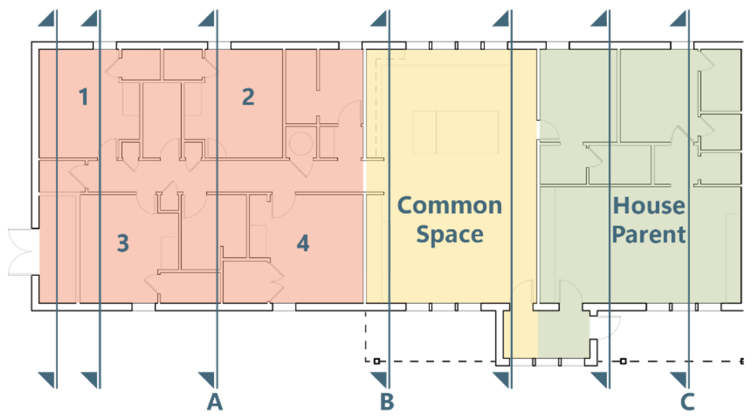
ENGINEERING / SYSTEMS INTEGRATION

Single-Room Systems Integration + Comfort



ENVELOPE / THERMAL ENCLOSURE

Journey women's center

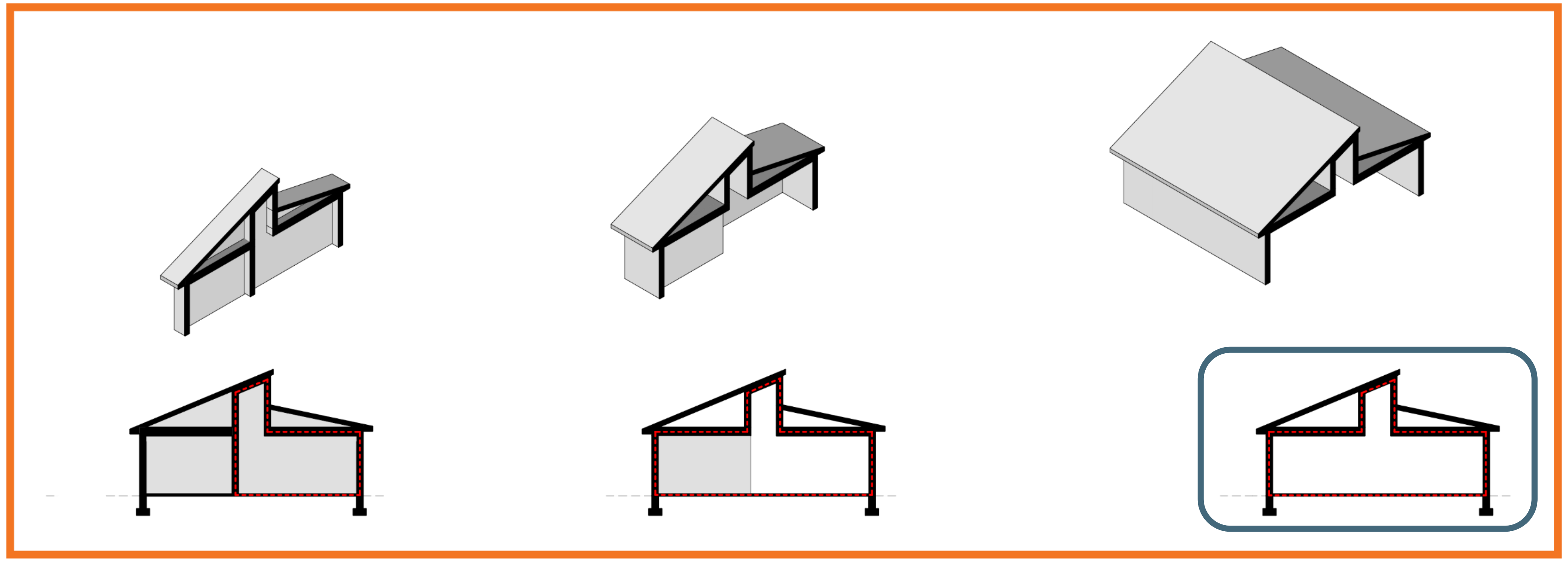


+ Orange: Clerestory

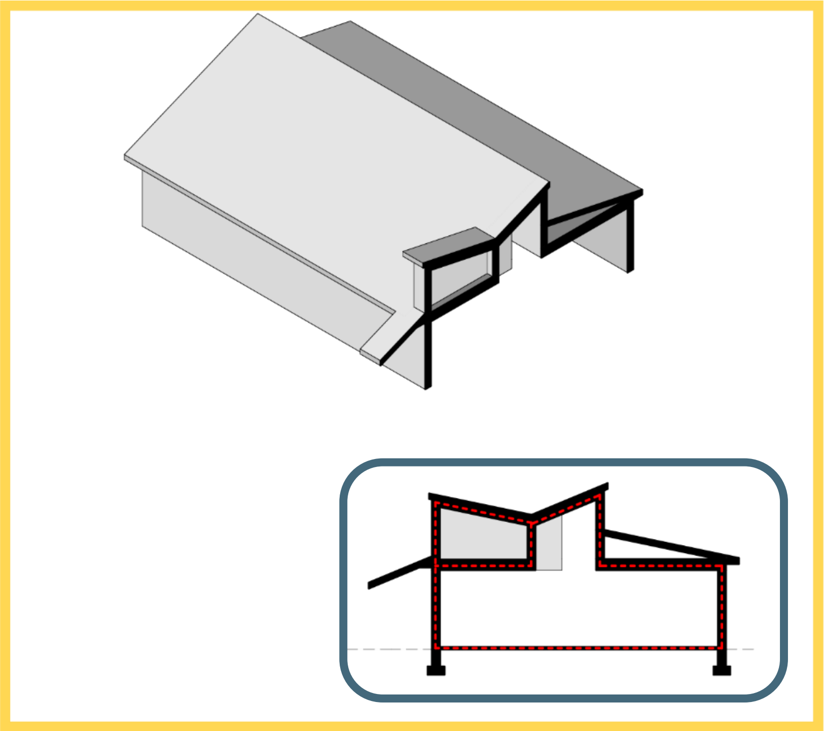
+ Yellow: Solar Collector

+ Green: Vented Attic

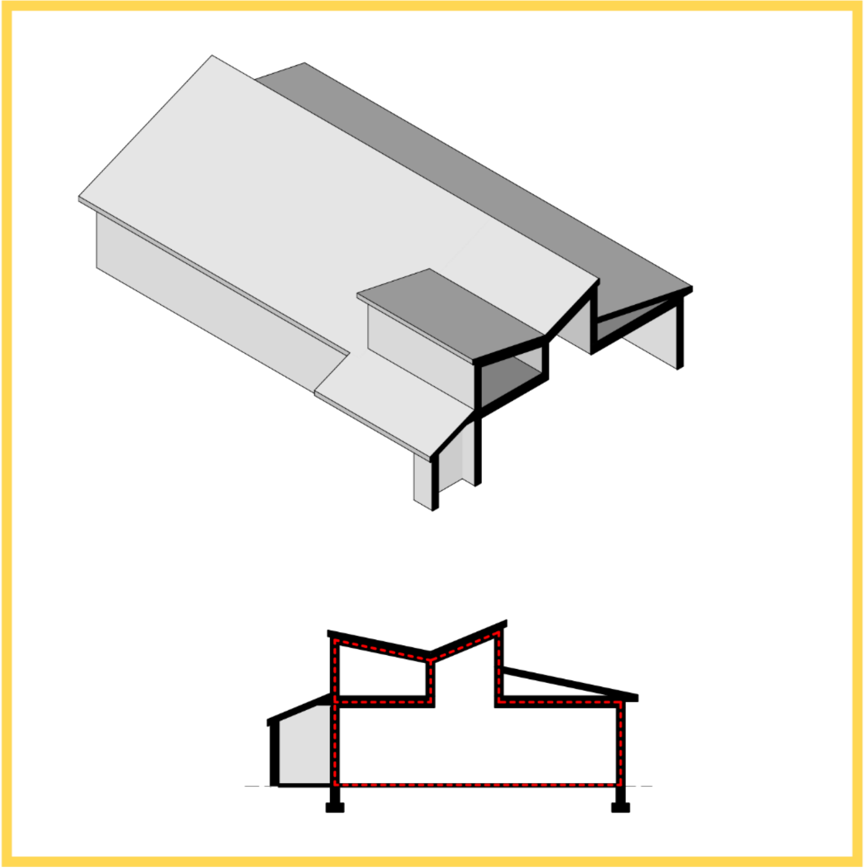
Although the exterior building form is relatively simple, the configuration of the thermal enclosure allows for a **dynamic interior**, which is ideal for the programmatic uses of the associated spaces. A clerestory window illuminates the Mothers' Rooms, the Solar Collector warms the Common Space, and the Vented Attic ensures natural ventilation in the House Parent Suite.

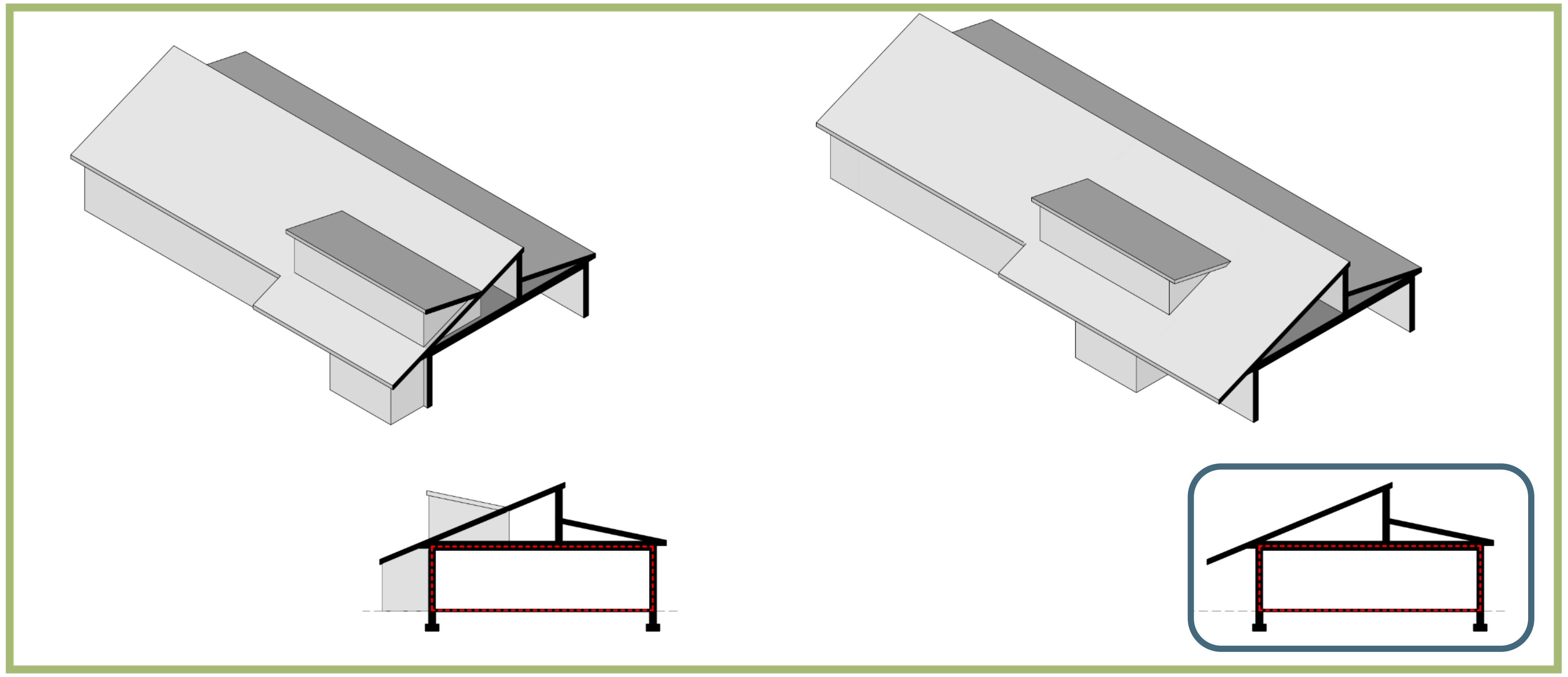


Section A



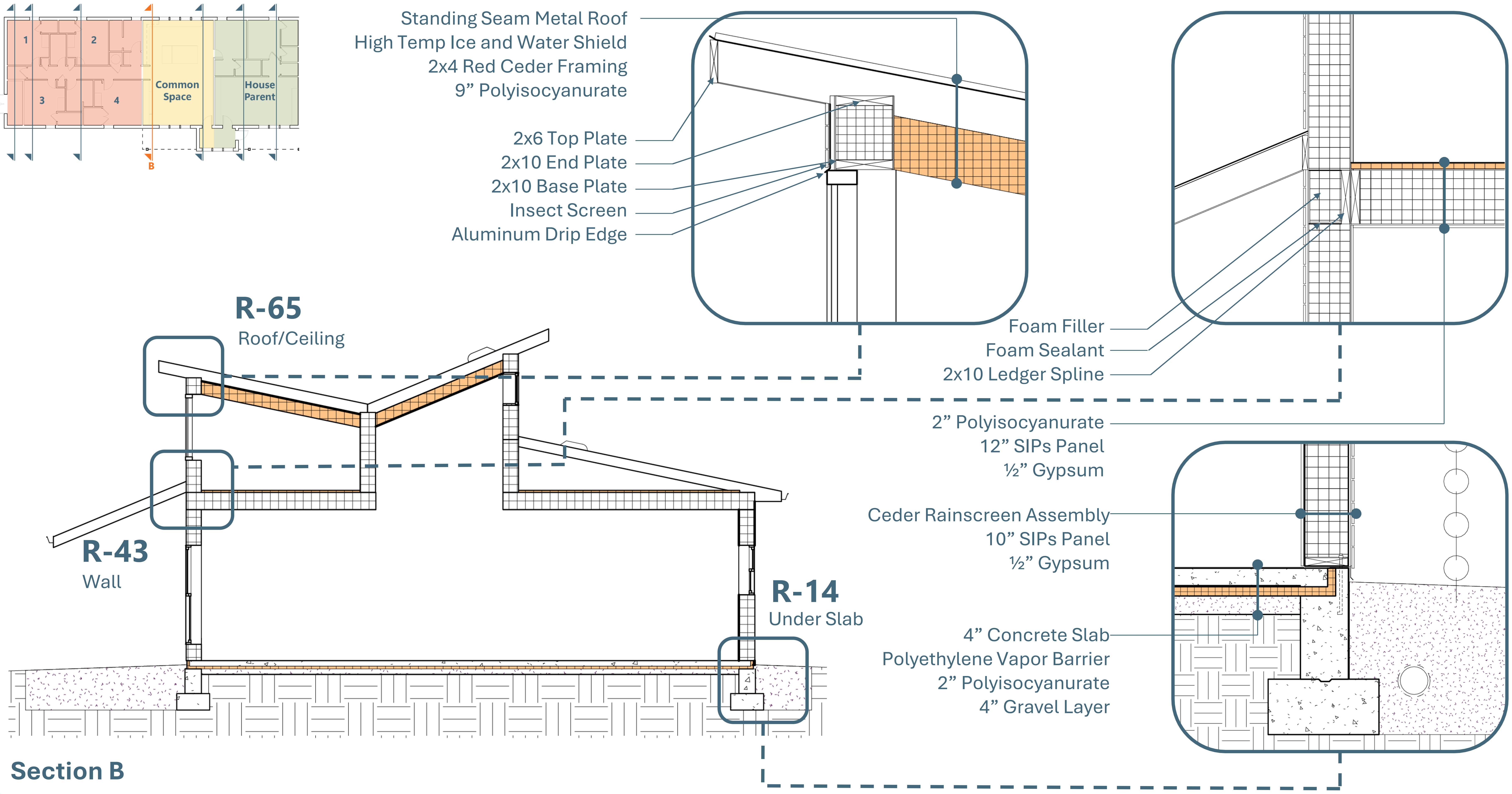
Section B





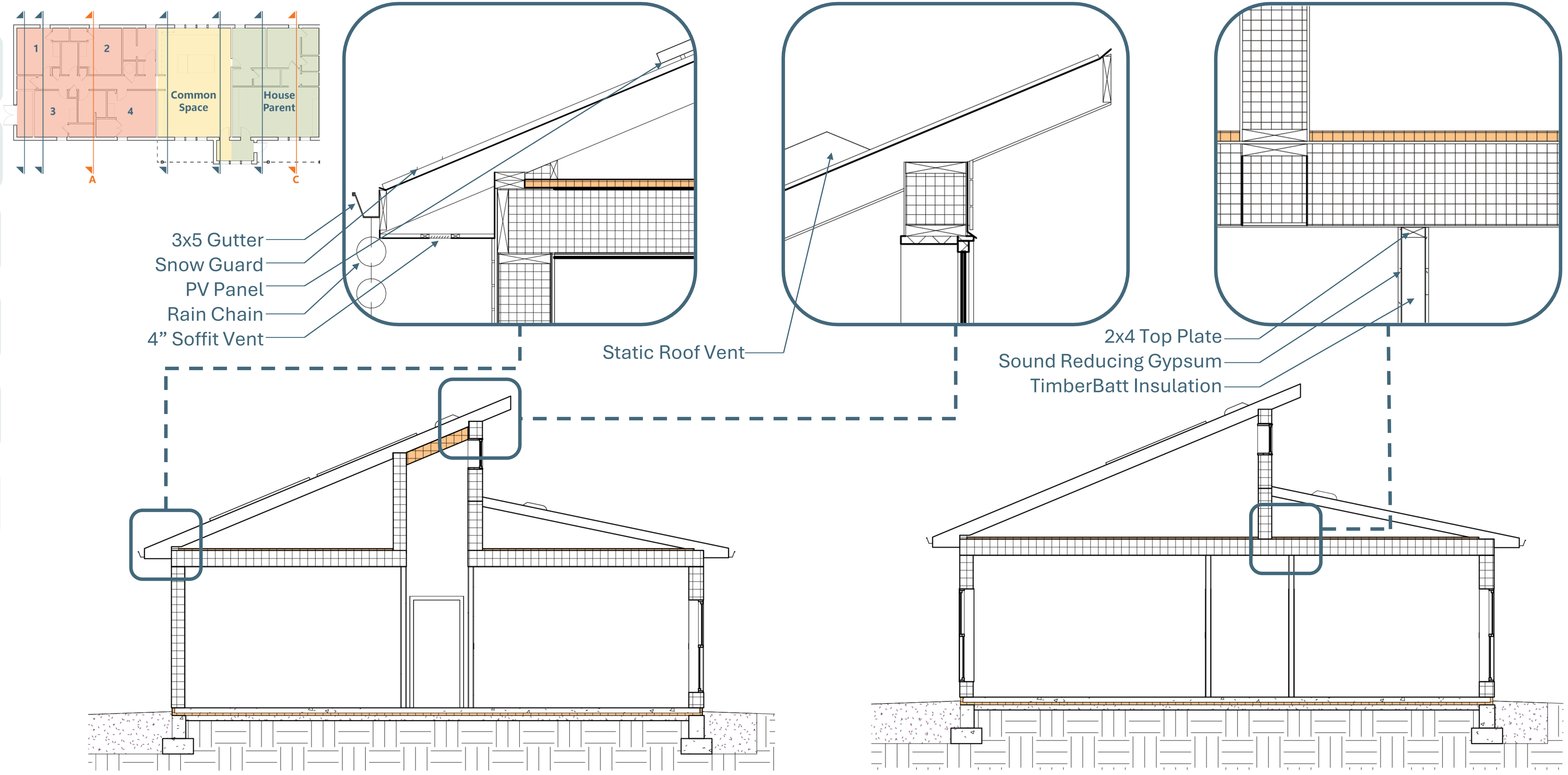
Section C

ENVELOPE / SECTION B DETAILING



Section B

ENVELOPE / SECTIONS A & C DETAILING



Section A

Section C

ENVELOPE / WALL SECTION MODEL

Architecture
Engineering
Envelope
Efficiency
Grid-Interactivity
Life-Cycle
Health
Market
Community

Solar Collector

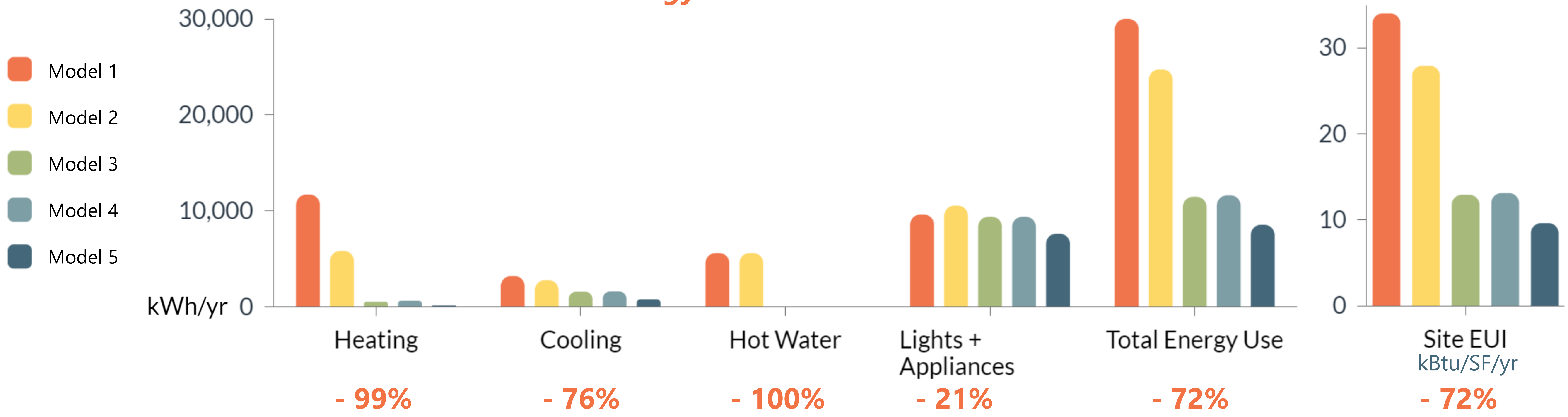
Wall Section

Wall Detailing

EFFICIENCY / END USE + TOTAL + EUI

Energy Demand (kWh/yr)

Annual Energy Use & EUI Decrease = 72%



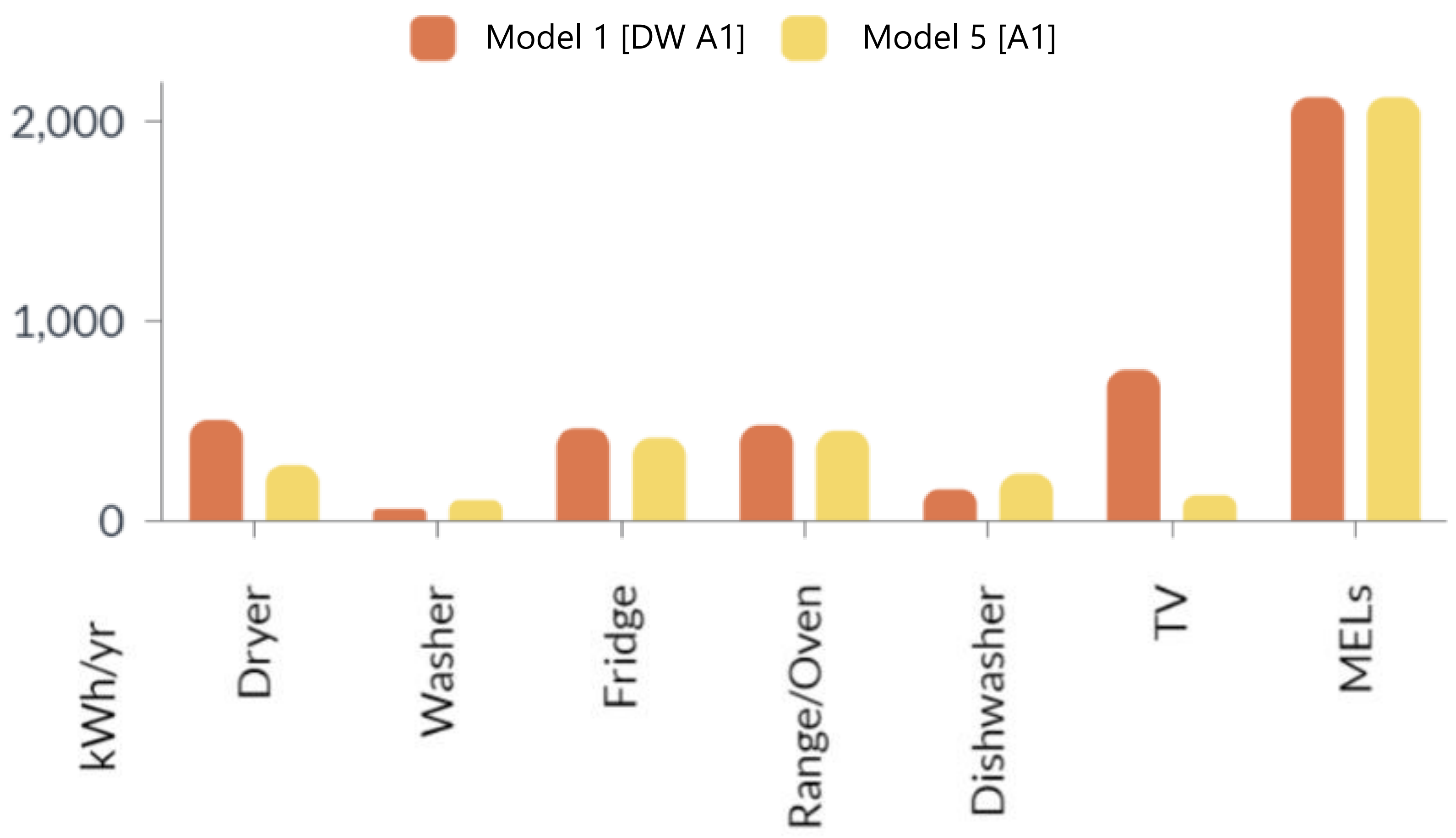
Heating and Cooling Equipment + Efficiencies

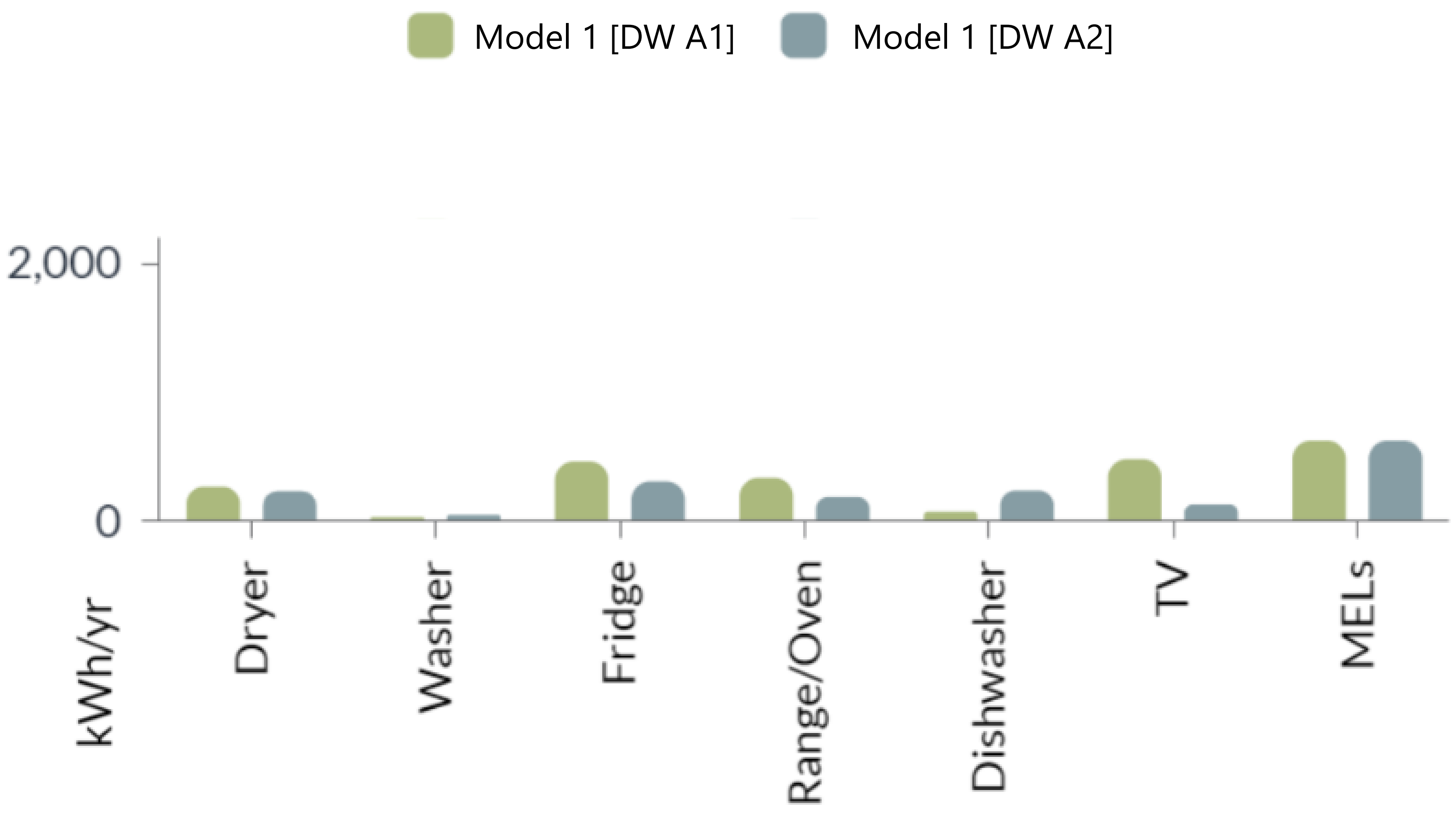
	Model 1	Model 2	Model 3	Model 4	Model 5
Heating	Furnace	Furnace	Ductless Mini-Split	Ductless Mini-Split	Water to Water Heat Pump
Efficiency - HSPF	7.7	9.2	15.8	15.8	15.4
Cooling	AC Unit	AC Unit	Ductless Mini-Split	Ductless Mini-Split	Water to Water Heat Pump
Efficiency - SEER	13	16	18.35	18.35	19.92

EFFICIENCY / APPLIANCES

Journey women's center

Appliance Loads (kWh/yr)





Lights + Appliances

	Model 1	Model 2	Model 3	Model 4	Model 5
Lights	100% Fluorescent	100% Fluorescent	100% LED	100% LED	100% LED + Improvements
Appliances	HERS Reference	HERS Reference	HERS Reference	HERS Reference	Energy Star + Improvements

Overall Load Reduction

= 20%

EFFICIENCY / PARAMETRIC ANALYSIS + COMBINED MEASURES

Journey women's center

Architecture
Engineering
Envelope
Efficiency
Grid-Interactivity
Life-Cycle
Health
Market
Community

Ekotrope to Open Studio

Occupancy Schedule **Room-by-Room Thermal Zones** **Detailed Hourly Outputs**

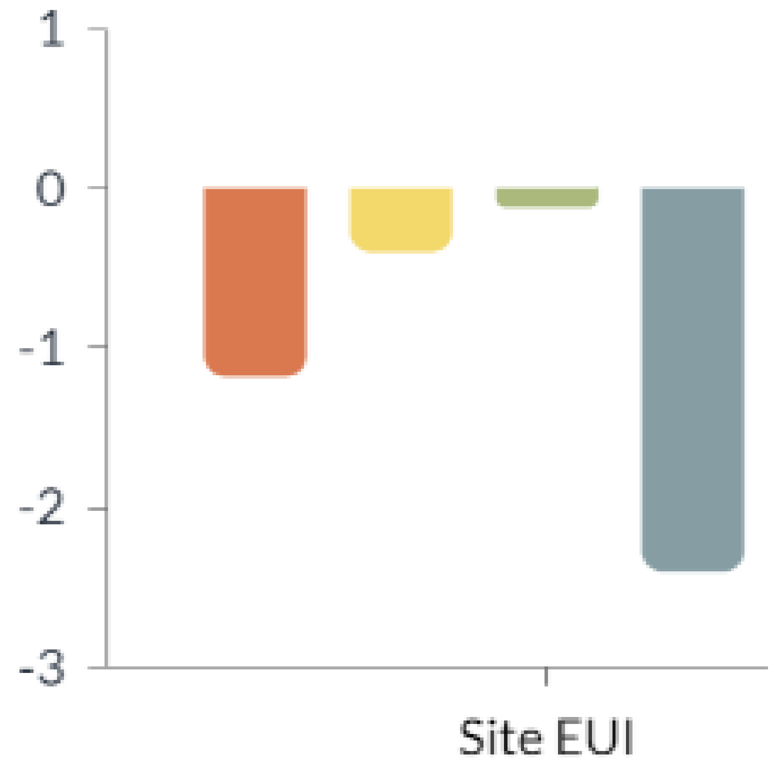
Daylighting Integration **Passive Systems Integration**

Open Studio Model Improvements

Energy Use & EUI Decrease = 36.5%

	kBtu/SF/yr					
Iteration	Heating	Cooling	Lighting	Appliances	EUI	% change
Model 4 Ekotrope	0.71	1.81	1.05	9.53	13.1	
Model 4 Open Studio	1.04	1.81	2.34	9.99	15.2	
Improved Lighting	1.17	1.71	1.14	9.99	14.0	-7.8%
Daylighting	1.05	1.77	1.97	9.99	14.8	-2.6%
Interior Shading	0.95	1.77	2.34	9.99	15.1	-0.8%
Improved Appliances	1.20	1.57	2.34	7.65	12.8	-15.8%
Model 4 (Combined)	1.33	1.28	0.95	7.65	11.22	-26.1%
Model 5 (Combined + Passive Solar)	0.16	1.80	0.95	7.65	10.6	-30.5%
Model 5 (Combined + Passive Solar + Natural Ventilation)	0.16	0.88	0.95	7.65	9.6	-36.5%

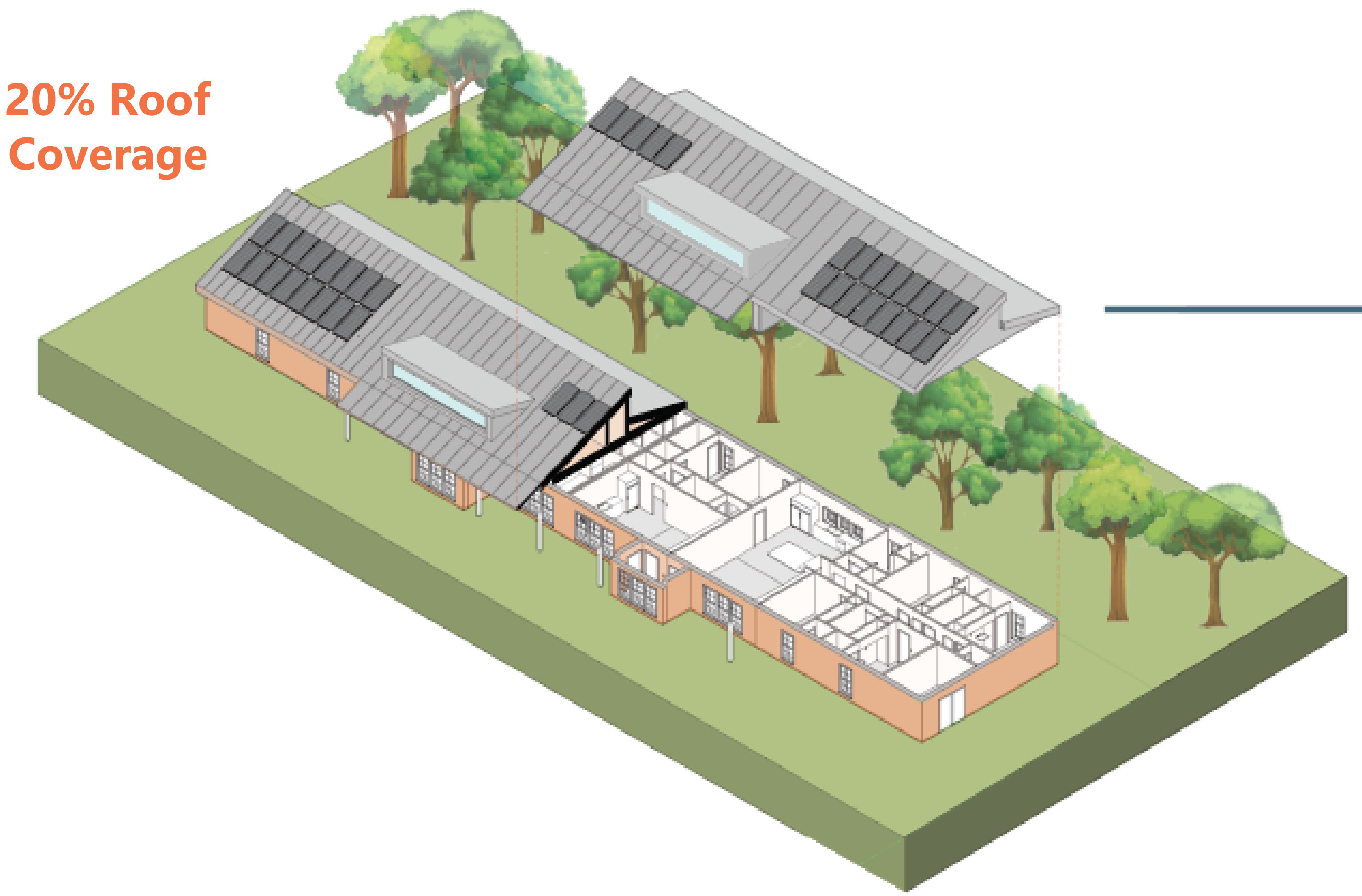
EUI Decrease from Model 4 Open Studio

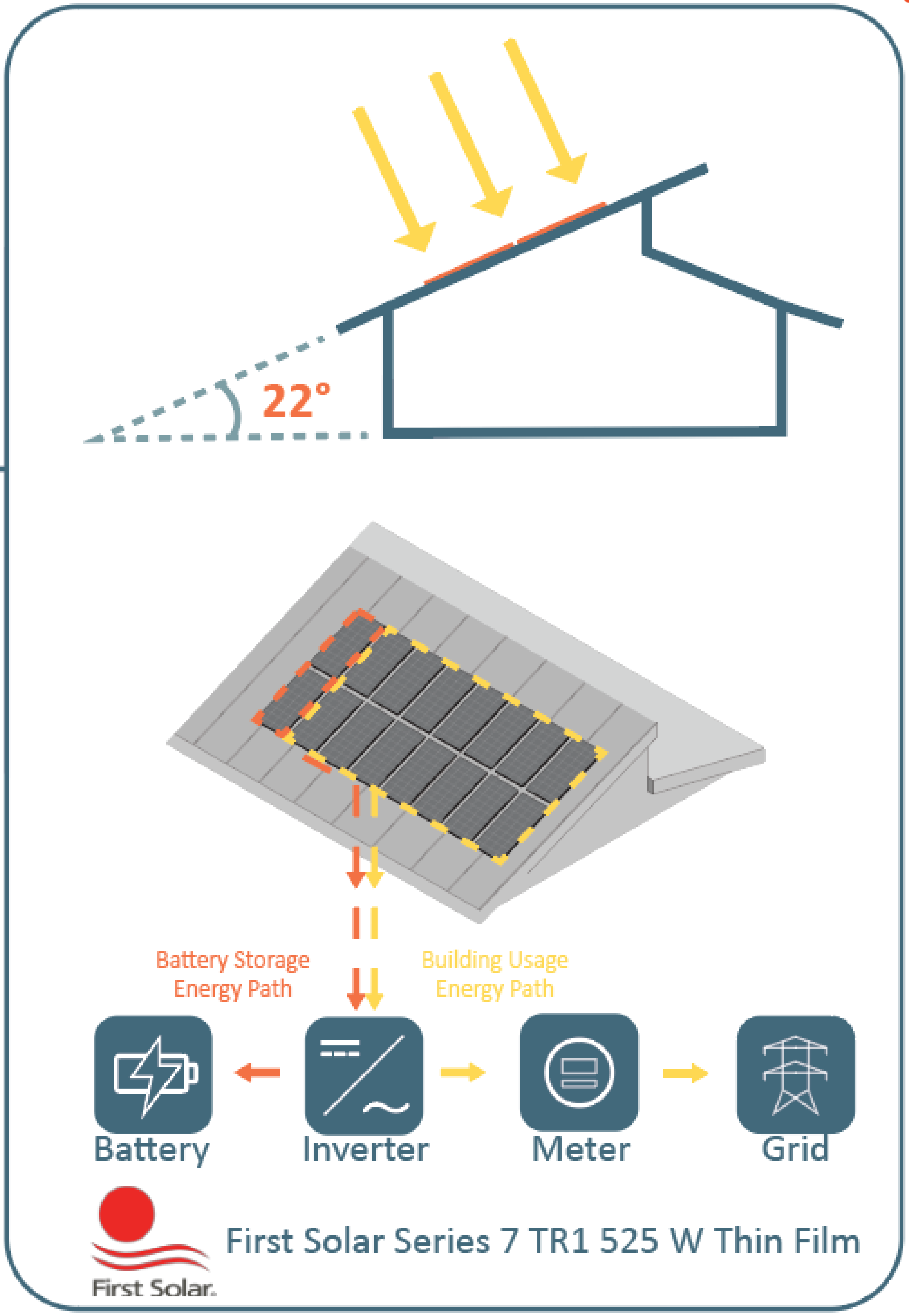


GRID-INTERACTIVITY / PV PANELS

Architecture
Engineering
Envelope
Efficiency
Grid-Interactivity
Life-Cycle
Health
Market
Community

20% Roof Coverage





PV System

Total Area of Unit	616 s.f.	Number of Panel	22 (+2)
Conversion Efficiency	19.7%	Attachment	Roof Mounted
Power Rating	525 W	Battery	Lithium-ion
System Size	7 kW DC	Module Type	Thin Film

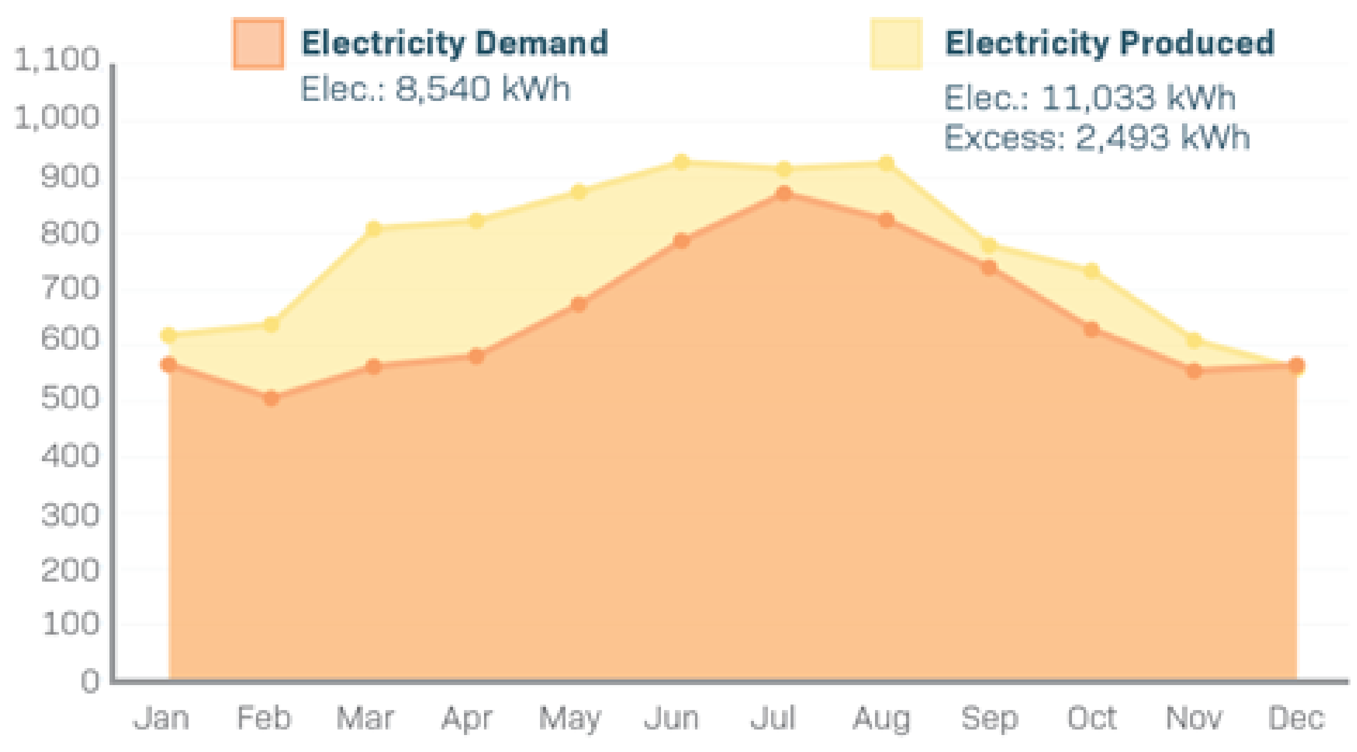
Electric Off-Grid w/ Battery System

H C R

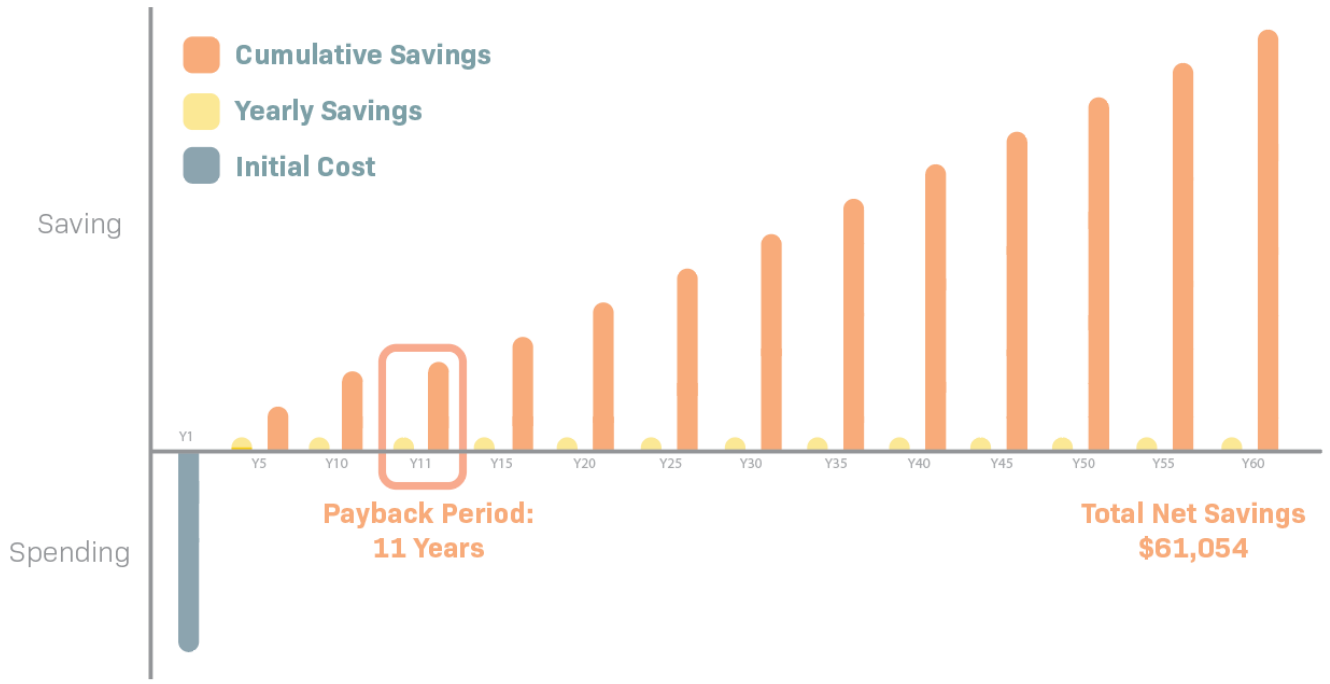
GRID-INTERACTIVITY

Journey women's center

PV Electric Output vs Demand



PV Life Cycle Savings



PV Panel Carbon

PV Panel Embodied CO_2		Grid Emissions	
LCA A-D	0.258 kg CO_2 eq/W	SPSO Emission Factor	138 kg CO_2/MBtu
Wattage/Panel	525 W	SPSO Emission Factor	0.4701 kg CO_2/kWh
Initial Panel	22	Final + Energy Demand	8,540 kWh/yr
Replacement Panels	2	GWP/yr	4,015 kg CO_2 eq
GWP/60 yrs	3,251 kg CO2 eq	GWP/60 yrs	240,881 kg CO_2 eq

PV vs Grid Only Electricity = -99%

LIFE-CYCLE / EMBODIED CARBON / SUMMARY

Journey women's center

Life Cycle Stages

Product	Construction	Use	End of Life	Beyond
(A1-A3)	(A4-A5)	(B1-B7)	(C1-C4)	(D)

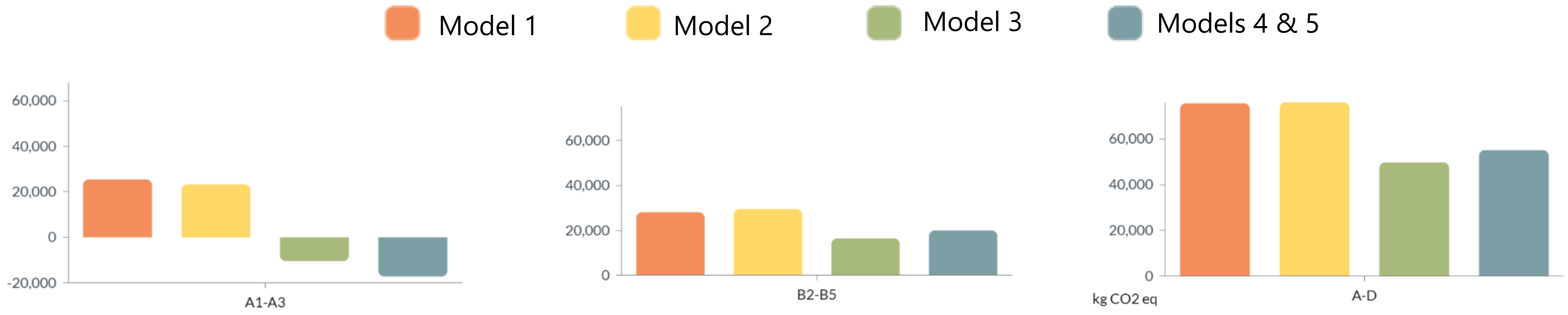
Cradle-to-Gate: (A1-A3)

Use: (B1-B7)

Cradle-to-Cradle: (A1-A3) through (D)

Code	Model
IECC2009	**1**
IECC2021	**2**
Material Substitutions	
PHIUS	**3 + 4 + 5**

Total Embodied Carbon



Percent Reduction b/w Model 1 and 4&5

A1-A3 = -168%

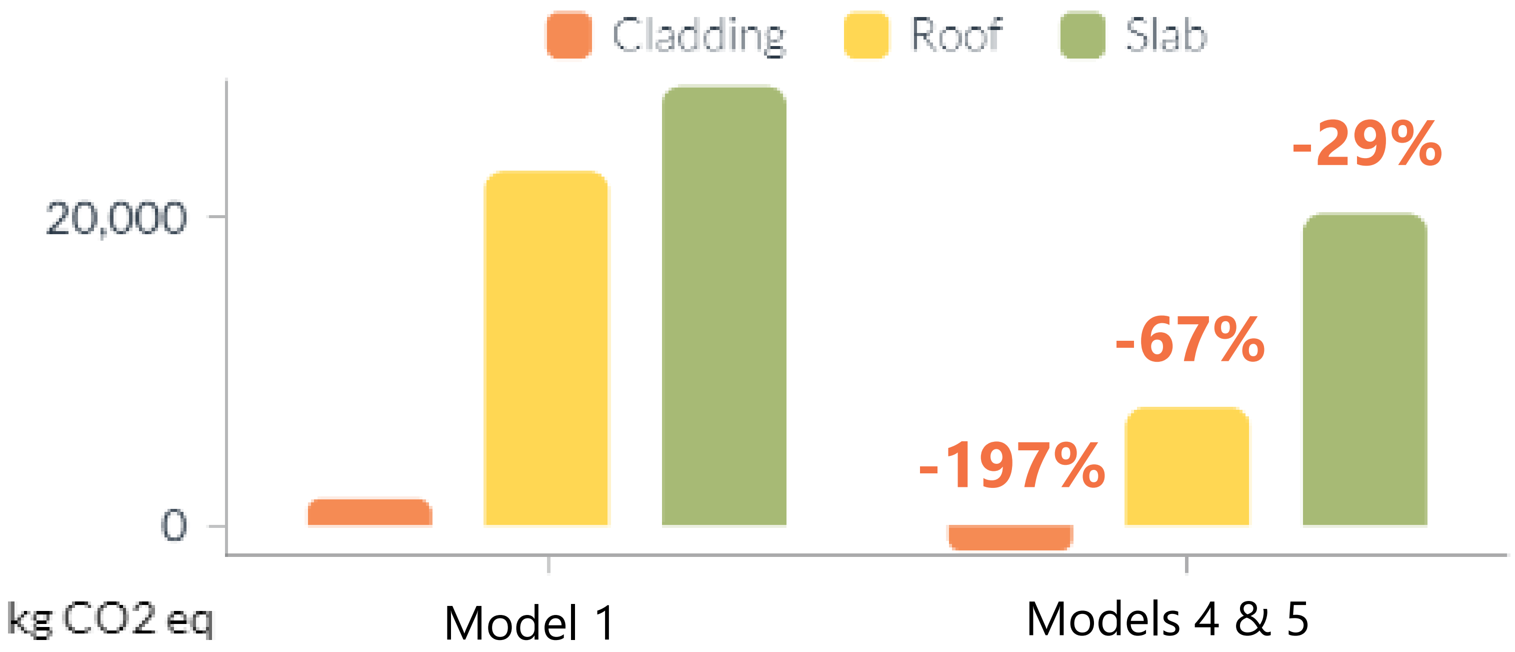
B2-B5 = -29%

A-D = -27%

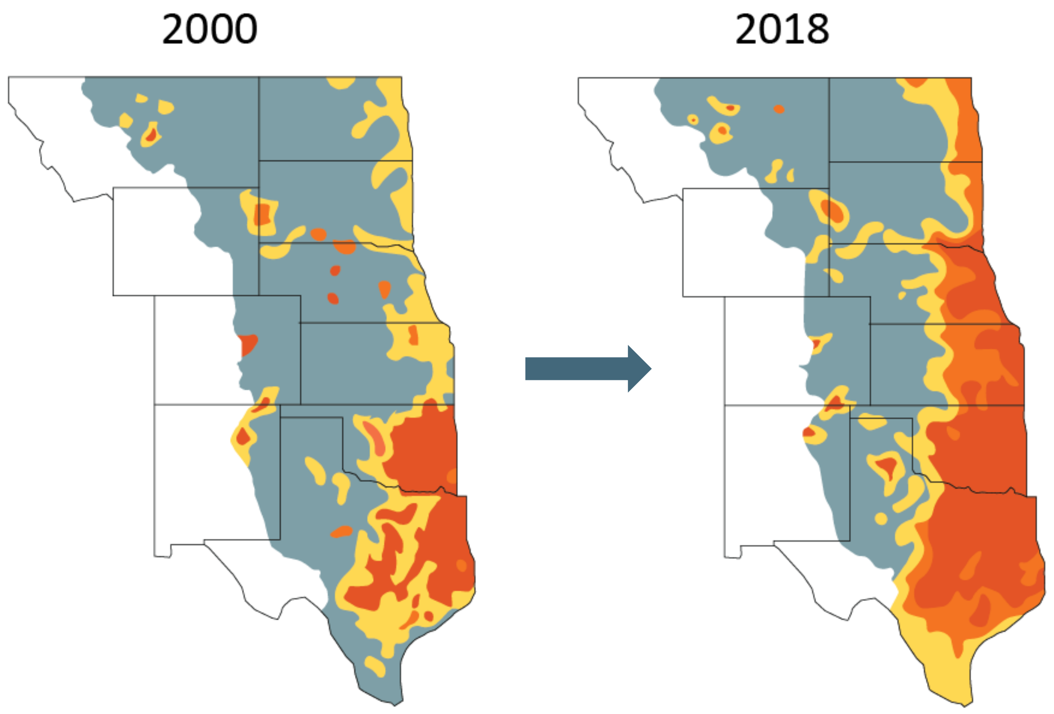
LIFE-CYCLE / EMBODIED CARBON / MATERIALS

Journey women's center

Carbon for Material Substitutions (A-D)

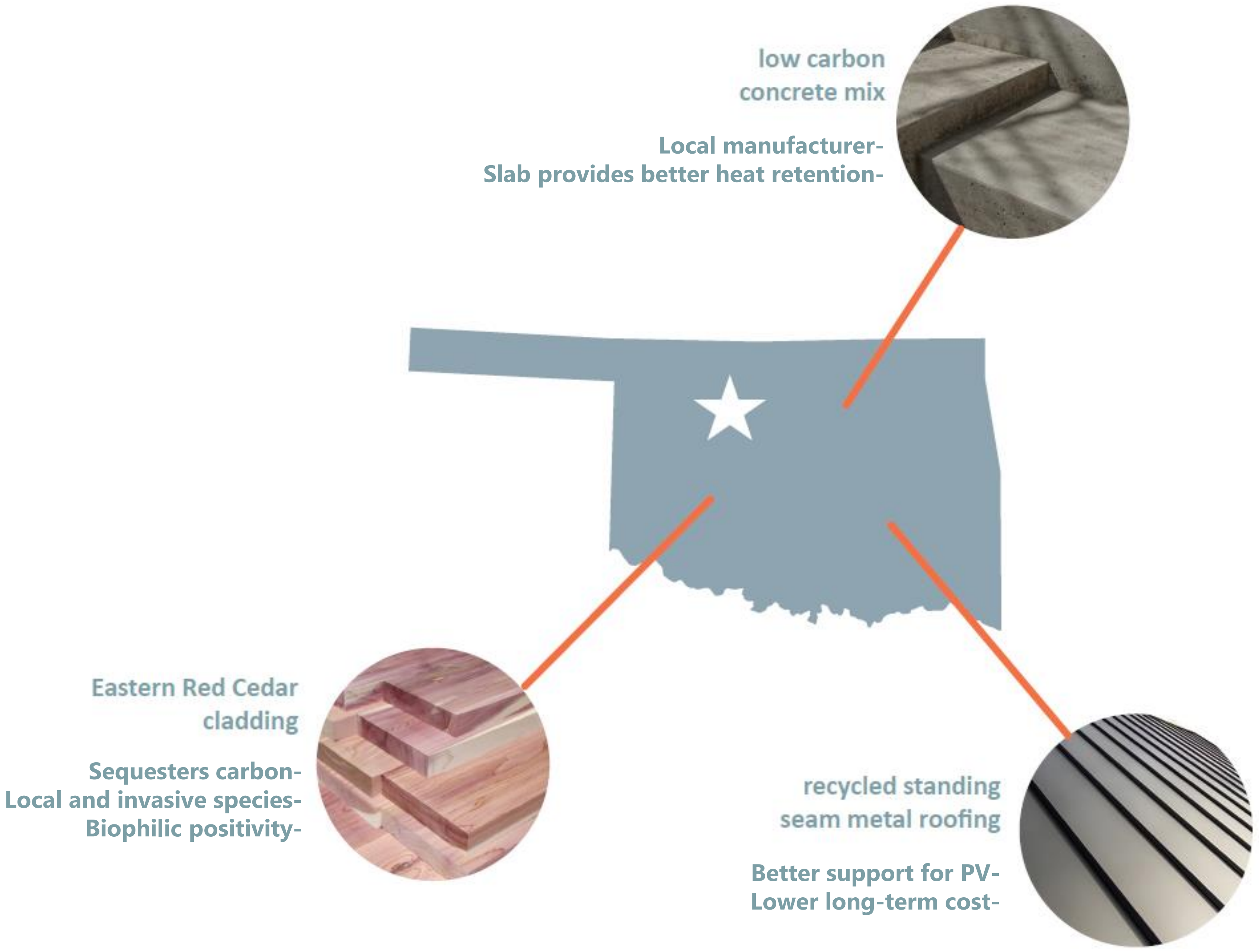


Eastern Red Cedar Availability



Invasive Eastern Red Cedar Expansion

Improved Materials & Location



LIFE-CYCLE / MATERIAL MODEL

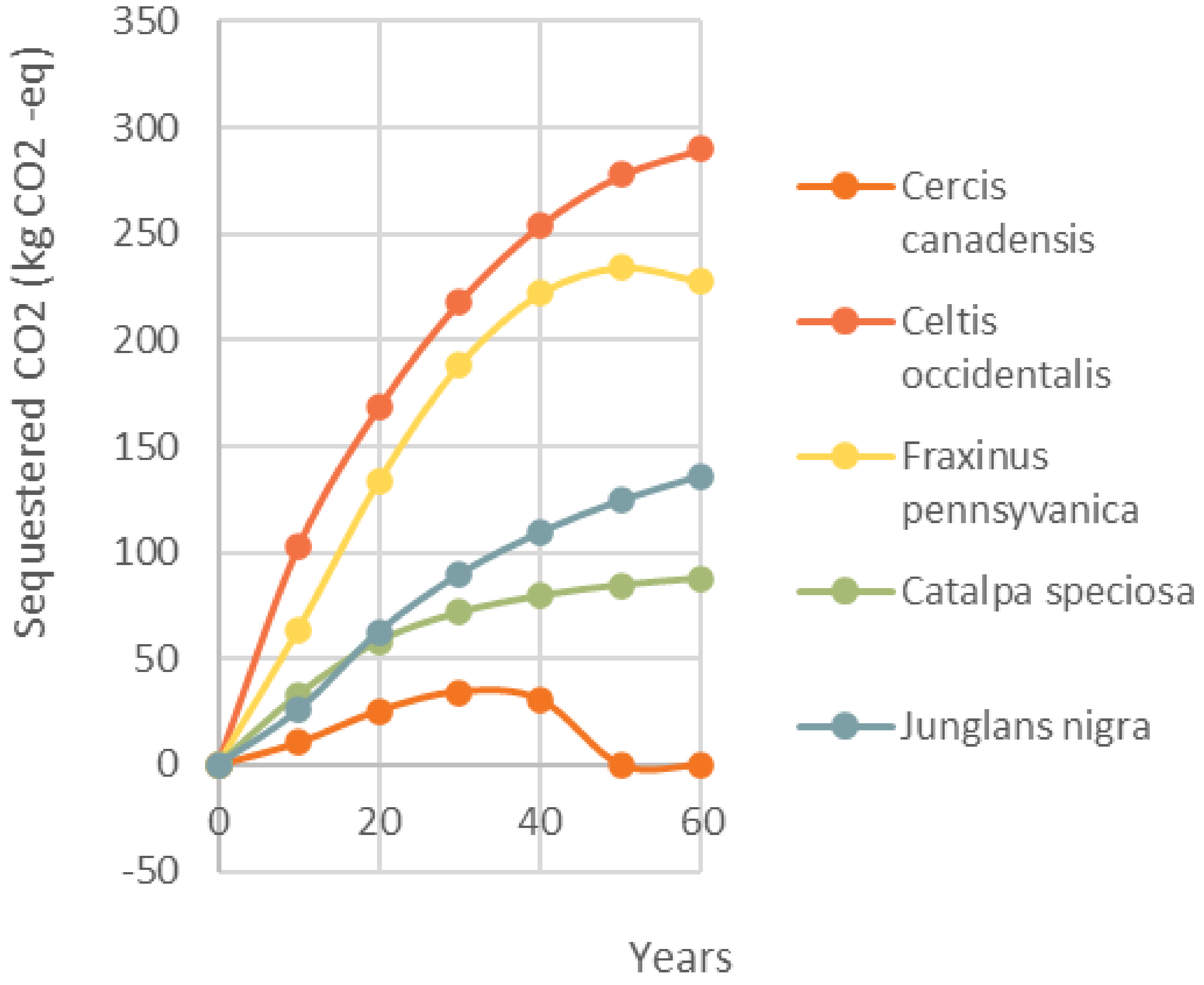
Architecture
Engineering
Envelope
Efficiency
Grid-Interactivity
Life-Cycle
Health
Market
Community

Front View + Entry Detail

Back View + Corner Detail

LIFE-CYCLE / EMBODIED CARBON / LANDSCAPING

Sequestered Carbon from Trees



Carbon by Building Category

	Materials	Model 1	Models 4 & 5
2	Foundation	29,767	20,293
3	Framing	-2,081	-14,319
4	Exterior Walls	7,645	14,677
5	Roofing + Ceiling	25,210	19,018
6	Interiors	9,137	16,832
7	Specialties	219	165
Total GWP		69897	56666
GWP per SF		23.14	18.76

Total Sequestered Carbon from Landscape

Unit A: 7,548.76 kg CO2 per year
Full Landscape: 22,646.28 kg CO2 per year

Research found with the help of the Center for Urban Forest Research and Gardenia

Net Carbon Cradle-to-Cradle

18.76 kgCO2/SF / 60 yrs = 0.31 kgCO2/SF/yr
-7549 kgCO2/yr / 3021 SF = -2.5 kgCO2/SF/yr
= -2.19 kg CO2 eq/SF/yr

86% more carbon sequestered than produced

HEALTH / EXTERIOR

PV Array

Garden

Future Wind Turbine

Water Feature

Butterfly Garden

Hammocks

Greenhouse

Site

Bioswale

The incorporation of biophilic design elements within the site aims to cultivate a sense of tranquility and connection with nature for its occupants. Biophilic design fosters a safe and nurturing environment. The design concept prioritizes organic elements that facilitate both communal gatherings and solitary moments of reflection. The bioswale on the north side of the site serves dual purposes by creating gathering spaces and harvesting rainwater.

HEALTH / INTERIOR

Journey women's center

Appliances
+ Induction cooktop
+ Filtered water
+ Closed Insert fireplace

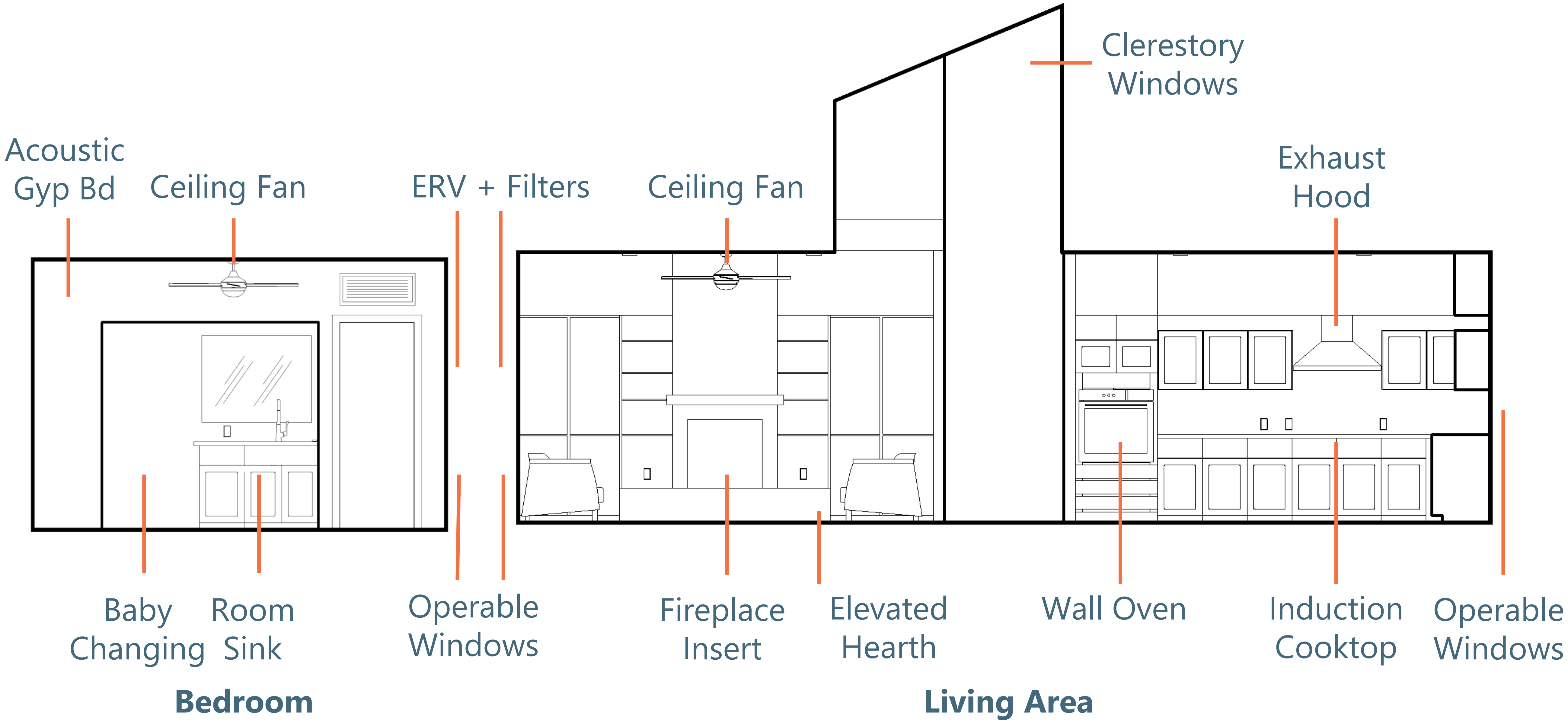
Fresh Air
+ 30 CFM per person for 100 sq ft
+ Operable windows
+ Natural ventilation

Clean Air
+ Low VOC materials
+ MERV 13 air filtration
+ ERV

Comfort Controls
+ Individual room thermal control
+ Natural ventilation
+ Ceiling fans

Privacy
+ Acoustic privacy (STC = 49)
+ Private rooms
+ Rural site

Interior Elevations + Health



Material Selection Criteria

+ Biophilic effects on wellbeing
+ Local availability
+ Reduction of water use
+ Low VOC materials
+ Healthy indoor air quality

ENERGY STAR
CRI GREEN LABEL PLUS
CERTIFIED cradle to cradle PRODUCTS PROGRAM
WaterSense Meets EPA Criteria
UL GREENGUARD GOLD

MARKET / COST ESTIMATION

Journey women's center

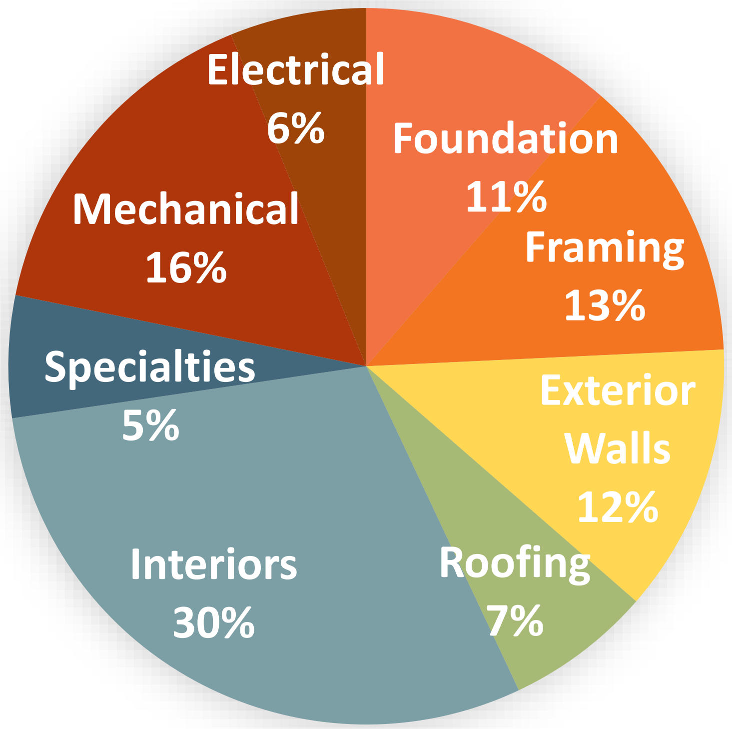
Building Information	Model 1 Total Cost ($)	Model 1 Replacement	Model 4 Total Cost ($)	Model 4 Replacement	Model 5 Total Cost ($)	Model 5 Replacement
2 Foundation	$37,456.60	$0.00	$39,365.28	$0.00	$39,365.28	$0.00
3 Framing	$42,365.22	$0.00	$37,133.95	$0.00	$37,133.95	$0.00
4 Exterior Walls	$39,950.16	$37,306.32	$70,332.37	$59,114.96	$70,332.37	$59,114.96
5 Roofing + Ceiling	$21,690.78	$35,859.27	$32,116.07	$23,985.77	$32,116.07	$23,985.77
6 Interiors	$97,690.30	$120,113.97	$101,491.14	$123,104.59	$101,491.14	$123,104.59
7 Specialties	$18,130.11	$0.00	$27,018.73	$15,852.90	$41,234.05	$15,852.90
8 Mechanical	$51,488.87	$0.00	$55,043.68	$0.00	$46,991.81	$0.00
9 Electrical	$20,293.32	$48,292.45	$20,465.62	$49,153.95	$20,656.45	$49,153.95
Subtotal	$329,065.36	$241,572.01	$382,966.84	$271,212.17	$389,321.12	$271,212.17
Contractor Fees (General Conditions, Overhead, Profit)	$131,626.14	$96,628.80	$153,186.74	$108,484.87	$155,728.45	$108,484.87
Architectural Fees	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
User Fees	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total	$460,691.50	$338,200.81	$536,153.58	$379,697.04	$545,049.57	$379,697.04
Cost Per SF	$152.50		$177.48		$180.42	
Total Life Span Cost		$798,892.32		$915,850.61		$924,746.61

MARKET / COST ESTIMATION

Model 1

~$152.50/SF

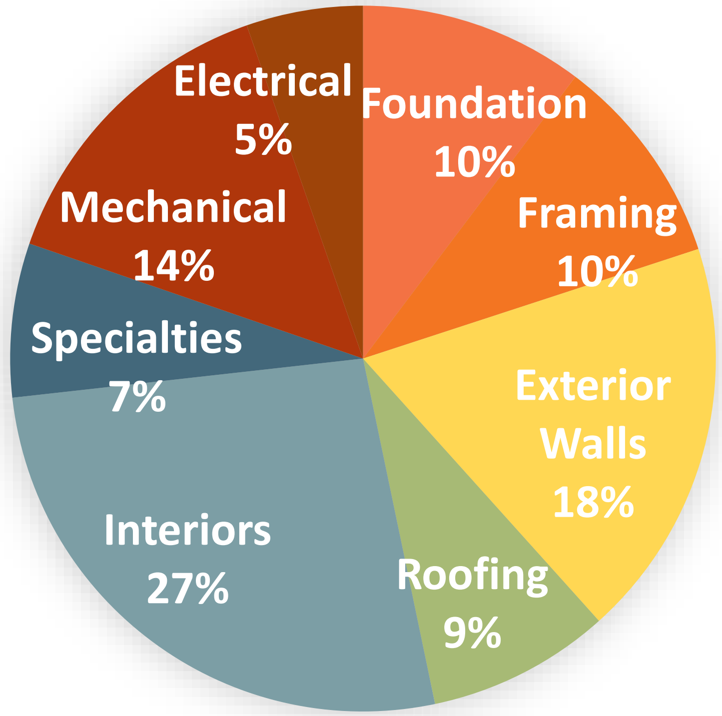
$460,691.50 Total



Model 4

~177.48/SF

$536,153.58 Total

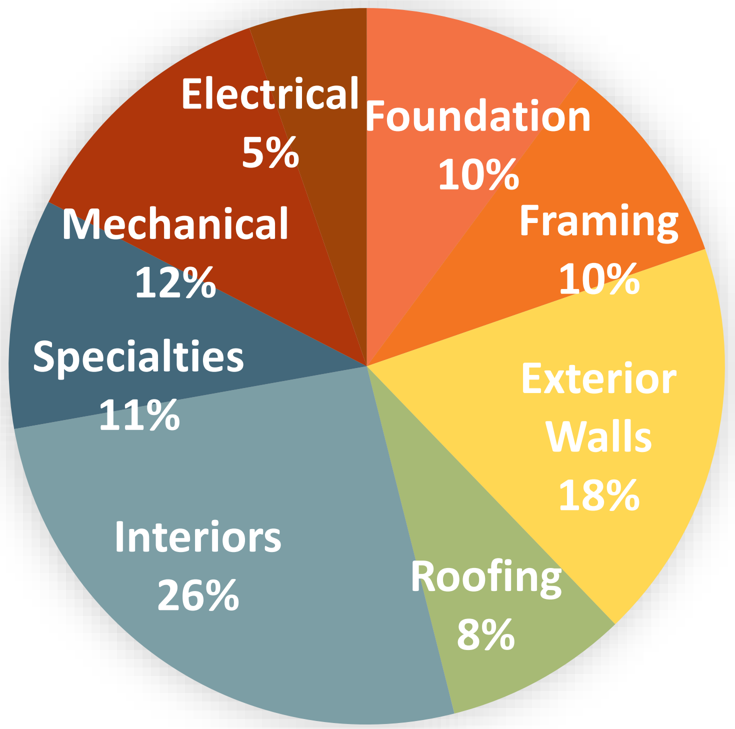


16% Increase

Model 5

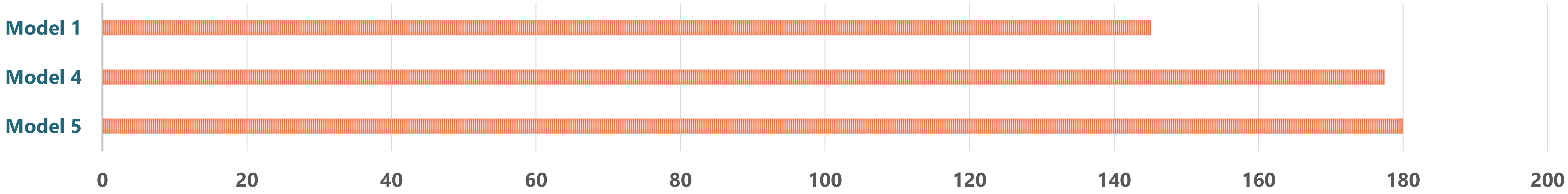
~180.02/SF

$543,837.94 Total



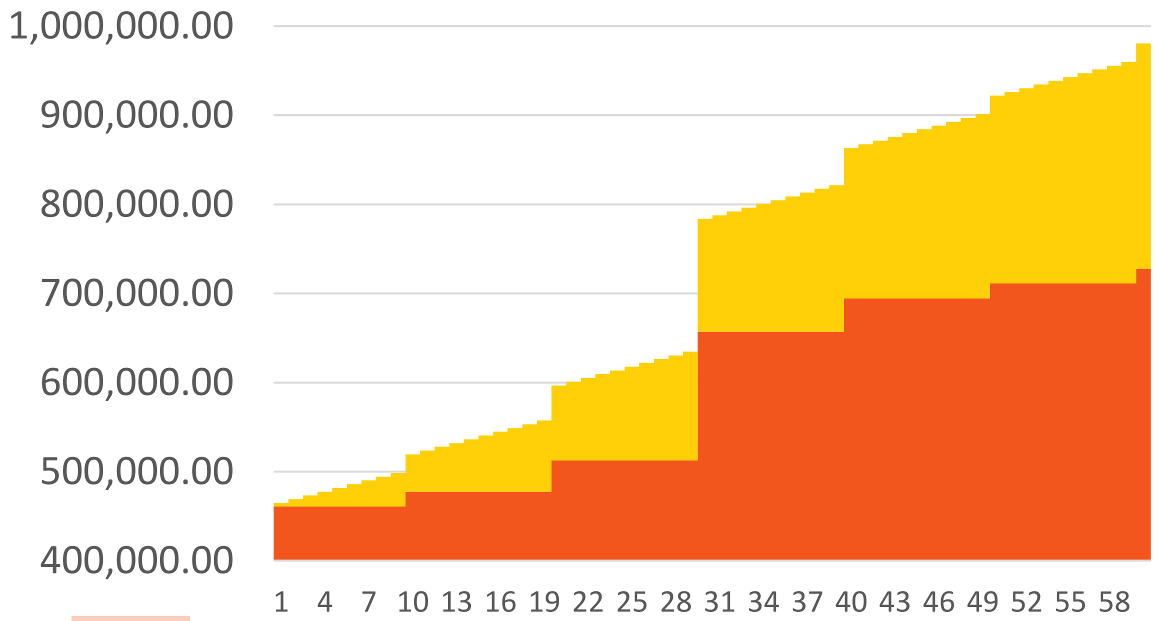
18% Cumulative Increase

COST PER SF

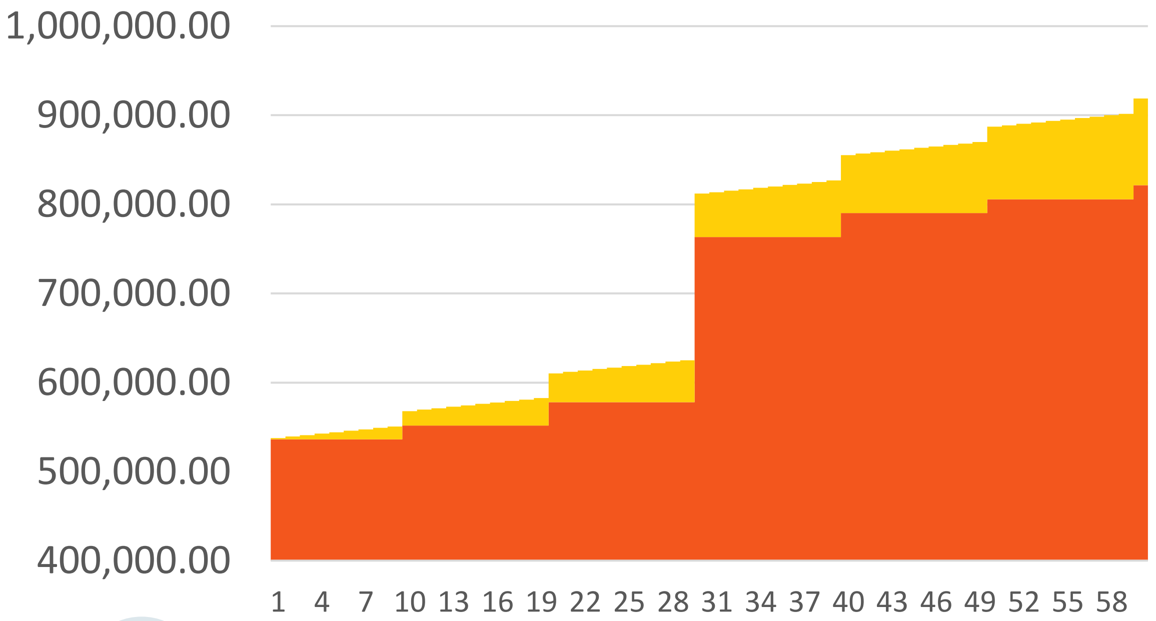


MARKET / LCA / CUMULATIVE COST

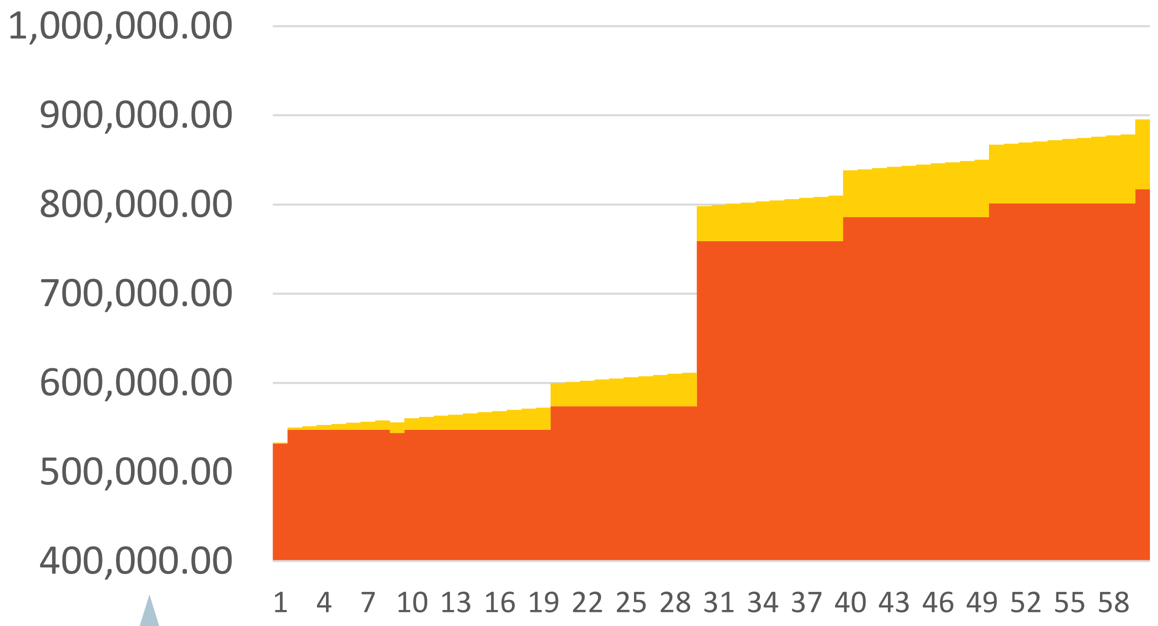
Model 1 Without P.V.



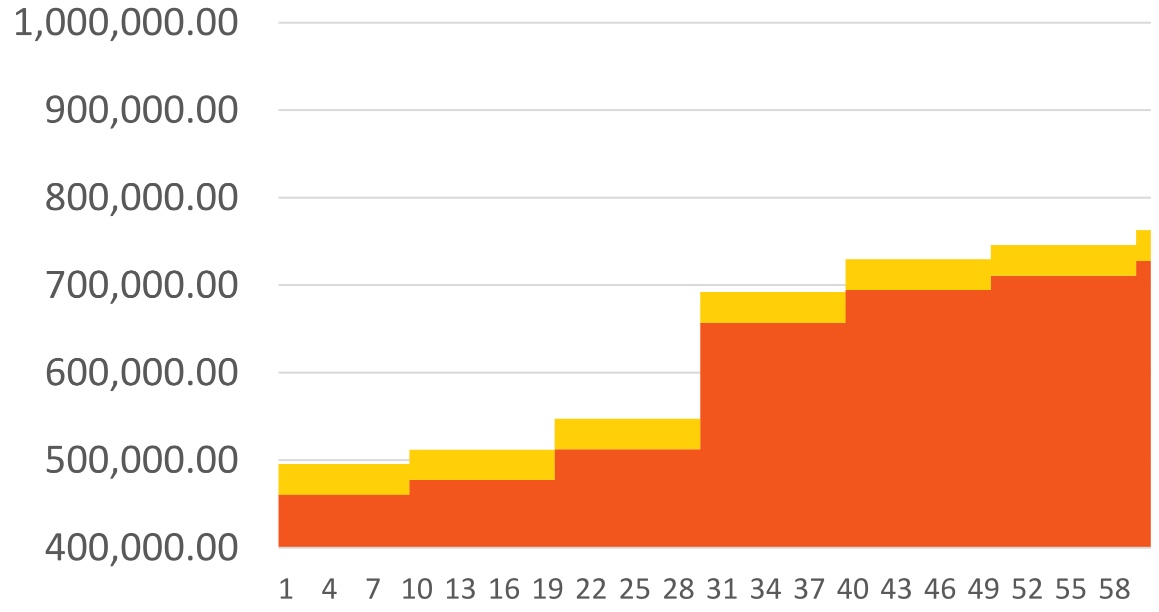
Model 4 Without P.V.



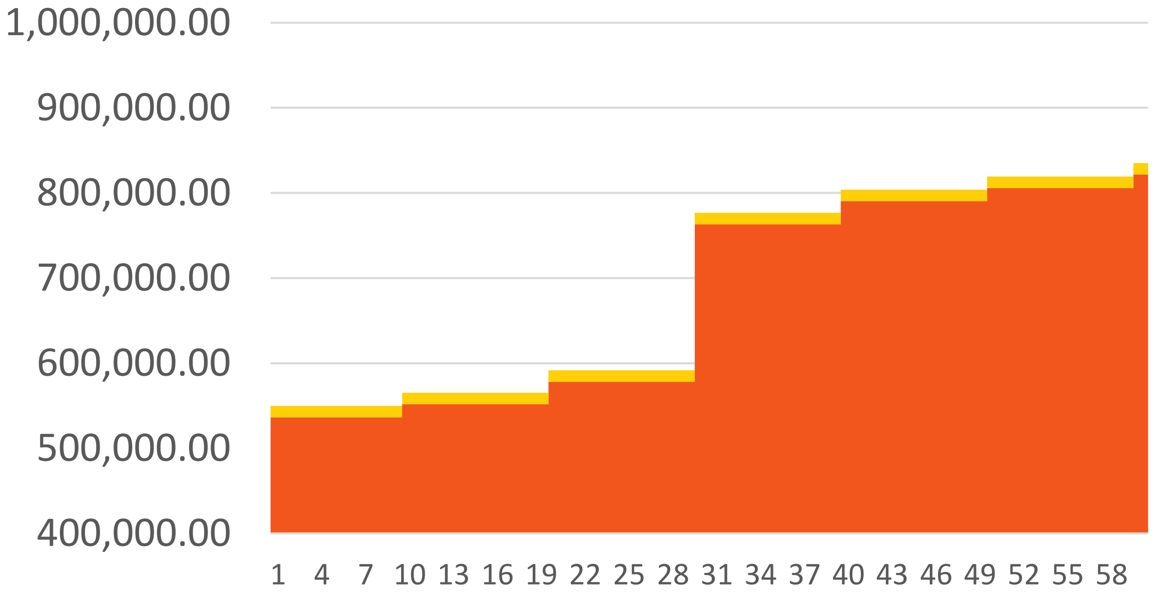
Model 5 Without P.V.



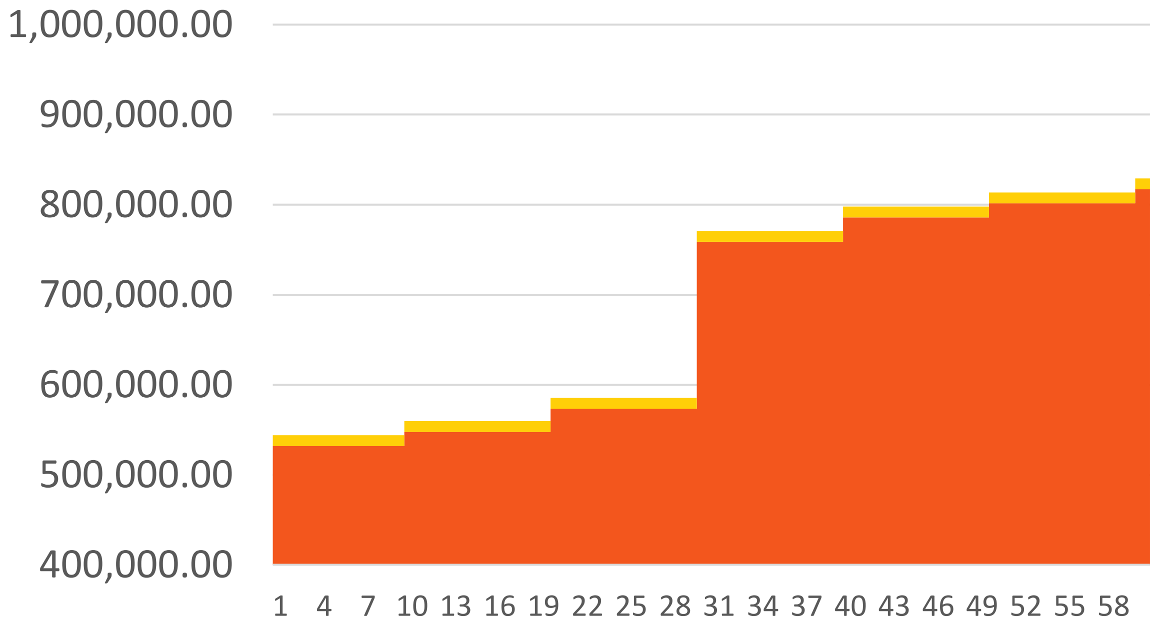
Model 1 With P.V.



Model 4 With P.V.



Model 5 With P.V.



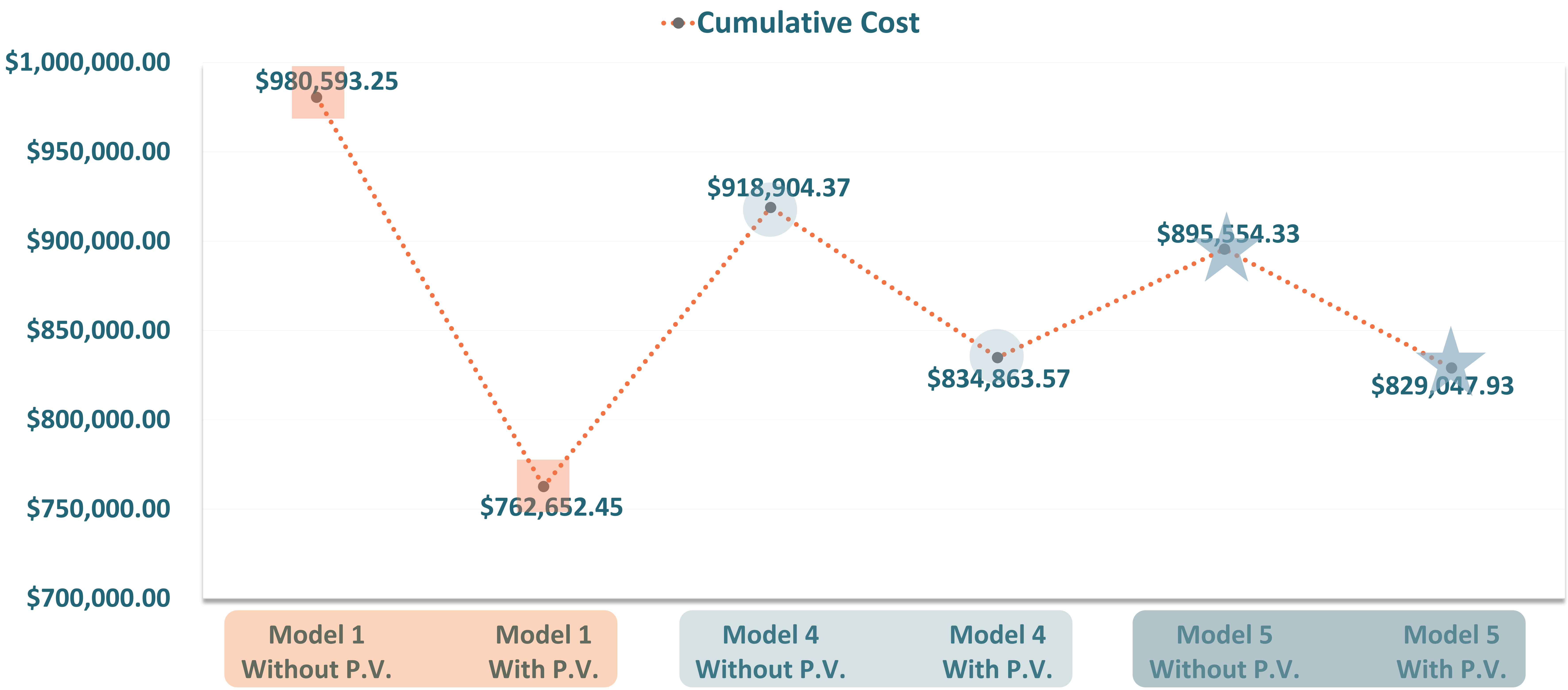
Energy/P.V. Cost

Building and Material Replacement Cost

MARKET / LCA / CUMULATIVE COST

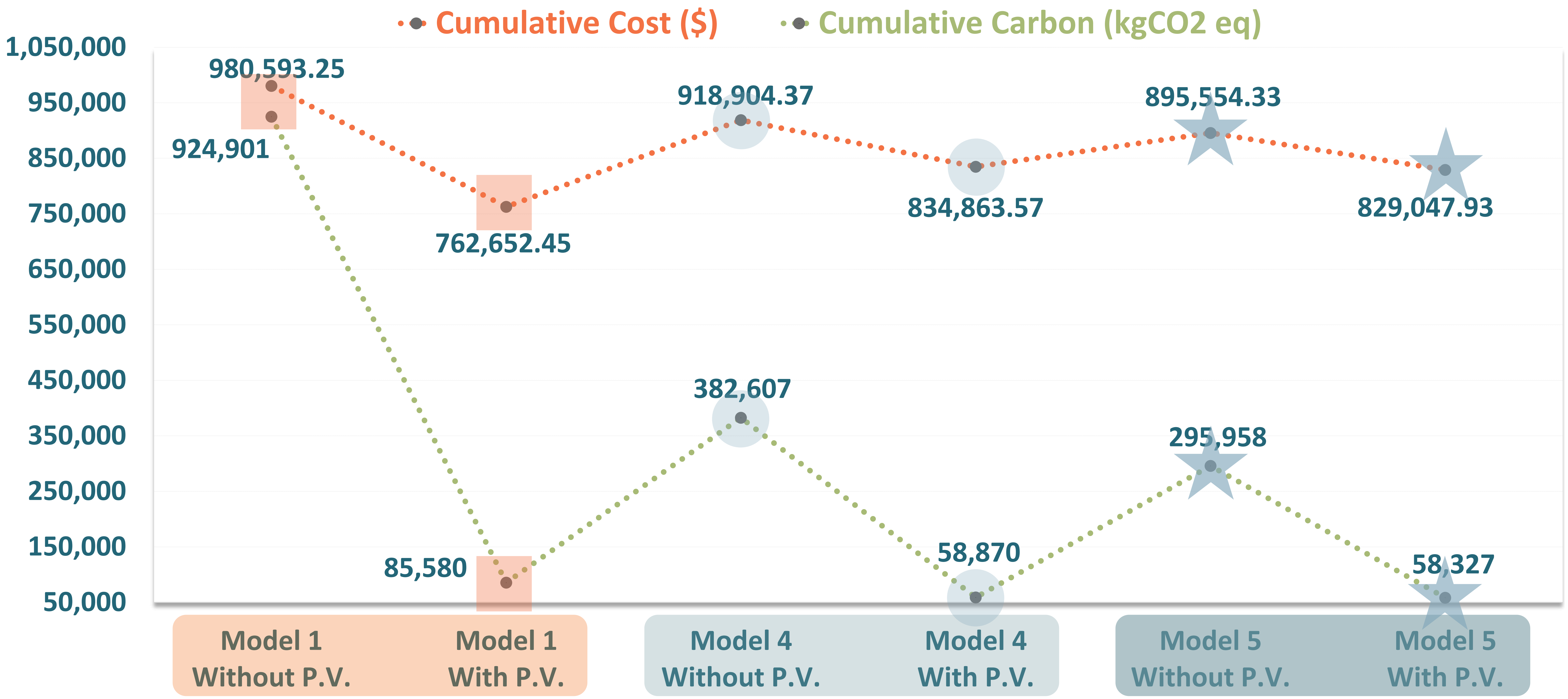
Journey women's center

Architecture
Engineering
Envelope
Efficiency
Grid-Interactivity
Life-Cycle
Health
Market
Community



Cumulative Cost = Upfront Cost (Construction) + Cost of Operational Energy

MARKET / LCA / ENERGY + COST + CARBON



Number of P.V. panels required would not fit on this roof

20% P.V. roof coverage

Cumulative Cost = Upfront Cost (Construction) + Cost of Operational Energy
Cumulative Carbon = Embodied Carbon + Operational Carbon

COMMUNITY / GOALS + SITE

"We recognize that an unplanned pregnancy is a complex issue that must be met with compassion and a loving approach."

Goals Within Design

Hillsdale Community

+ Land is donated by community member
+ House parents are Hillsdale residents
+ Local church offering support

Journey Community

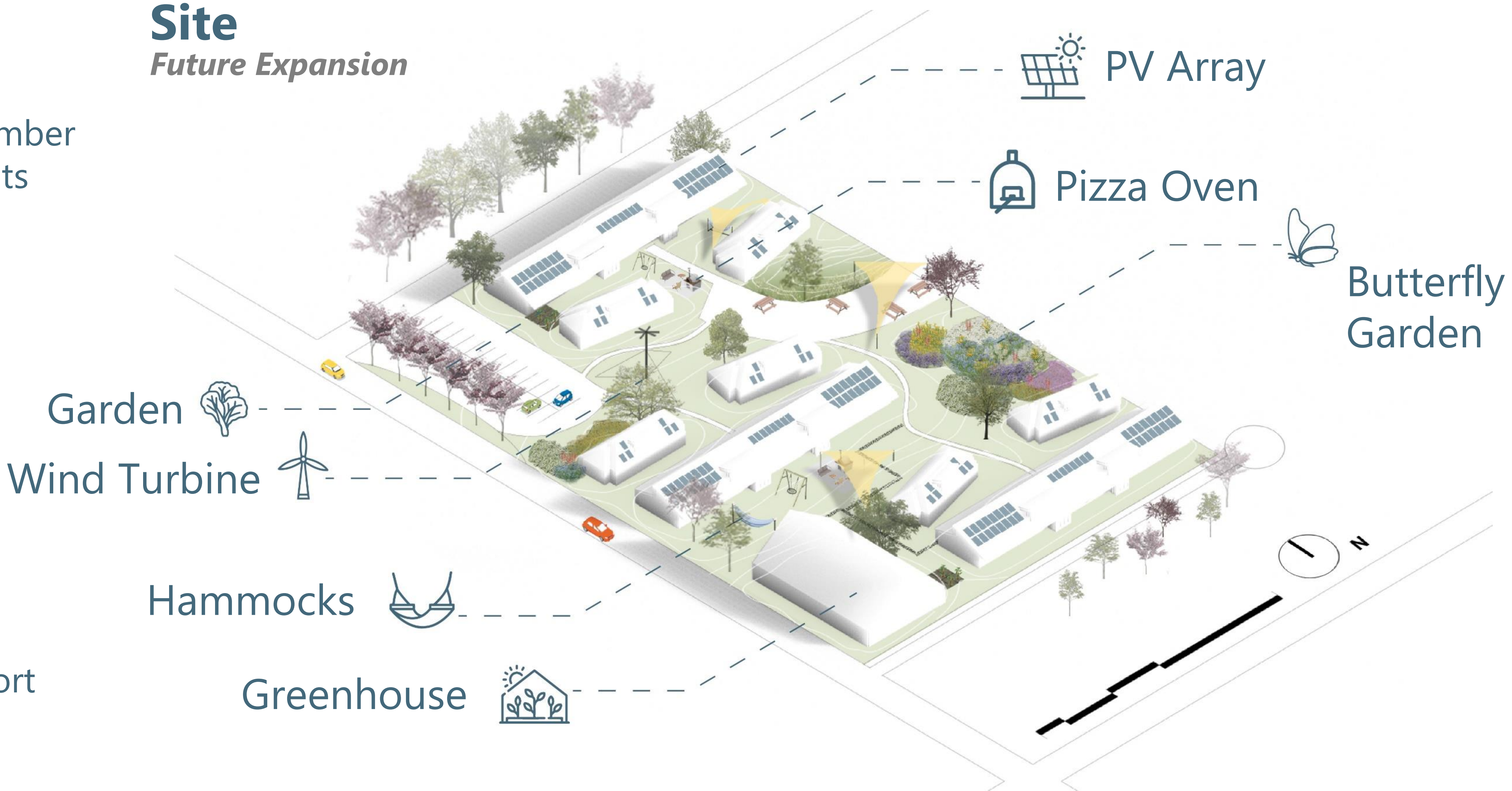
+ Cluster Design
+ Outdoor living space
+ Open plan Interiors

Resilient Construction

+ Local Material Choices
+ Passive Solar Heating and Cooling
+ Maintaining Human Thermal Comfort

Site

Future Expansion



COMMUNITY / SITE MODEL

Architecture
Engineering
Envelope
Efficiency
Grid-Interactivity
Life-Cycle
Health
Market
Community

Site Model

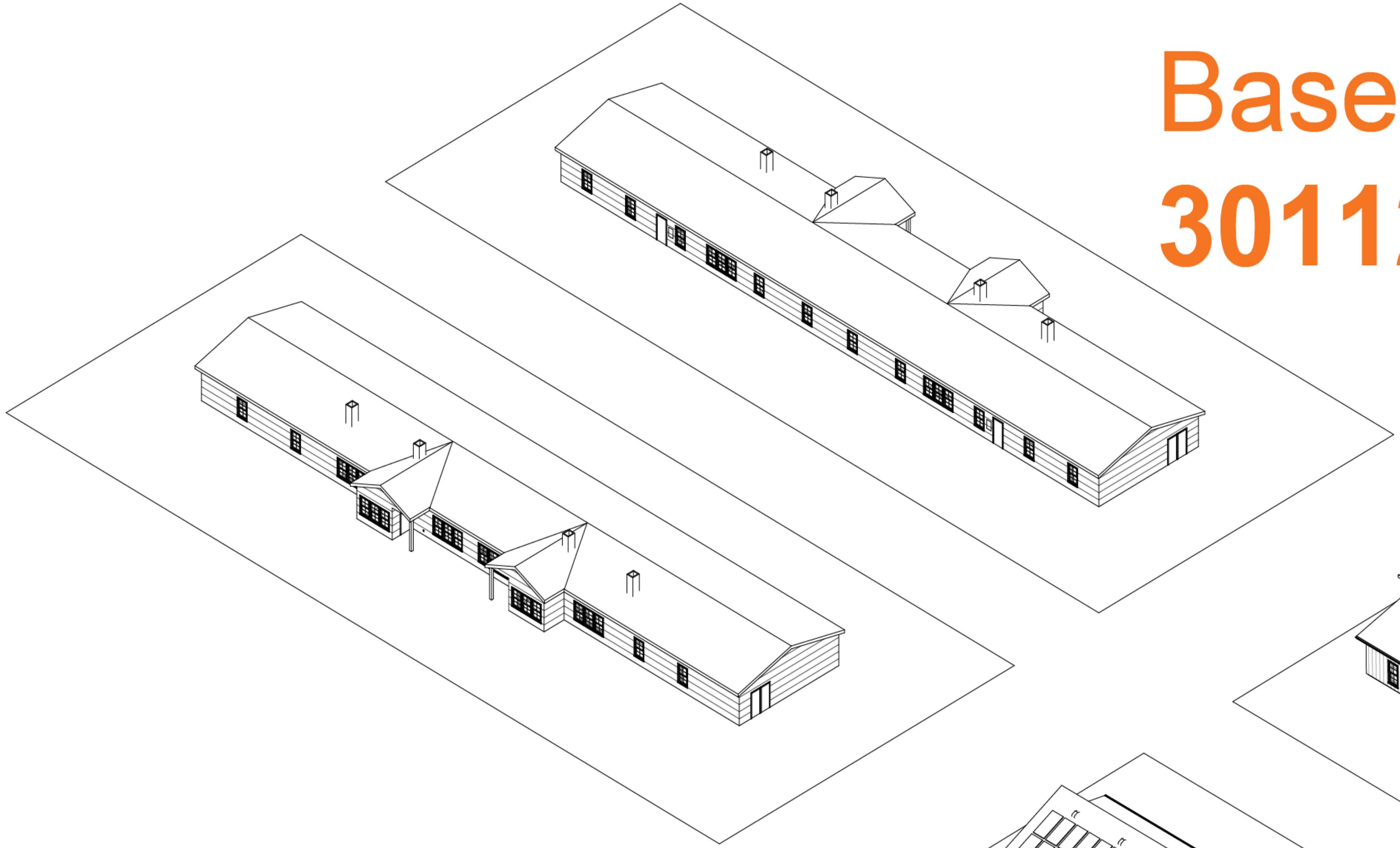
Site Axon

CONCLUSION

Hope **Community** **Resiliency**

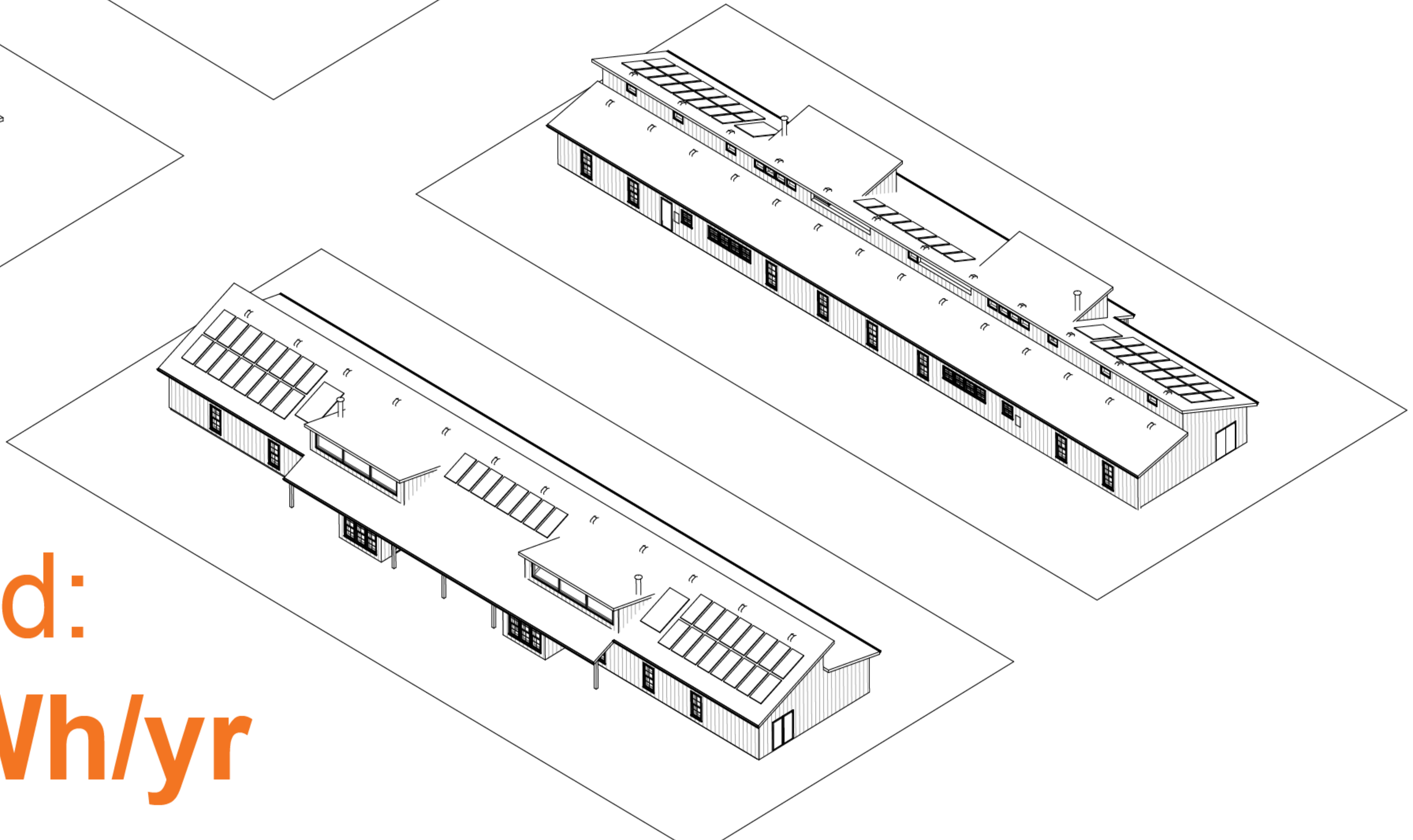
THANK YOU!
QUESTIONS?

Model 1 vs. Model 5 Comparison



Baseline:

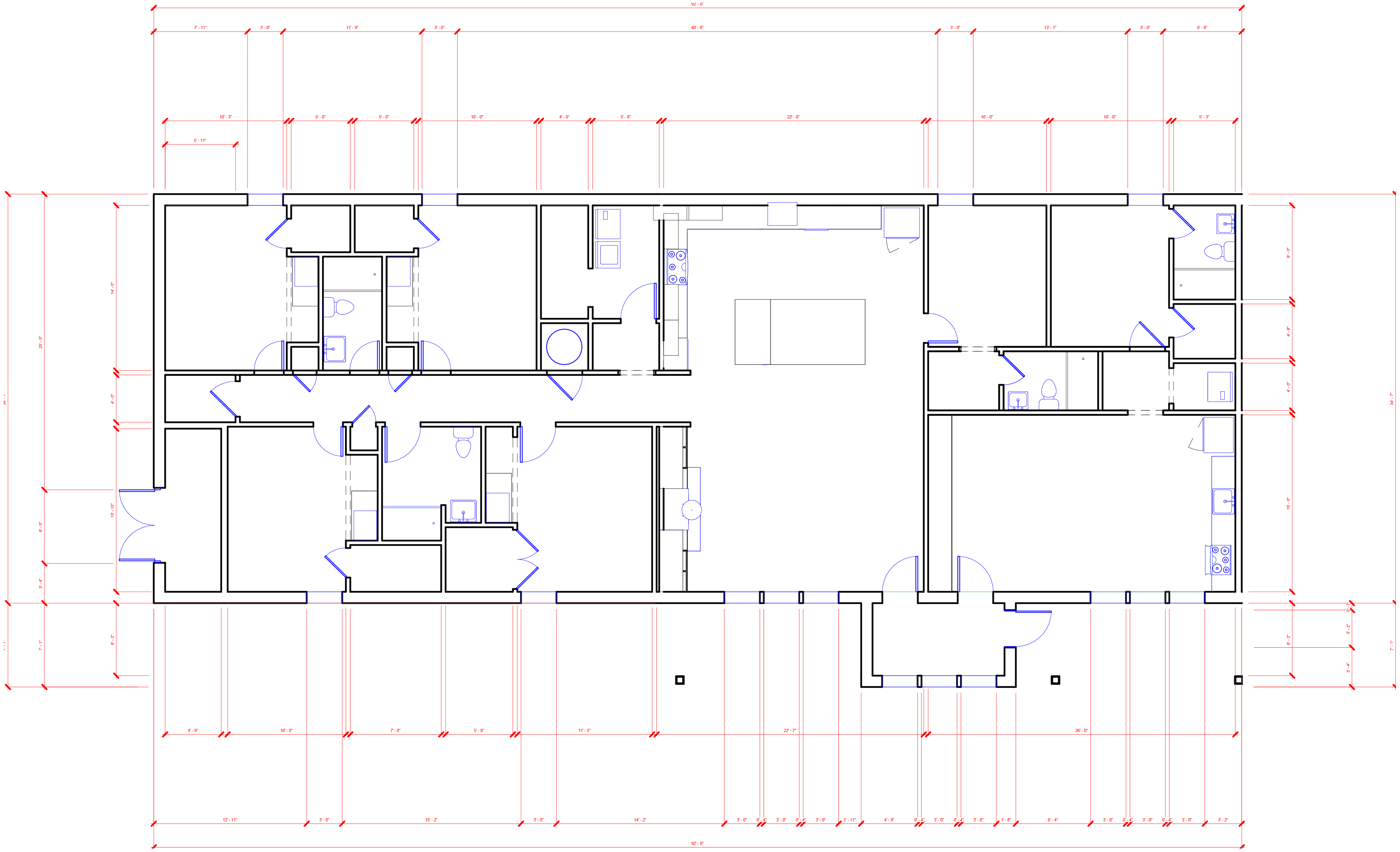
30112 kWh/yr



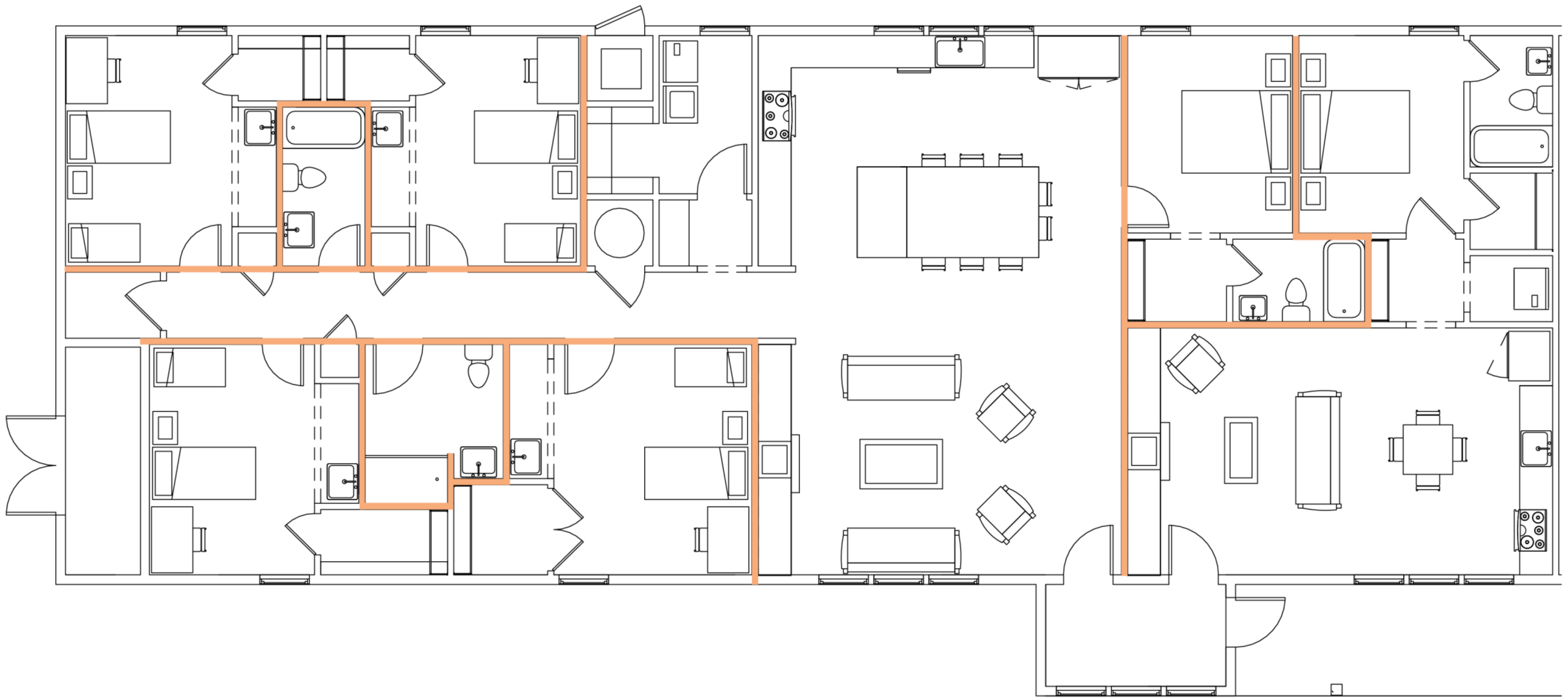
Improved:

9346 kWh/yr

Dimensioned Plan, Units A1 & A2

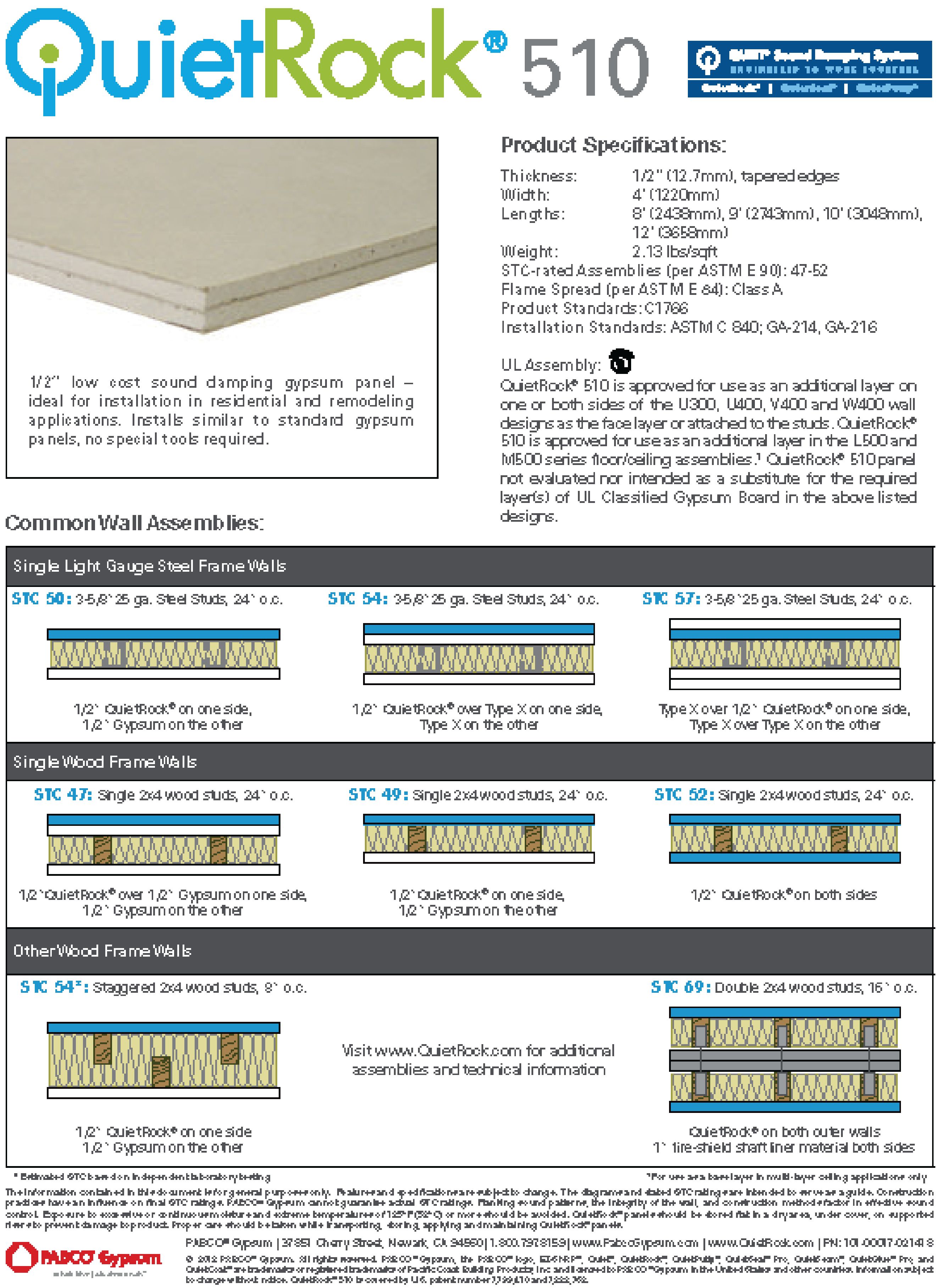


Acoustic Partitions Plan, Units A1 & A2



STC Rating of 49

International Well Building Institute recommends a minimum STC rating of 40 between circulation zones and regularly occupied spaces.



QuietRock® 510

1/2" low cost sound damping gypsum panel – ideal for installation in residential and remodeling applications. Installs similar to standard gypsum panels, no special tools required.

Product Specifications:

Thickness: 1/2" (12.7mm), tapered edges
Width: 4' (1220mm)
Lengths: 8' (2438mm), 9' (2743mm), 10' (3048mm), 12' (3658mm)
Weight: 2.13 lbs/sqft
STC-rated Assemblies (per ASTM E 90): 47-52
Flame Spread (per ASTM E 84): Class A
Product Standards: C1766
Installation Standards: ASTM C 840; GA-214, GA-216

UL Assembly:
QuietRock® 510 is approved for use as an additional layer on one or both sides of the U300, U400, V400 and W400 wall designs as the face layer or attached to the studs. QuietRock® 510 is approved for use as an additional layer in the L500 and M500 series floor/ceiling assemblies.[1] QuietRock® 510 panel not evaluated nor intended as a substitute for the required layer(s) of UL Classified Gypsum Board in the above listed designs.

Common Wall Assemblies:

Single Light Gauge Steel Frame Walls

STC 50: 3-5/8" 25 ga. Steel Studs, 24" o.c. — 1/2" QuietRock® on one side, 1/2" Gypsum on the other

STC 54: 3-5/8" 25 ga. Steel Studs, 24" o.c. — 1/2" QuietRock® over Type X on one side, Type X on the other

STC 57: 3-5/8" 25 ga. Steel Studs, 24" o.c. — Type X over 1/2" QuietRock® on one side, Type X over Type X on the other

Single Wood Frame Walls

STC 47: Single 2x4 wood studs, 24" o.c. — 1/2" QuietRock® over 1/2" Gypsum on one side, 1/2" Gypsum on the other

STC 49: Single 2x4 wood studs, 24" o.c. — 1/2" QuietRock® on one side, 1/2" Gypsum on the other

STC 52: Single 2x4 wood studs, 24" o.c. — 1/2" QuietRock® on both sides

Other Wood Frame Walls

STC 54*: Staggered 2x4 wood studs, 8" o.c. — 1/2" QuietRock® on one side, 1/2" Gypsum on the other

Visit www.QuietRock.com for additional assemblies and technical information

STC 69: Double 2x4 wood studs, 16" o.c. — QuietRock® on both outer walls, 1" fire-shield shaft liner material both sides

* Estimated STC based on independent laboratory testing

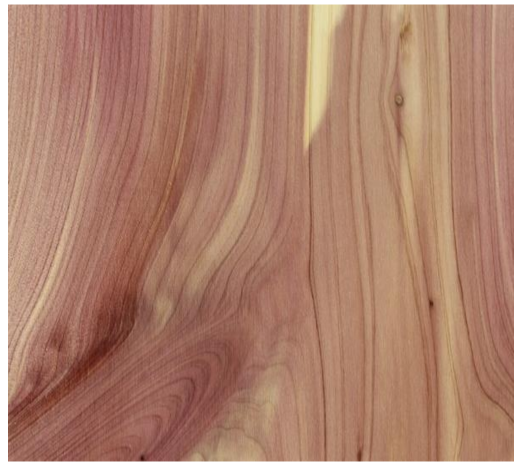
[1] For use as a base layer in multi-layer ceiling applications only

PABCO® Gypsum | 37851 Cherry Street, Newark, CA 94560 | 1.800.797.8159 | www.PabcoGypsum.com | www.QuietRock.com | PN: 101-00017-02141 8

Floor Plan, Units A1 & A2

Sherwin Williams – Pure White ProMar 200 Zero

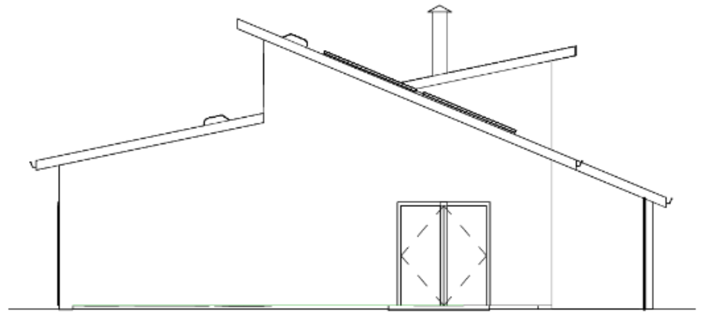
ShawContract - Reside 12 MIL Hearth 9141



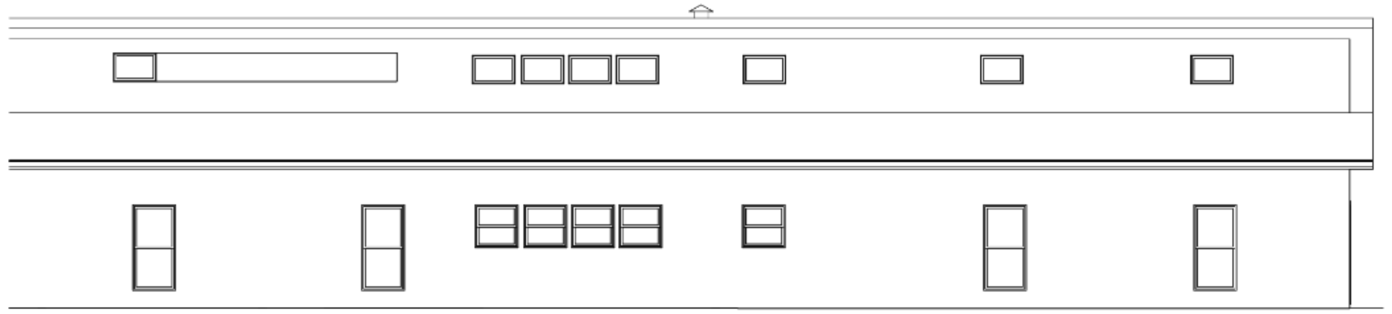
Local Lumber
Eastern Red Cedar Wood

Door and Window Schedules

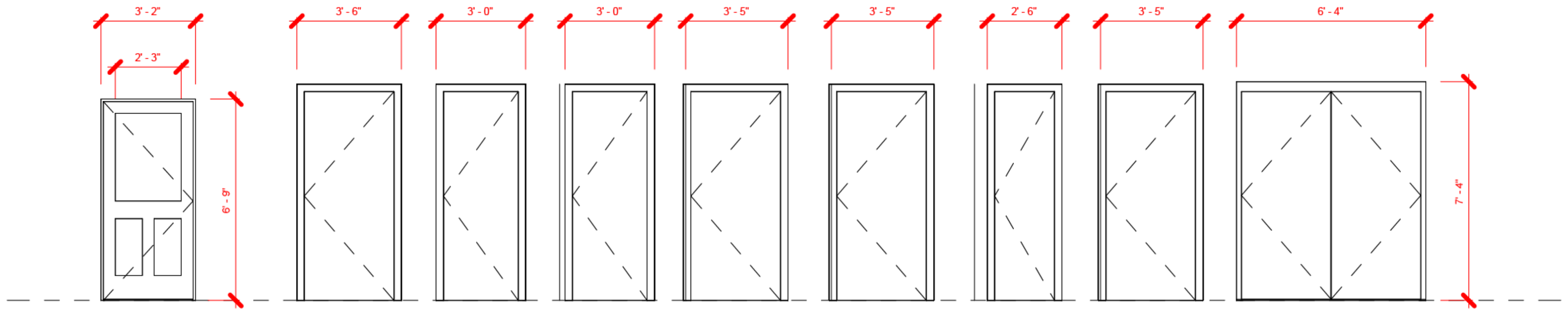
1 South Elevation
1/16" = 1'-0"



4 West Elevation
1/16" = 1'-0"



2 North Elevation
1/16" = 1'-0"



A
Exterior
Alum. Frame
Temp/ Glass Panel

B
Interior
Solid Core
Red Cedar

C
Interior
Solid Core
Red Cedar

D
Interior
Solid Core
Red Cedar

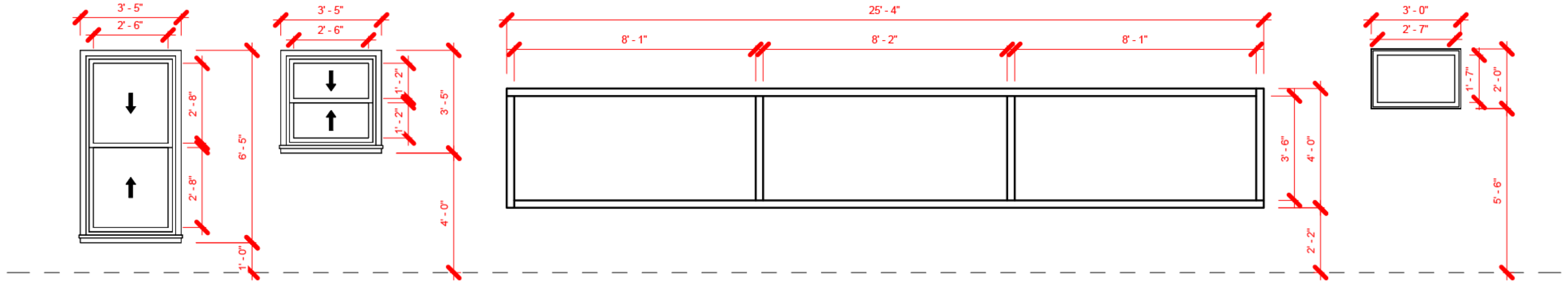
E
Interior
Solid Core
Red Cedar

F
Interior
Solid Core
Red Cedar

G
Interior
Solid Core
Red Cedar

H
Interior
Solid Core
Red "Cedar

I
Exterior
Alum. Frame
Polycarb. Panel



A1
Double-Hung
Wood Frame
QTY. 14

A2
Double-Hung
Wood Frame
QTY. 5

B
Fixed
Wood Frame
QTY. 1

C
Fixed
Wood Frame
QTY. 8

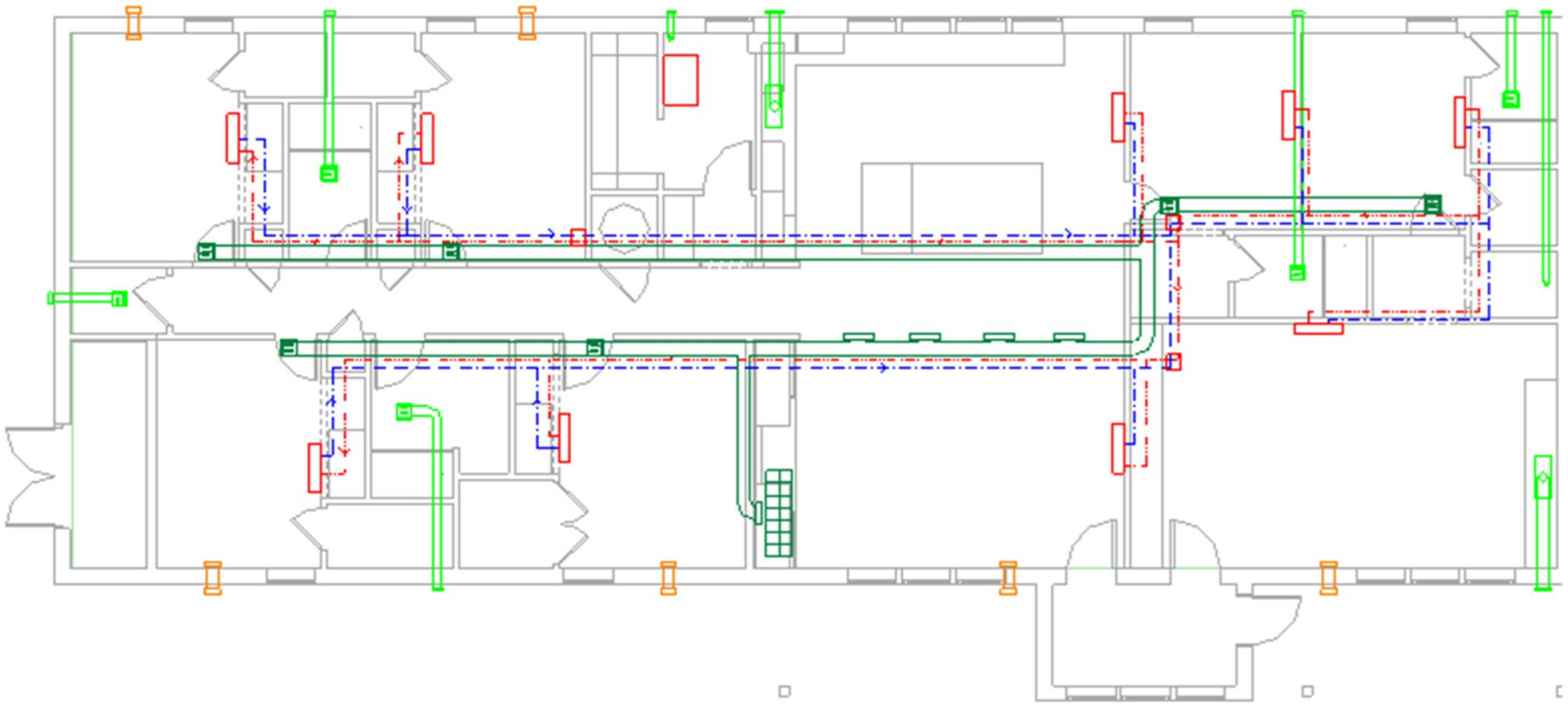
MARK	DOOR TYPE	COMMENTS
100	A	EXT.
101	B	INT.
102	B	INT.
103	C	INT.
104	D	INT.
105	D	INT.
106	E	INT.
107	D	INT.
108	B	INT.
109	F	INT.
110A	B	INT.
110B	C	INT.
110C	C	INT.
110D	C	INT.
111A	D	INT.
111B	D	INT.
112B	D	INT.
112C	D	INT.
112D	D	INT.
113A	B	INT.
113B	C	INT.
114	G	INT.
115	G	EXT.
116	H	EXT.
117	I	EXT.

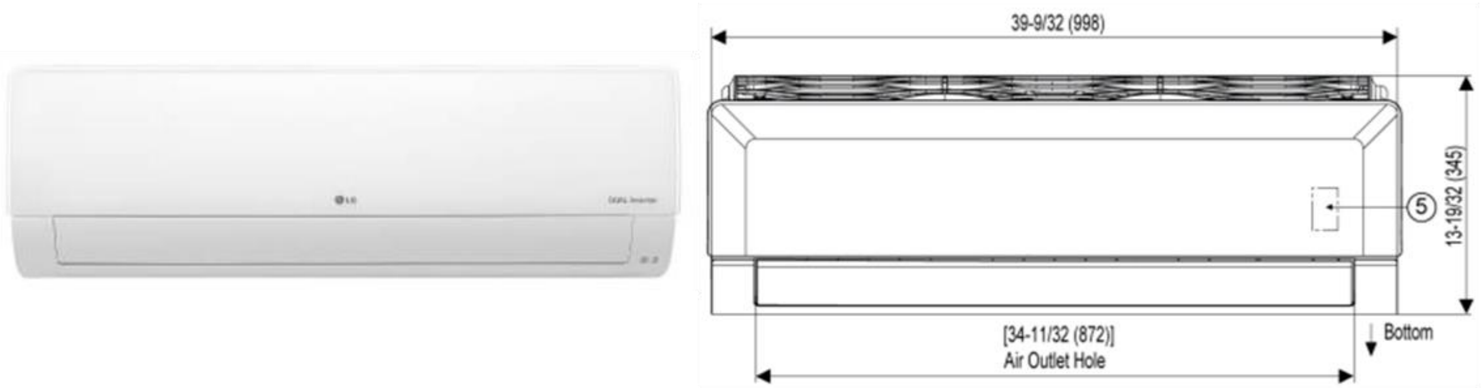
DOOR SCHEDULE

MARK	COMMENTS
A1	Single Hung
A2	Single Hung
B	Fixed
C	Fixed

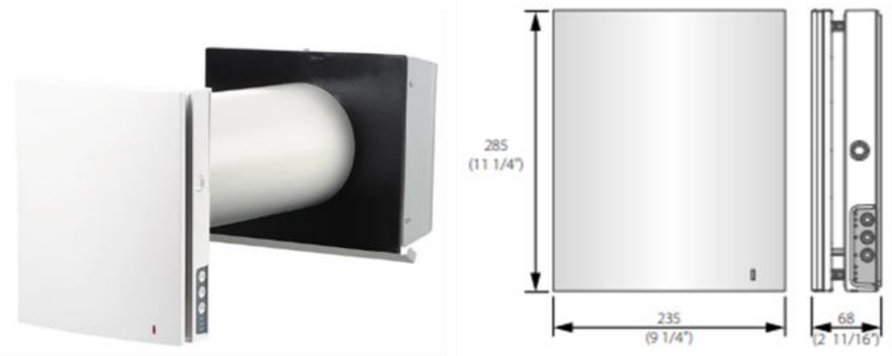
WINDOW SCHEDULE

Mechanical Plan / VRF + Ductless ERV

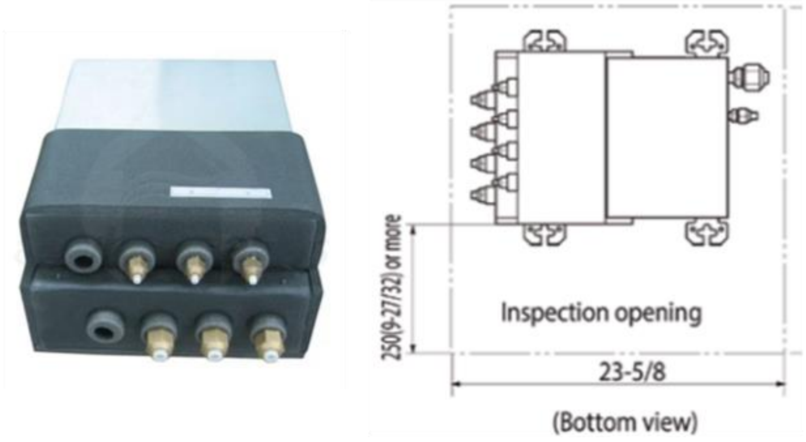




Multi-Zone LG Mini Split

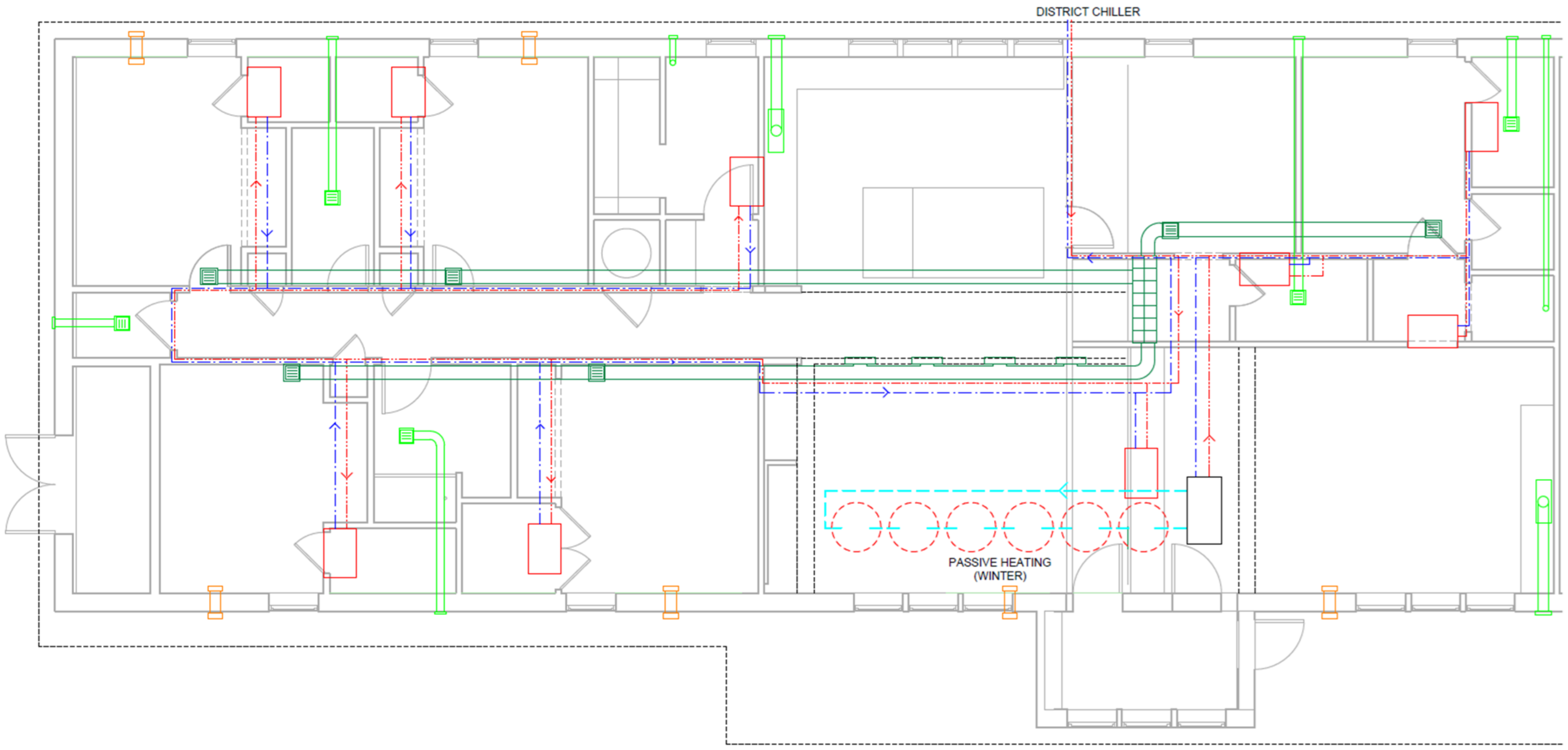


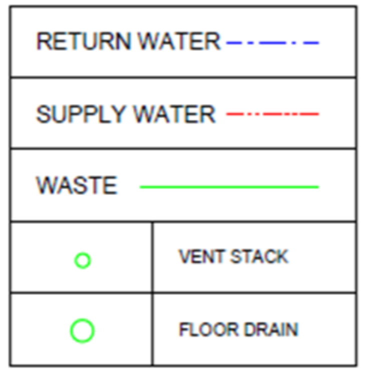
Twin Fresh Expert RHA - 50

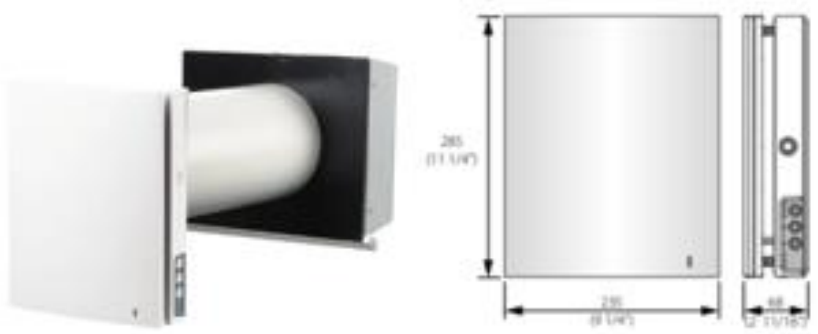


Decision Box

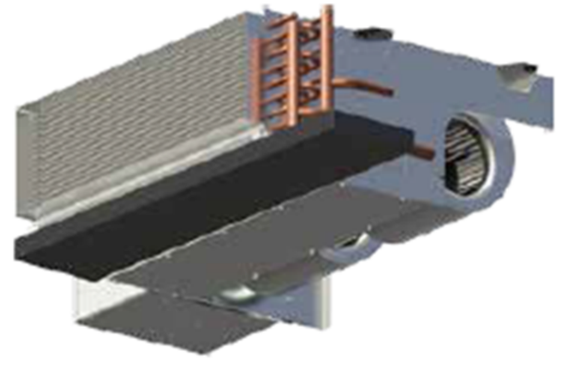
Mechanical Plan / 4-Pipe Fan Coil + Passive Solar + Ductless ERV



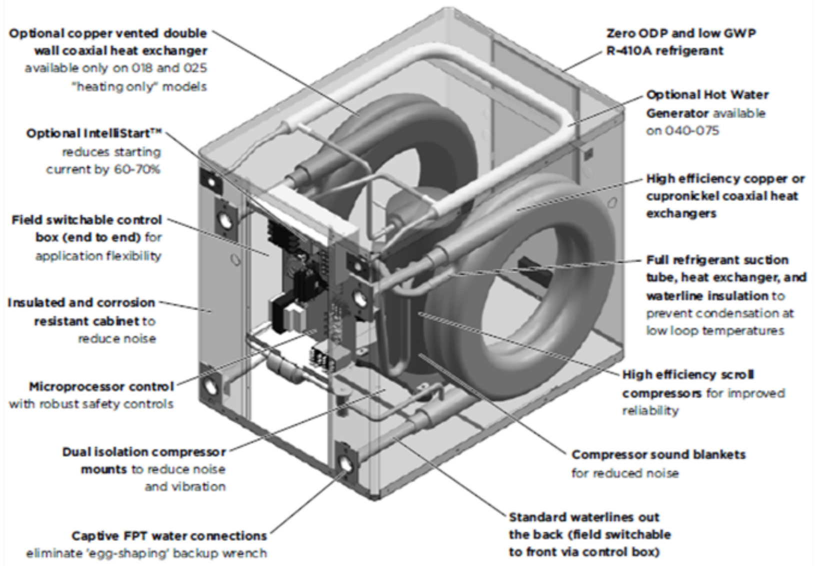




Twin Fresh Expert RHA - 50

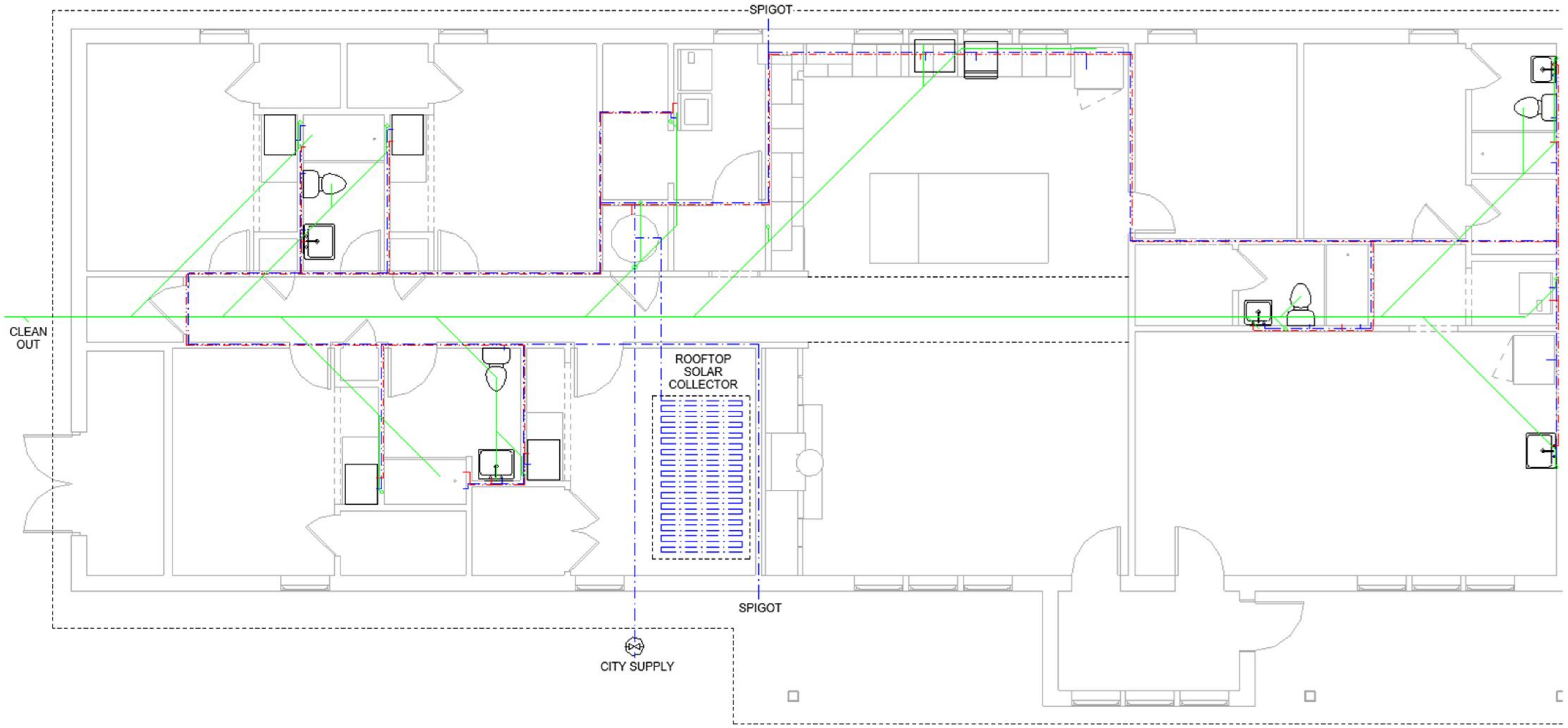


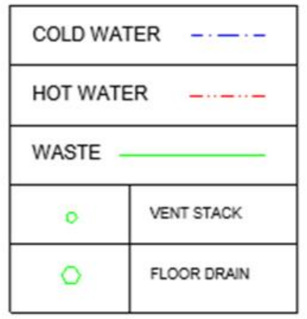
FH Fan Coil Units Low Profile Horizontal Series D



Envision Geothermal Hydronic Heat Pump

Plumbing Plan





Water Consumption:
110,000 gal/year

H2Optimum 1.1gpf 12" Rough Tank

Origin 21 2-handle WaterSense Bathroom Sink Faucet with Drain

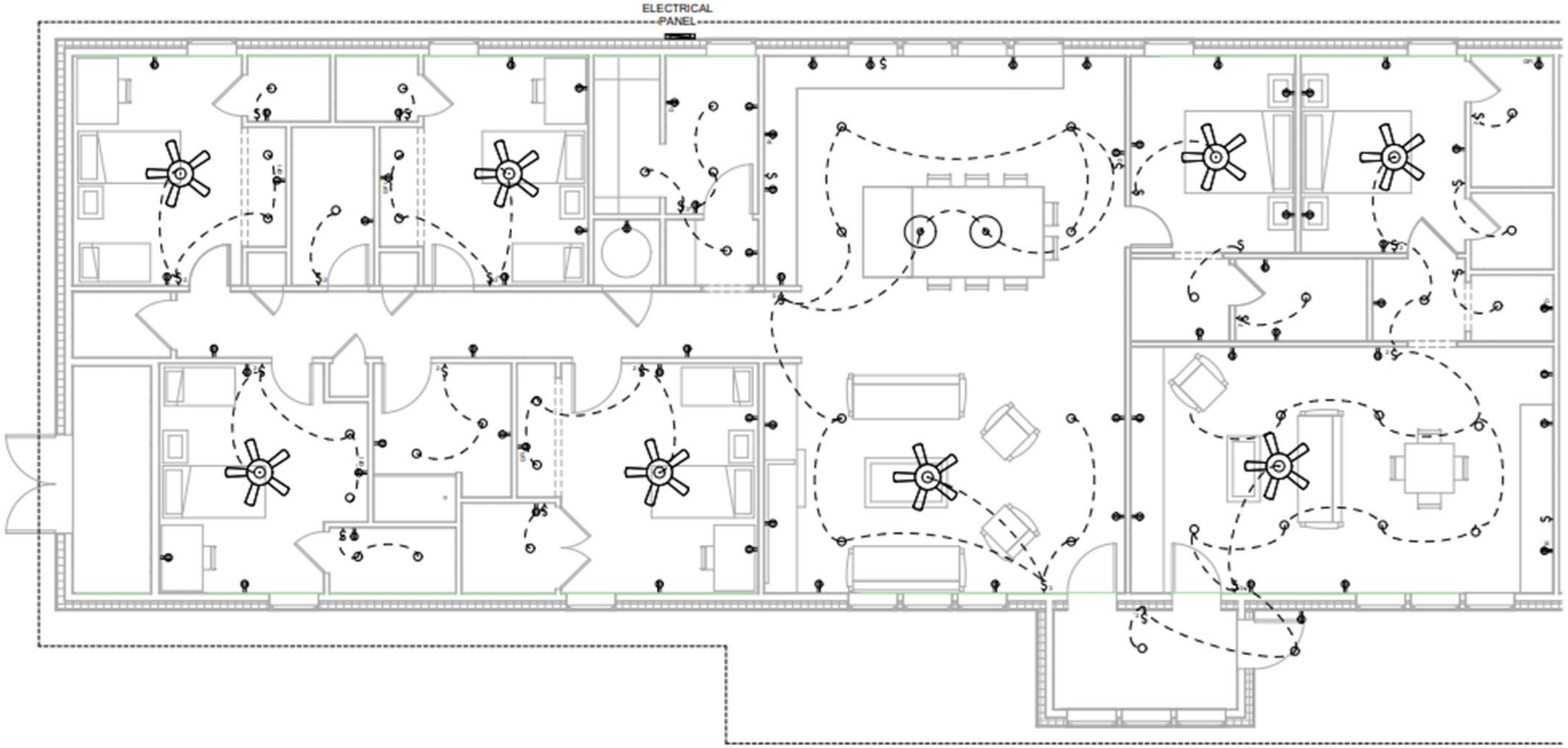
Niagara Conservation HealthGuard 1.5-gpm

Allen + Roth Single Handle Pull-down Kitchen Faucet with Sprayer

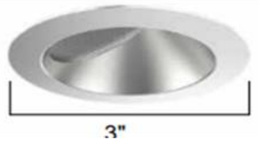
Premium Drinking Water Safe Garden Hose

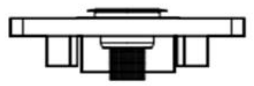
AET – EagleSun DX: DX-80-64

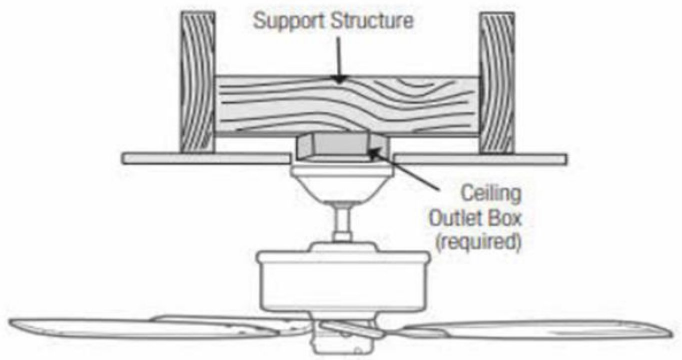
Electrical Plan



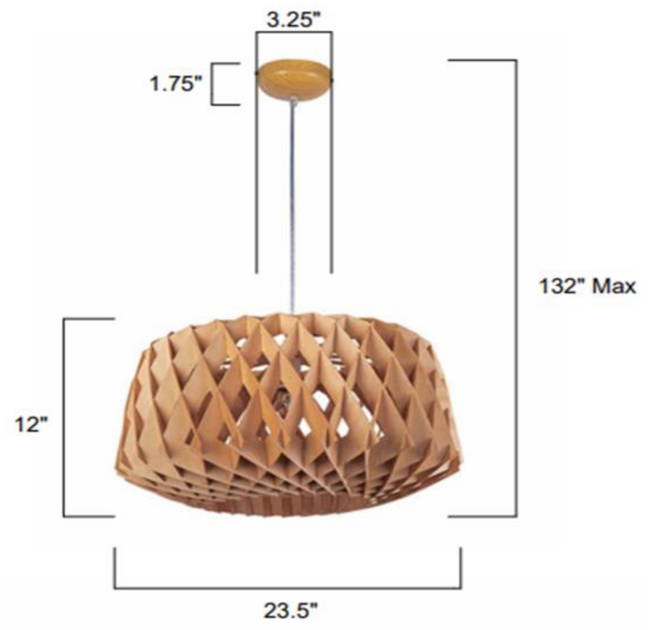
SWITCH OUTLETS	
$	SINGLE SWITCH
$_2$	DOUBLE SWITCH
$_3$	TRIPLE SWITCH
S_{TH}	THERMOSTAT
RECEPTACLE OUTLETS	
	DUPLEX OUTLET
R	RANGE OUTLET
D	DRYER OUTLET
GFI	GFI OUTLET
LIGHTING FIXTURES	
6" CAN	52" CEILING FAN
8" CAN	

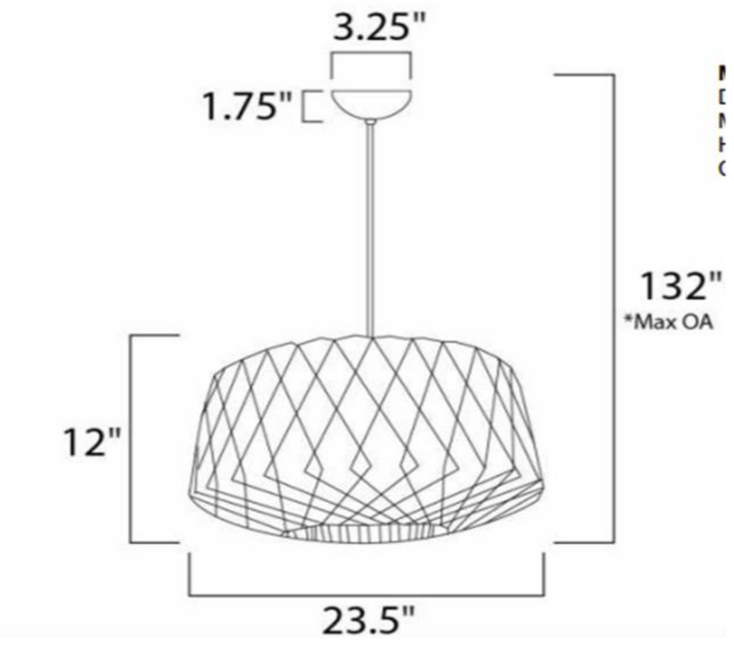






Hunter Aerodyne Fan

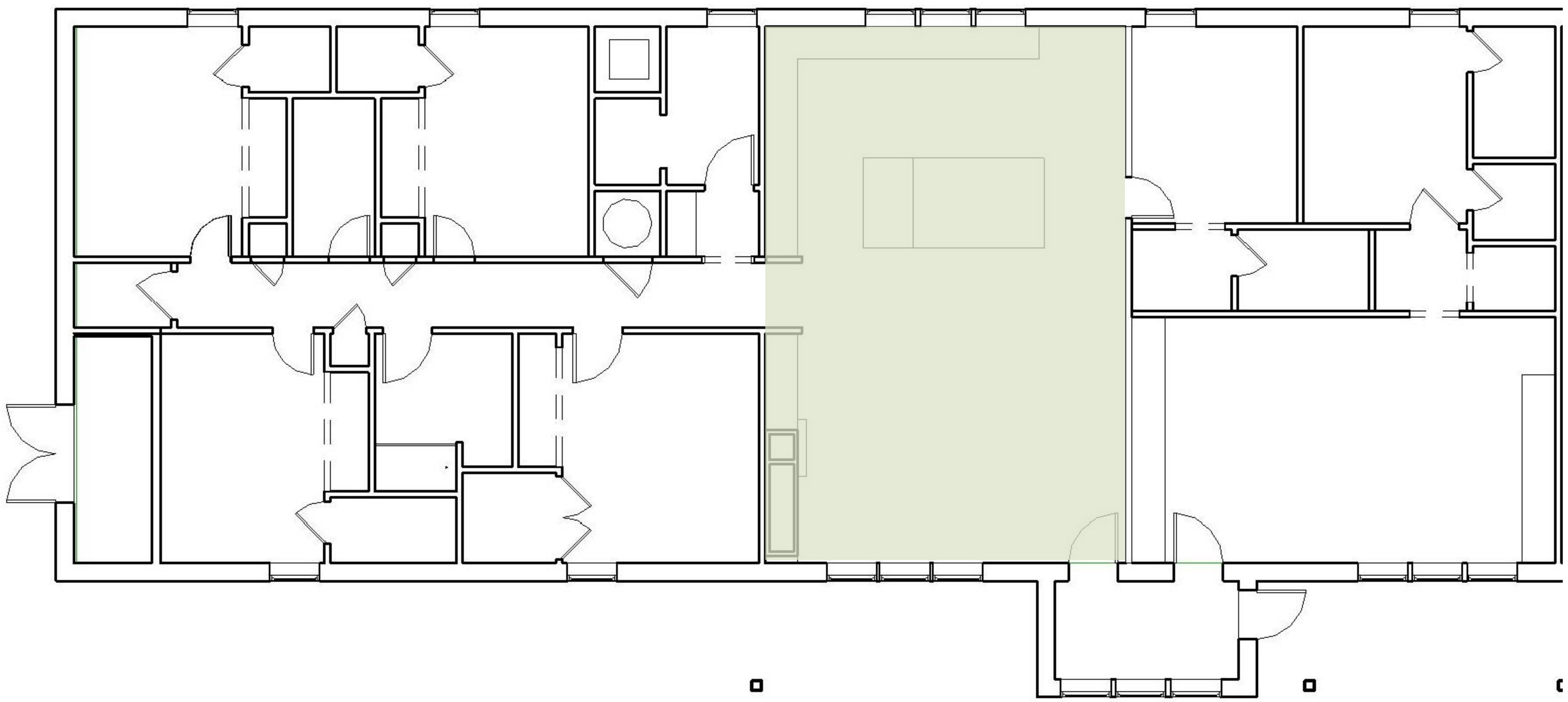




Maxim Horgen Pendant Light

Electric Lighting Design

TOTAL WATTS / SQ.FT = 0.2 W/SQ.FT



AVERAGE ILLUMINANCE WORKSHEET - ELECTRIC LIGHTING LUMEN METHOD [SIMPLIFIED]

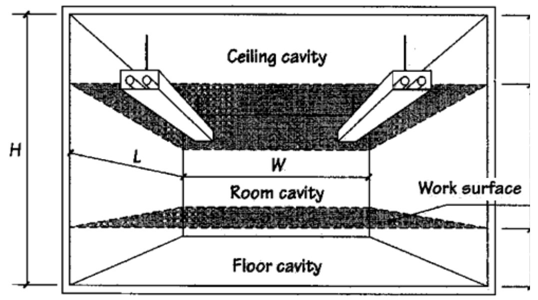
Designer : INIT3 D

Space Type: Laboratory Space

IECC Lighting Power Alloawnce = 0.45 Watt/SF

1 PHOTOMETRIC DATA

IESNA Illumination Category	R	
IESNA Recommended Illuminance:	20	fc
Lamp type:	INIT3 D	
Lamp lumen output:	1,294.0	Lumens
Lamp wattage:	12.0	Watt
Lamp efficacy:	107.8	Lumens/Watt
Recommended spacing, 0° (between parallel rows)	1	
Recommended spacing, 90° (within the same row)	1	
Number of lamps per fixture	1	Lamps
Fixture lumen output	1,294.0	Lumens
Fixture efficiency	100.00	%
Fixture wattage	12.00	Watt
Reduced efficacy (luminaire efficacy)	107.83	Lumens/Watt



2 ROOM DESIGN

Length of space (L) =	32.667	ft
Width of space (W) =	22	ft
Height of space (H) =	9	ft
Ceiling cavity reflectance (CCR)	80	%
Room cavity reflectance (RCR)	50	%
Floor cavity reflecatnce (FCR)	20	%

Height of the three cavities

h_{CC} =	0	ft
h_{RC} =	5.5	ft
h_{FC} =	3.5	ft

CU interpolation

RCR	2	2.15	3
CU	106	105.24	101

3 SIZING THE LIGHTING SYSTEM

A: Effect of room geometry: determine the equivalent-square room length (W_{sq}) and the room cavity ratio (RCR).

W_{sq} = W + [(L-W) / 3] = 22 + [(33 - 22) / 3] = 25.56 ft

RCR = (10 x H_{RC}) / W_{sq} = (10 x 5.5) / 25.56 = 2.15

According to the photometric data, obtain the Coefficient of Utilization (CU) of this luminaire in the given space

CU = 105.24%

B: Effect of maintenance conditions of the space and the system (cleaning, lumen depreciation, relamping, ... etc.)

Light Loss Factor (LLF) = 0.85

0.85 for good conditions, 0.75 for average conditions, and 0.65 for poor conditions

C: Calculate useful lumens from one luminaire reaching the workplane

Useful lumens from one luminaire = fixture lumen output x CU x LLF =

= 1,294.00 x 1.052 x 0.85 = 1,157.53 Lumens

D: Calculate total lumens needed on the workplane

Total lumens on the workplane = Recommended illuminance x space area =

= 20 x 718.67 = 14,373.48 Lumens

E: Calculate number of luminaires

Number of luminaires = Total lumens on the workplane / Useful lumens from one =

= 14,373.48 / 1,157.53 = 12.42 Luminaires

4 DESIGN EVALUATION

Actual number of luminaires used	=	12							
Acctual illumination level provided	=	20	x	12	/	12.42	=	19.33	fc
Light load	=	12	x	12	/	718.67	=	0.20	Watt/SF
Light load index	=	0.20			/	19.33	=	0.010	Watt/fc.SF
Floor area covered per luminaire	=	718.67			/	12	=	59.89	SF/Luminaire
System's overall efficiency	=	100	x	1.05	x	0.85	=	89.45	%

Red text denotes user-provided input data. Last updated October 27, 2022

Passive Solar Heating Information

Phius CORE Prescriptive 2021 Snapshot

Input or select data in teal cells

State	OKLAHOMA
City	VANCE AFB
ASHRAE (169-2021) Climate Zone	4A
iCFA* (ft^2)	3021
Number of Bedrooms*	6
Number of Stories	1

**per dwelling unit*

1	General			
1.1.2	iCFA divided by Number of Bedrooms	Maximum Limit	900	ft^2
	(Calculated Value based on Inputs)	*OK, Meets Limit*	504	ft^2
3	Compactness			
3.1.1	Envelope Area	Maximum	9700	ft^2
	(Maximum Envelope to Floor Area Ratio)		3.21	
4	Solar Protection			
4.1.1	Whole Window SHGC	Maximum	0.40	
4.4.1	Projection Factor for Fixed Overhangs	Minimum	NR	
5	Thermal Enclosure			
5.1.1a	Fenestration / Openings	Maximum Whole U-Value	0.19	(BTU/h.ft^2.°F)
5.1.1b	Walls & Overhang Floors - Effective R-value	Minimum Effective R-Value	31	(ft^2.°F.h/BTU)
5.1.1c	Roofs / Ceilings	Minimum Effective R-Value	61	(ft^2.°F.h/BTU)
5.1.1d	Whole Slab Foundations, Below-Grade Walls, Floors of Conditioned Basements & Crawl Spaces	Minimum Effective R-Value	12	(ft^2.°F.h/BTU)
5.1.1e	Ceilings of Unconditioned Basements or Crawl Spaces & Pier and Beam Floors	Minimum Effective R-Value	17	(ft^2.°F.h/BTU)
6	Moisture Risk Limitation			
6.2.1	Fenestration Condensation Resistance	Minimum	63%	
7	Mechanical Ventilation			
7.2.1	Sensible Recovery Efficiency, Heating Mode	Minimum	75%	
7.2.2	Total Recovery Efficiency, Cooling Mode	Minimum	50%	
7.2.5	Total Length of Fresh Air Ducts to Outside	Maximum	44	ft
8	Mechanical Systems			
	Select System Type			
8.2.1	Air Source Heat Pump	Minimum COP @ 5F	1.8	
		Minimum SEER	15.0	

**NR = No Requirement*
For further details, please see the Phius CORE Prescriptive 2021 Checklist.

Changes for Design:

Values: South Windows: 0.44
Solar Collector: 0.6

Values: South Windows: 0.22
Solar Collector: 0.21

ERV: 93% recovery efficiency
Rise.com

Triple Pane

VS.

Double Pane

Triple Pane vs. Double Pane Glass

	DOUBLE-PANE WINDOWS	TRIPLE-PANE WINDOWS
AVAILABLE MATERIALS	Wood, fiberglass and vinyl	Wood, fiberglass and vinyl
COST	\$-\$\$\$ Commonly less expensive	\$\$-\$\$\$\$ Commonly more expensive
ENERGY EFFICIENCY	More efficient than single-pane windows	Most energy efficient
NOISE REDUCTION	Better sound performance than single-pane windows	Best sound performance
SIZES	Available in all sizes	Available in all sizes
WHERE TO USE	Good for moderate climates, quieter environments and south- and west- facing rooms	Best for extreme climates, noisy places and north- and east-facing rooms

Table from Pella.com

+ Due to the utilization of night insulation, isolated solar heat gain space, roof and wall insulation, and energy recovery ventilator, we were able to choose double pane to save on cost while still be close to the Phius Passive House U-Value of 0.19. The values we chose were 0.21 and 0.22. The value of the SHGC (Solar Heat Gain Coefficient) was originally 0.4. However, we are wanting more solar transmission to the solar heat collector space for the water tubes, so that was increased to 0.6.

Passive Solar Heating / Baseline vs Improved

Average Outdoor Temperature for December 21st : 15.6°F

BEFORE IMPROVEMENTS:

Passive Solar Heating Calculations, Whole Dwelling Unit, Isolated Heat Gain — Hillsdale, OK — December 21

Based on the Balance Point Temperature Method. [Simplified] — Dwelling unit [envelope load dominated building type]

Location:			Design:			Occupancy:	People		Materials:	House	
	Hillsdale, OK	36.33 ° NL	Total interior area (sq.ft):	3,188.22	Enclosed & Heated	Number of people:	6.00		R roof insulation:	61.00	
Average outdoor temperature °F:	15.6	December 21	Area of roof (sq.ft):	3,582.17	Insulated	People (Btuh/person):	245.00	sensible	R wall insulation:	31.00	
			Area of exterior south wall (sq.ft):	813.01	South, including windows	Hours of occupancy/day:	3.00	day-out	U roof:	0.016	
Thermostat temperature °F:	72.0		Area of other exterior walls (sq.ft):	1,764.22	All other, including windows		6.50	day-in	U wall:	0.030	
			Area of South windows (sq.ft):	144.00	South-facing		8.50	night-awake	U glass:	0.190	day
Orientation:	South		Area of all other windows (sq.ft):	120.00	All other directions		6.00	night-asleep	U glass:	0.190	night
All day solar intensity (Btu/sq.ft):	1,577.6	All day (direct)	Exposed perimeter (ft'):	230.17			Lighting		SHGC of glass:	0.400	
	137.7	All day (diffuse)	Net area of south wall (sq.ft):	669.01	Positive value!!!	Light load (Watt/sq ft):	0.120		SC of glass:	0.460	
Sunshine hours (sunpath diagram):	9.5	Hours	Total area of windows (sq.ft):	264.00	All directions		Equipment		R added night insulation:	0.00	
Nighttime hours:	14.5		Net area of exterior walls (sq.ft):	2,313.23	Excluding windows	Equip. load (Watt/sq ft):	0.300			Solar Collector	
			Gross area of exterior walls (sq.ft):	2,577.23	Including windows		Ventilation		U glass:	0.190	day
			Total area of exterior walls + roof (sq.ft):	6,159.40	Including windows	Number of Bedrooms:	6.00		U glass:	0.190	night
Building's Balance Point Temperature:	34.5	°F	Glass to wall ratio:	10.2%		Dwelling Unit Floor Area (sq.ft):	3,188.22		SHGC of glass:	0.400	
			Envelope-to-floor area ratio:	1.93	(roof + exterior walls) / interior area	Ventilation rate (CFM):	148.1466		SC of glass:	0.460	
			Solar Collector glass-to-floor area ratio:	0.00%	South facing glass / interior area				R added night insulation:	0.000	
Required Thermal Mass (Weight of Water_in lb):	0.0			Solar Collector						Heat recovery	
(Volume of Water_in Cubic ft):	0.0		Glass area of Solar Collector (sq.ft):	0.00	South-facing				Heat recovery %:	75.0%	

- No Night Insulation
- Phius Glass Value Requirements
- No Solar Collector Space
- No Thermal Mass

AFTER IMPROVEMENTS:

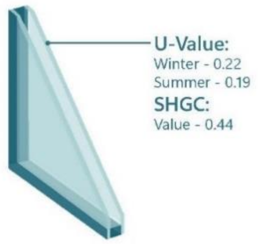
Passive Solar Heating Calculations, Whole Dwelling Unit, Isolated Heat Gain — Hillsdale, OK — December 21

Based on the Balance Point Temperature Method. [Simplified] — Dwelling unit [envelope load dominated building type]

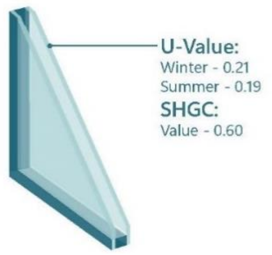
Location:			Design:			Occupancy:	People		Materials:	House	
	Hillsdale, OK	36.33 ° NL	Total interior area (sq.ft):	3,188.22	Enclosed & Heated	Number of people:	6.00		R roof insulation:	78.35	
Average outdoor temperature °F:	15.6	December 21	Area of roof (sq.ft):	3,582.17	Insulated	People (Btuh/person):	245.00	sensible	R wall insulation:	39.98	
			Area of exterior south wall (sq.ft):	813.01	South, including windows	Hours of occupancy/day:	3.00	day-out	U roof:	0.013	
Thermostat temperature °F:	72.0		Area of other exterior walls (sq.ft):	1,764.22	All other, including windows		6.50	day-in	U wall:	0.023	
			Area of South windows (sq.ft):	144.00	South-facing		8.50	night-awake	U glass:	0.220	day
Orientation:	South		Area of all other windows (sq.ft):	120.00	All other directions		6.00	night-asleep	U glass:	0.108	night
All day solar intensity (Btu/sq.ft):	1,577.6	All day (direct)	Exposed perimeter (ft'):	230.17			Lighting		SHGC of glass:	0.330	
	137.7	All day (diffuse)	Net area of south wall (sq.ft):	669.01	Positive value!!!	Light load (Watt/sq ft):	0.120		SC of glass:	0.379	
Sunshine hours (sunpath diagram):	9.5	Hours	Total area of windows (sq.ft):	264.00	All directions		Equipment		R added night insulation:	4.70	
Nighttime hours:	14.5		Net area of exterior walls (sq.ft):	2,313.23	Excluding windows	Equip. load (Watt/sq ft):	0.300			Solar Collector	
			Gross area of exterior walls (sq.ft):	2,577.23	Including windows		Ventilation		U glass:	0.210	day
			Total area of exterior walls + roof (sq.ft):	6,159.40	Including windows	Number of Bedrooms:	6.00		U glass:	0.106	night
Building's Balance Point Temperature:	5.0	°F	Glass to wall ratio:	10.2%		Dwelling Unit Floor Area (sq.ft):	3,188.22		SHGC of glass:	0.600	
			Envelope-to-floor area ratio:	1.93	(roof + exterior walls) / interior area	Ventilation rate (CFM):	148.1466		SC of glass:	0.690	
			Solar Collector glass-to-floor area ratio:	3.61%	South facing glass / interior area				R added night insulation:	4.700	
Required Thermal Mass (Weight of Water_in lb):	1,564.0			Solar Collector						Heat recovery	
(Volume of Water_in Cubic ft):	25.0		Glass area of Solar Collector (sq.ft):	115.00	South-facing				Heat recovery %:	93.0%	

- Night Insulation – Double Cell Black Out Cellular Shades on Tracks
- Glass Values: (Utilized Viracon)
- Solar Collector Space
- Thermal Mass

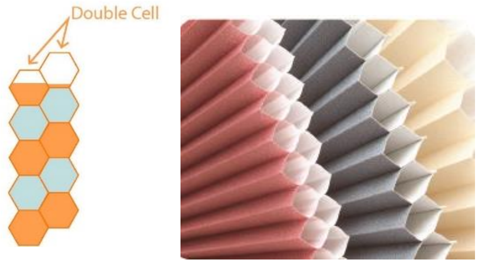
Viracon:
1" (25mm) Insulating with RoomSide Low-E VE13-85



Viracon:
1" (25mm) Insulating with RoomSide Low-E VE13-85



Cellular Window Shade:
Double Cell Cellular Window Shades Black Out on Tracks



Rise:
Energy Recovery Ventilator
Vents-US TwinFresh Expert RA1-50-2 Ductless Energy Recovery Ventilator

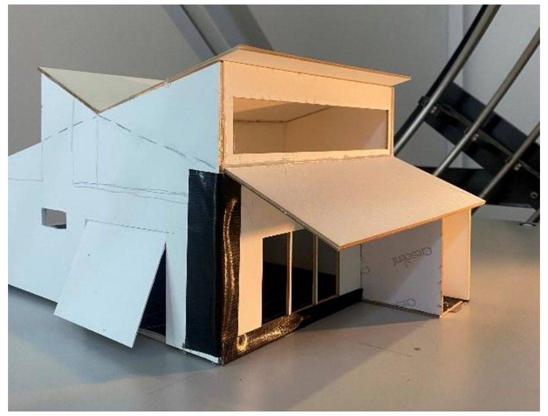
With an integrated humidity sensor or connection to an external sensor, the unit provides a comfortable microclimate, while the integrated control system ensures easy operation

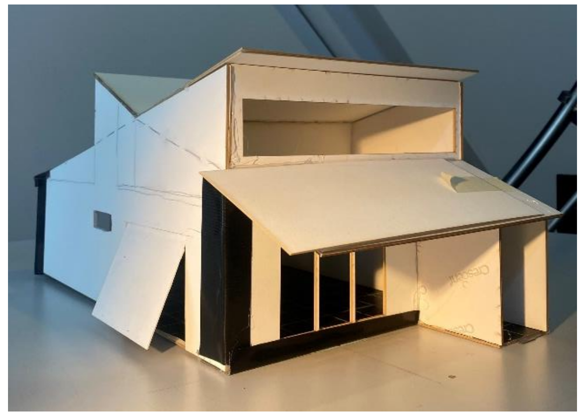
Result: Building's Balance Point Temperature : 34.5 °F > 15.6 °F
Code-compliant design cannot provide 100% passive solar heating

Result: Building's Balance Point Temperature : 15.6 °F (exceeds necessary)
Due to the deep overhang, February was the critical month (design condition).

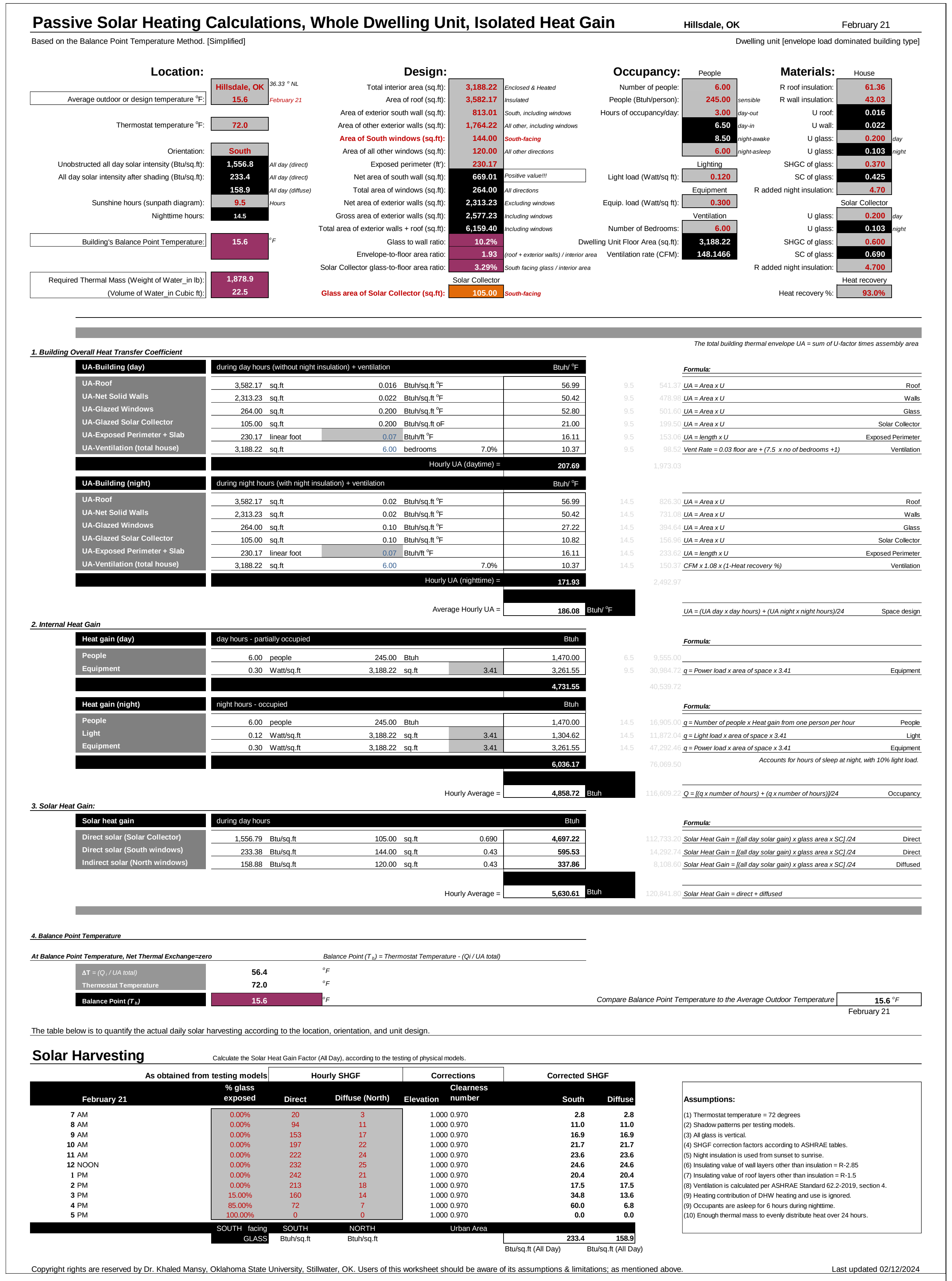
Passive Solar Heating / Sizing the Systems' Components

Heliodon





The Heliodon was beneficial in determining the percentage of light intake the overhang and window combination. The created model was tracked for every hour of sunlight during the day. We were able to alter the form and distance of windows to bring more light for passive solar heating.



Passive Solar Heating Calculations, Whole Dwelling Unit, Isolated Heat Gain — Hillsdale, OK — February 21

Based on the Balance Point Temperature Method. [Simplified] — Dwelling unit [envelope load dominated building type]

Location:

	Hillsdale, OK	36.33 ° NL
Average outdoor or design temperature °F:	15.6	February 21
Thermostat temperature °F:	72.0	
Orientation:	South	
Unobstructed all day solar intensity (Btu/sq.ft):	1,556.8	All day (direct)
All day solar intensity after shading (Btu/sq.ft):	233.4	All day (direct)
	158.9	All day (diffuse)
Sunshine hours (sunpath diagram):	9.5	Hours
Nighttime hours:	14.5	
Building's Balance Point Temperature:	15.6	°F
Required Thermal Mass (Weight of Water_in lb):	1,878.9	
(Volume of Water_in Cubic ft):	22.5	

Design:

Total interior area (sq.ft):	3,188.22	Enclosed & Heated
Area of roof (sq.ft):	3,582.17	Insulated
Area of exterior south wall (sq.ft):	813.01	South, including windows
Area of other exterior walls (sq.ft):	1,764.22	All other, including windows
Area of South windows (sq.ft):	144.00	South-facing
Area of all other windows (sq.ft):	120.00	All other directions
Exposed perimeter (ft'):	230.17	
Net area of south wall (sq.ft):	669.01	Positive value!!!
Total area of windows (sq.ft):	264.00	All directions
Net area of exterior walls (sq.ft):	2,313.23	Excluding windows
Gross area of exterior walls (sq.ft):	2,577.23	Including windows
Total area of exterior walls + roof (sq.ft):	6,159.40	Including windows
Glass to wall ratio:	10.2%	
Envelope-to-floor area ratio:	1.93	(roof + exterior walls) / interior area
Solar Collector glass-to-floor area ratio:	3.29%	South facing glass / interior area
Solar Collector — Glass area of Solar Collector (sq.ft):	105.00	South-facing

Occupancy:

	People	
Number of people:	6.00	
People (Btuh/person):	245.00	sensible
Hours of occupancy/day:	3.00	day-out
	6.50	day-in
	8.50	night-awake
	6.00	night-asleep
Lighting — Light load (Watt/sq ft):	0.120	
Equipment — Equip. load (Watt/sq ft):	0.300	
Ventilation — Number of Bedrooms:	6.00	
Dwelling Unit Floor Area (sq.ft):	3,188.22	
Ventilation rate (CFM):	148.1466	

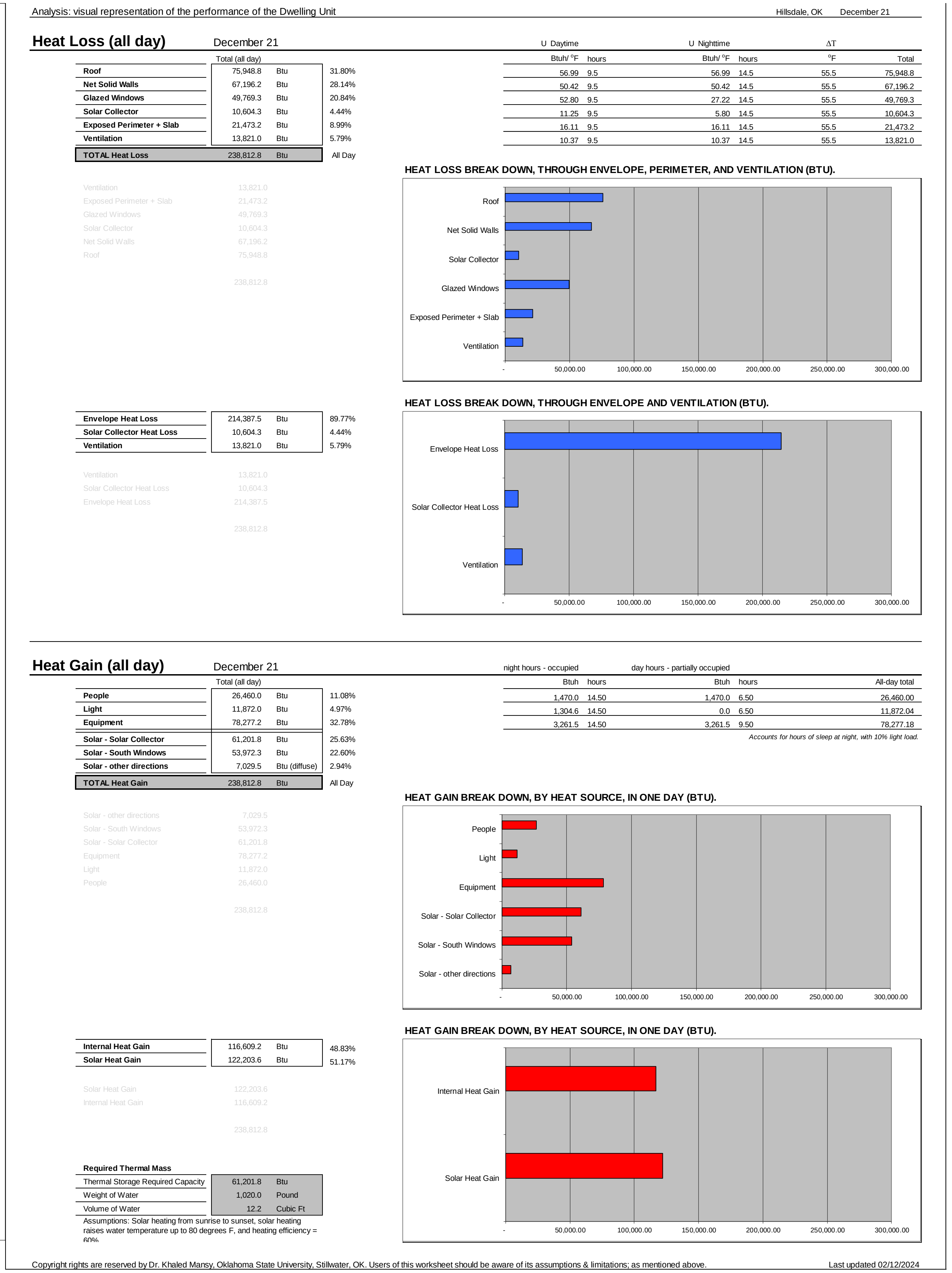
Materials:

	House	
R roof insulation:	61.36	
R wall insulation:	43.03	
U roof:	0.016	
U wall:	0.022	
U glass:	0.200	day
U glass:	0.103	night
SHGC of glass:	0.370	
SC of glass:	0.425	
R added night insulation:	4.70	
Solar Collector — U glass:	0.200	day
U glass:	0.103	night
SHGC of glass:	0.600	
SC of glass:	0.690	
R added night insulation:	4.700	
Heat recovery — Heat recovery %:	93.0%	

The total building thermal envelope UA = sum of U-factor times assembly area

1. Building Overall Heat Transfer Coefficient

UA-Building (day)	during day hours (without night insulation) + ventilation				Btuh/ °F	Formula:	
UA-Roof	3,582.17	sq.ft	0.016	Btuh/sq.ft °F	56.99	UA = Area x U	Roof
UA-Net Solid Walls	2,313.23	sq.ft	0.022	Btuh/sq.ft °F	50.42	UA = Area x U	Walls
UA-Glazed Windows	264.00	sq.ft	0.200	Btuh/sq.ft °F	52.80	UA = Area x U	Glass
UA-Glazed Solar Collector	105.00	sq.ft	0.200	Btuh/sq.ft oF	21.00	UA = Area x U	Solar Collector



Analysis: visual representation of the performance of the Dwelling Unit — Hillsdale, OK — December 21

Heat Loss (all day) — December 21

	Total (all day)			U Daytime Btuh/ °F	hours	U Nighttime Btuh/ °F	hours	ΔT °F	Total
Roof	75,948.8	Btu	31.80%	56.99	9.5	56.99	14.5	55.5	75,948.8
Net Solid Walls	67,196.2	Btu	28.14%	50.42	9.5	50.42	14.5	55.5	67,196.2
Glazed Windows	49,769.3	Btu	20.84%	52.80	9.5	27.22	14.5	55.5	49,769.3
Solar Collector	10,604.3	Btu	4.44%	11.25	9.5	5.80	14.5	55.5	10,604.3
Exposed Perimeter + Slab	21,473.2	Btu	8.99%	16.11	9.5	16.11	14.5	55.5	21,473.2
Ventilation	13,821.0	Btu	5.79%	10.37	9.5	10.37	14.5	55.5	13,821.0
TOTAL Heat Loss	238,812.8	Btu	All Day						

HEAT LOSS BREAK DOWN, THROUGH ENVELOPE, PERIMETER, AND VENTILATION (BTU).

HEAT LOSS BREAK DOWN, THROUGH ENVELOPE AND VENTILATION (BTU).

Heat Gain (all day) — December 21

	Total (all day)			night hours - occupied Btuh	hours	day hours - partially occupied Btuh	hours	All-day total
People	26,460.0	Btu	11.08%	1,470.0	14.50	1,470.0	6.50	26,460.00
Light	11,872.0	Btu	4.97%	1,304.6	14.50	0.0	6.50	11,872.04
Equipment	78,277.2	Btu	32.78%	3,261.5	14.50	3,261.5	9.50	78,277.18
Solar - Solar Collector	61,201.8	Btu	25.63%					
Solar - South Windows	53,972.3	Btu	22.60%					
Solar - other directions	7,029.5	Btu (diffuse)	2.94%					
TOTAL Heat Gain	238,812.8	Btu	All Day					

Accounts for hours of sleep at night, with 10% light load.

HEAT GAIN BREAK DOWN, BY HEAT SOURCE, IN ONE DAY (BTU).

Passive Cooling / Natural Ventilation

Thermostat Temp = 85°F

LIVING ROOM:

Type of space: Residential		**Location:** Hillsdale, OK	**Month:** May, 21st		*All exterior walls, roofs and windows are shaded*
		IECC Climate Zone: 4A			*No impact of sol-air temperature*
					Solar heat gain is due to diffused component only
STEP 1: INPUT DATA	Time of day:	12:00	Military time		*Outside temperature is lower than inside*

Location & Climate:			Design:			Occupancy:		
Outside Air Temperature	83.0	°F	Area of space (to be ventilated)	170.00	sq.ft.	Number of people	1.0	person(s)
Solar Heat Gain Factor (diffuse)	37.5	Btuh/sq.ft	Average height of space	9.00	ft.	Metabolism	245.0	Btuh/person
Wind Speed (at weather station)	35.0	mph (from hourly data)	Gross area of the wind-facing wall	90.00	sq.ft.	Light load	0.12	W/sq.ft
Wind Effectiveness Factor (due to context and height)	0.55	(from Figure 1)	Area of the wind-facing glazed windows	18.00	sq.ft. (note 2)**	Equipment load	0.30	W/sq.ft
Wind Effectiveness Factor (due to azimuth)	0.55	(read note 1)*	Area of glazed windows not facing the wind	0.00	sq.ft.			
			Shading Coefficient of glass (SC)	0.46	(note 3)***	Thermostat temperature	85.0	°F
Effective Wind Speed at Window	10.59	mph	Window type (air inlet)	Single-Hung				
			Stack height (if any)	14.00	ft			
			Top-of-stack opening type (air outlet)	Jalousie				

STEP 2:
HEAT GAIN (at the design condition)

							Formula:
Windows'solar heat gain	37.50 Btuh/sq.ft	18.00 sq.ft.	0.46		310.50	Btuh	*= SHGF x Glass area x SC*
Solid Walls & Roof	NA	NA			NA	Btuh	*ignored if all walls and roof are shaded*
People	1.00 person(s)	245.00 Btuh			245.00	Btuh	*= number x metabolism of each*
Lights	170.00 sq.ft.	0.12 Watt/sq.ft	3.41		69.56	Btuh	*= area x light load x 3.41*
Equipment	170.00 sq.ft.	0.30 Watt/sq.ft	3.41		173.91	Btuh	*= area x equipment load x 3.41*
Total Peak Heat Gain					798.97	Btuh	*= SUM of all of the above*

Outdoor Temperature = 83°F

BEDROOMS:

Type of space: Residential		**Location:** Hillsdale, OK	**Month:** May, 21st		*All exterior walls, roofs and windows are shaded*
		IECC Climate Zone: 4A			*No impact of sol-air temperature*
					Solar heat gain is due to diffused component only
STEP 1: INPUT DATA	Time of day:	12:00	Military time		*Outside temperature is lower than inside*

Location & Climate:			Design:			Occupancy:		
Outside Air Temperature	83.0	°F	Area of space (to be ventilated)	685.00	sq.ft.	Number of people	6.0	person(s)
Solar Heat Gain Factor (diffuse)	37.5	Btuh/sq.ft	Average height of space	9.00	ft.	Metabolism	245.0	Btuh/person
Wind Speed (at weather station)	35.0	mph (from hourly data)	Gross area of the wind-facing wall	260.00	sq.ft.	Light load	0.12	W/sq.ft
Wind Effectiveness Factor (due to context and height)	0.55	(from Figure 1)	Area of the wind-facing glazed windows	54.00	sq.ft. (note 2)**	Equipment load	0.30	W/sq.ft
Wind Effectiveness Factor (due to azimuth)	0.55	(read note 1)*	Area of glazed windows not facing the wind	27.00	sq.ft.			
			Shading Coefficient of glass (SC)	0.46	(note 3)***	Thermostat temperature	85.0	°F
Effective Wind Speed at Window	10.59	mph	Window type (air inlet)	Single-Hung				
			Stack height (if any)	14.00	ft			
			Top-of-stack opening type (air outlet)	Jalousie				

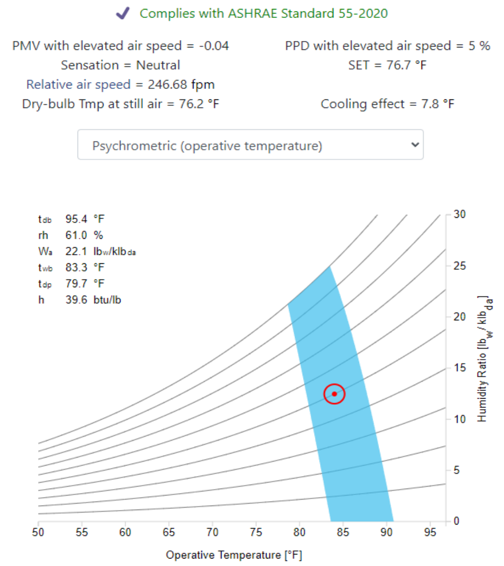
STEP 2:
HEAT GAIN (at the design condition)

							Formula:
Windows'solar heat gain	37.50 Btuh/sq.ft	81.00 sq.ft.	0.46		1,397.25	Btuh	*= SHGF x Glass area x SC*
Solid Walls & Roof	NA	NA			NA	Btuh	*ignored if all walls and roof are shaded*
People	6.00 person(s)	245.00 Btuh			1,470.00	Btuh	*= number x metabolism of each*
Lights	685.00 sq.ft.	0.12 Watt/sq.ft	3.41		280.30	Btuh	*= area x light load x 3.41*
Equipment	685.00 sq.ft.	0.30 Watt/sq.ft	3.41		700.76	Btuh	*= area x equipment load x 3.41*
Total Peak Heat Gain					3,848.31	Btuh	*= SUM of all of the above*

Cross Ventilation:
Works with ambient temp of 83 degrees F

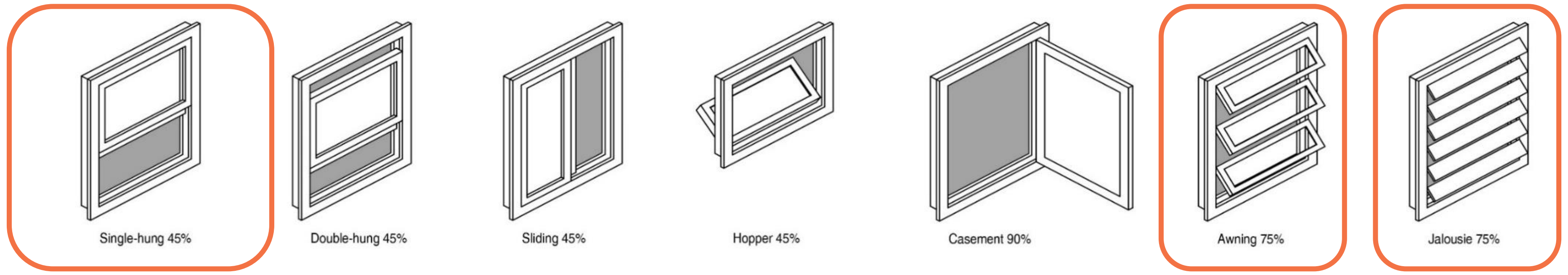
Forced Stack Ventilation:
Cools space when wind speeds inadequate
Up to 83 degrees F

Air is drawn in from windows and exhausted through stack. A fan array proportionally activates based on how many spaces turn on their inlet fans.



Ceiling Fan:

Operative Temp: 85° F



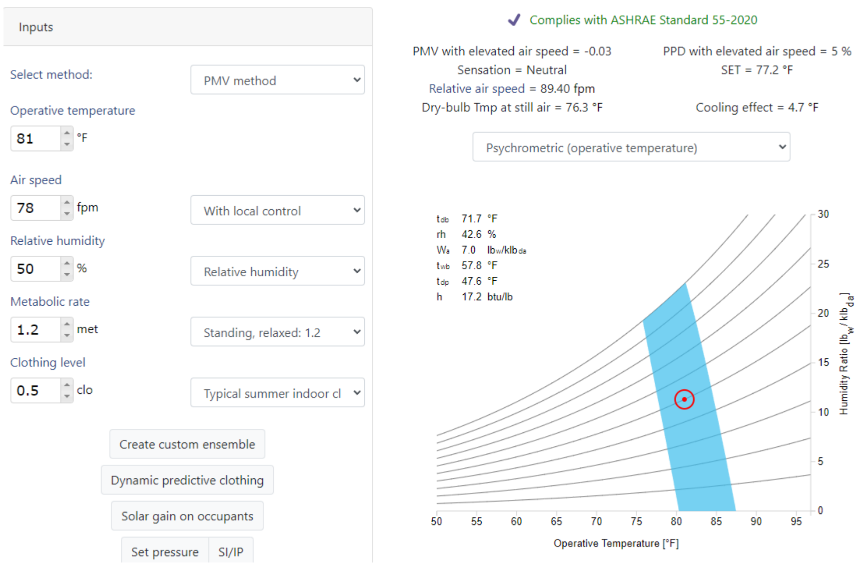
Standard

Kitchen

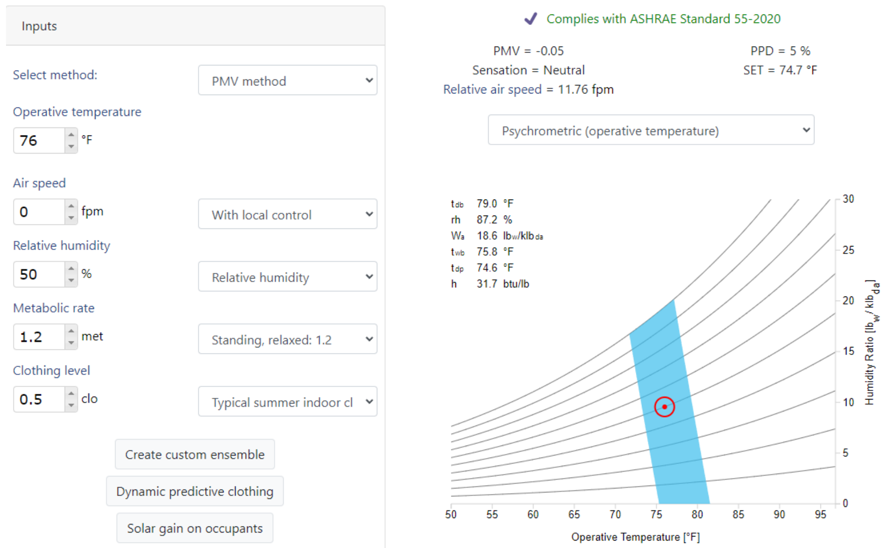
Top of Stack

Natural Ventilation / Sizing

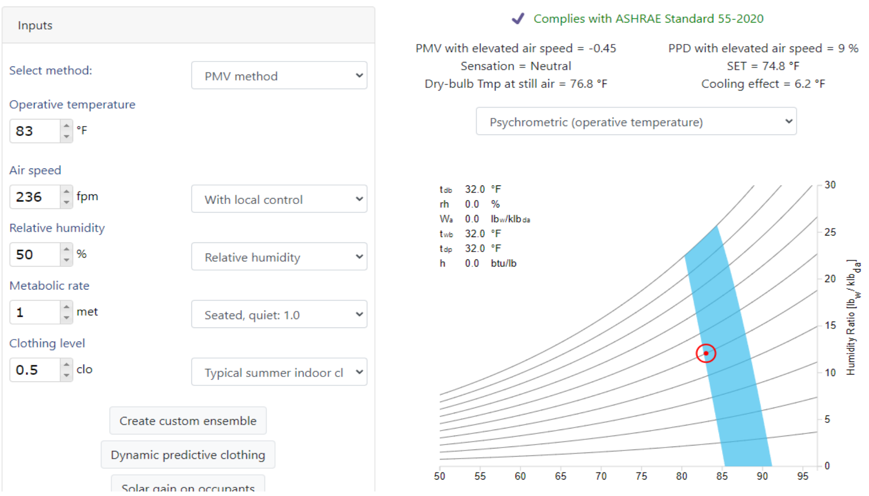
Hunter Aerodyne 52" Smart LED Indoor Ceiling Fan



Adjusted Thermal Comfort for Ceiling Fan: Low Speed



Thermal Comfort for No Ceiling Fan in Space



Adjusted Thermal Comfort for Ceiling Fan: High Speed

Passive Cooling - Comfort Ventilation (baseline design)

Living Room

Type of space: Residential — Location: Hillsdale, OK — IECC Climate Zone: 4A — Month: May, 21st

Assumptions
All exterior walls, roofs and windows are shaded
No impact of sol-air temperature
Solar heat gain is due to diffused component only
Outside temperature is lower than inside

STEP 1: INPUT DATA Time of day: 12:00 Military time

Location & Climate:			Design:			Occupancy:		
Outside Air Temperature	80.0	°F	Area of space (to be ventilated)	685.00	sq.ft.	Number of people	6.0	person(s)
Solar Heat Gain Factor (diffuse)	37.5	Btuh/sq.ft	Average height of space	9.00	ft.	Metabolism	245.0	Btuh/person
Wind Speed (at weather station)	35.0	mph (from hourly data)	Gross area of the wind-facing wall	260.00	sq.ft.	Light load	0.12	W/sq.ft
Wind Effectiveness Factor (due to context and height)	0.55	(from Figure 1)	Area of the wind-facing glazed windows	54.00	sq.ft. (note 2)**	Equipment load	0.30	W/sq.ft
Wind Effectiveness Factor (due to azimuth)	0.55	(read note 1)*	Area of glazed windows not facing the wind	27.00	sq.ft.			
			Shading Coefficient of glass (SC)	0.46	(note 3)***	Thermostat temperature	83.0	°F
Effective Wind Speed at Window	10.59	mph	Window type (air inlet)	Single-Hung				
			Stack height (if any)	14.00	ft			
			Top-of-stack opening type (air outlet)	Jalousie				

CROSS VENTILATION - Sizing Operable Windows ΔT 3.0 | 80.0 Assumed Ambient Temp (°F), must be lower than thermostat temperature

Hourly Heat Gain	3,848.31	Btuh (total from the peak heat gain table in step 2)	*From Step 2: Heat gain calculations*
Required Rate of Air Flow	1,187.75	CFM (in order to balance heat gain) (min. fan size)	*CFM = peak heat gain / (ΔT x 1.08)*
Effective wind speed at window	10.59	mph (from climate data above)	*According to location & climate input data*
	931.70	feet per minute	*For unit conversion, FPM = MPH x 88*
Effective area of operable windows (inlet)	1.27	sq.ft. Window type	*Effective area = CFM / effective wind speed*
Effectiveness of window type	0.45	(from Figure 2) Single-Hung	
Gross area of operable windows	2.83	sq.ft. without insect screen	*Gross area of windows = required net effective area /effectivenesss of window type*
	9.44	sq.ft. with insect screen, compare area to 54.00	*Gross area of windows with screen = gross area without screen / 0.3*

[NOTE]: Actual area of air inlet and outlet should not be smaller than the calculated gross area of operable windows.

11.56 ACH : resulting Air Change per Hour (cross ventilation) should not exceed 30

Type of space: Residential — Location: Hillsdale, OK — IECC Climate Zone: 4A — Month: May, 21st

All exterior walls, roofs and windows are shaded
No impact of sol-air temperature
Solar heat gain is due to diffused component only
Outside temperature is lower than inside

STEP 1: INPUT DATA Time of day: 12:00 Military time

Location & Climate:			Design:			Occupancy:		
Outside Air Temperature	80.0	°F	Area of space (to be ventilated)	170.00	sq.ft.	Number of people	1.0	person(s)
Solar Heat Gain Factor (diffuse)	37.5	Btuh/sq.ft	Average height of space	9.00	ft.	Metabolism	245.0	Btuh/person
Wind Speed (at weather station)	35.0	mph (from hourly data)	Gross area of the wind-facing wall	90.00	sq.ft.	Light load	0.12	W/sq.ft
Wind Effectiveness Factor (due to context and height)	0.55	(from Figure 1)	Area of the wind-facing glazed windows	18.00	sq.ft. (note 2)**	Equipment load	0.30	W/sq.ft
Wind Effectiveness Factor (due to azimuth)	0.55	(read note 1)*	Area of glazed windows not facing the wind	0.00	sq.ft.			
			Shading Coefficient of glass (SC)	0.46	(note 3)***	Thermostat temperature	83.0	°F
Effective Wind Speed at Window	10.59	mph	Window type (air inlet)	Single-Hung				
			Stack height (if any)	14.00	ft			
			Top-of-stack opening type (air outlet)	Jalousie				

STACK VENTILATION - Sizing Inlet, Cross Section, and Outlet ΔT 3.0 | 80.0 Assumed Ambient Temp (°F), must be lower than thermostat temperature

Hourly Heat Gain	798.97	Btuh (total from the peak heat gain table in step 2)	*From Step 2: Heat gain calculations*
Required Rate of Air Flow	246.60	CFM (in order to balance heat gain) (min. fan size)	*CFM = peak heat gain / (ΔT x 1.08)*
Assumed height of stack	14.00	ft (from input data in step 1)	
Air speed at windows	61.57	feet per minute	*Air speed = required rate of air flow / Effective area of air inlet*
Effective area of operable windows (inlet)	4.01	Window type	
Effectiveness of selected window type (inlet)	0.45	(from Figure 2) Single-Hung	
Gross area of operable windows (inlet)	8.90	sq.ft. without insect screen	*Gross area of windows = required net effective area /effectivenesss of window type*
	29.67	sq.ft. with insect screen, compare area to 18.00	*Gross area of windows with screen = gross area without screen / 0.3*

[NOTE]: Actual area of windows must not be smaller than the calculated gross area of air inlet.

Stack's cross section (Minimum)	4.01	sq.ft. Outlet type:	
Effectiveness of selected window type (outlet)	0.75	(from Figure 2) Jalousie	
Gross area of opening at top of stack (outlet)	5.34	sq.ft. without insect screen	*Gross area of windows = required net effective area /effectivenesss of window type*
	17.80	sq.ft. with insect screen (30% net free area)	*Gross area of windows with screen = gross area without screen / 0.3*

[NOTE]: Actual area of air outlet must not be smaller than the calculated gross area of air outlet.

9.67 ACH : resulting Air Change per Hour (stack ventilation) should not exceed 30

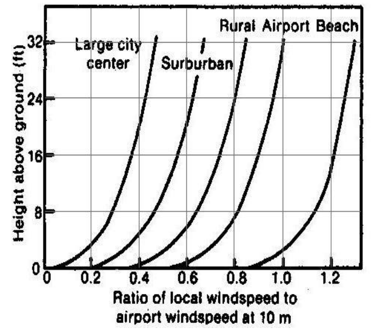


Figure 1: Correction factor for wind speed for height and context

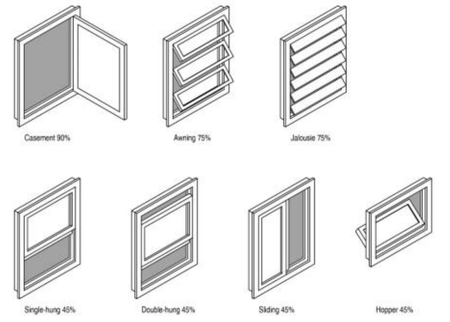


Figure 2: Effectiveness open area of different window types

Source of figure 1: Cooling with Ventilation, Chandra et al, Florida Solar Energy Center, 1986, page 30 .

Energy Recovery Ventilator Information

Specifications

Room Size	One TwinFresh Expert unit in ventilation mode can serve rooms up to 500 sq. ft in accordance with ANSI/ASHRAE Standard 62.2-2016		
Features	• Unique Single Room Energy Recovery Ventilator. • One TwinFresh Expert unit in ventilation mode can serve rooms up to 500 sq. ft*. • Communication between several ventilators for coordinated operation. • Efficient supply and exhaust single-room ventilation up to 30 CFM. • High-tech ceramic energy regenerator with max. heat recovery efficiency up to 93 %. • Reversible DC motors with low energy demand from 3.61 W and safe voltage of 12 V. • Integrated humidity sensor or connection to external sensor for comfortable microclimate. • Integrated control system. • Silent operation from 0.3 Sones. • Easy mounting and maintenance. • Air cleaning with total MERV 5 class filters (optionally MERV 14 filter). • Rated for continuous operation. • Frost- and condensate-free.		
Speed	1	2	3
Voltage / 50 (60) Hz [V]	1~100-240		
Power consumption [W]	3.61	4.15	5.20
Current consumption [A]	0.025	0.030	0.039
Air flow in ventilation mode [CFM]	9	18	30
Air flow in regeneration mode [CFM]	4	9	15
RPM	800	1300	1900
Sound pressure level @ 3 ft [Sones]	0.6	1.0	1.2
Sound pressure level @ 10 ft [Sones]	0.3	0.5	0.6
Outdoor sound pressure attenuation [Sones]	2.5		
Transported air temperature [°F]	from +5 up to +104		
Regeneration efficiency [%]	max. 93		
Regenerator type	Ceramic		
Filter	MERV 5 (option: MERV 14)		
MINIMUM WALL THICKNESS	5 7/8"		
Ingress protection	IP24		

→ Serves up to rooms up to 500 sq. ft

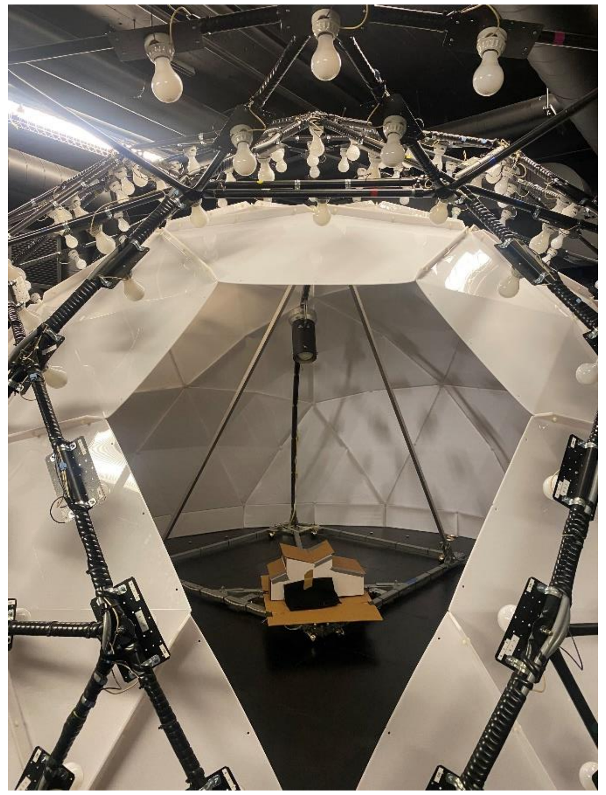
→ Efficient supply and exhaust single-room ventilation up to 30 CFM.

→ Silent Operation from 0.3 Sones

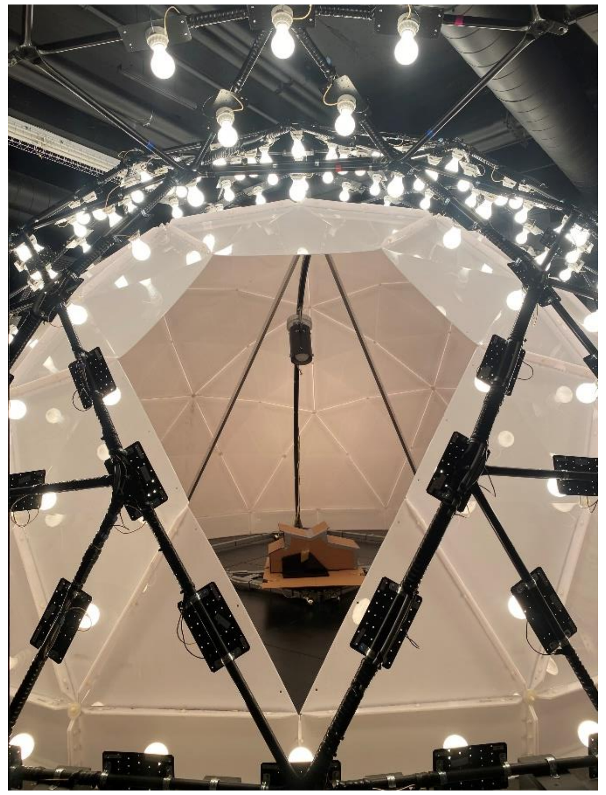
→ ERV: 93% recovery efficiency

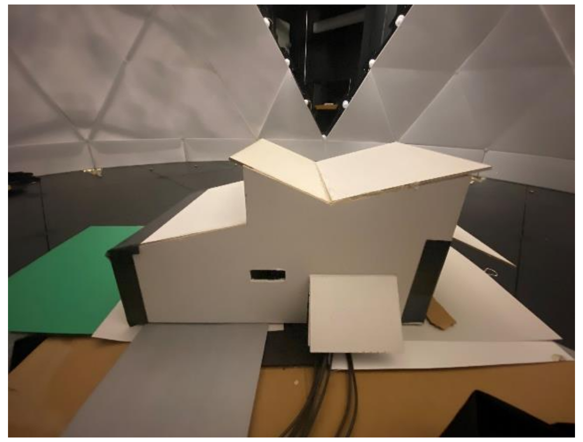
Daylight Analysis

Artificial Sky Dome



The Artificial Daylighting Dome was an integral component in designing an even level of illuminance distribution within the central living space. Several tests were examined to alter the form and window openings.





Daylight Analysis — Multi-Purpose Hall, Stillwater, OK, 36^{o} NL

Assumptions

Type of space: Sports Facility
Recommended illuminance: 20 (fc) according to IESNA
System designed: Assumption:
20 (fc) general lighting
0 (fc) task lighting
0.70 Glass visible transmittance
0.85 Glass transmittance depreciation for dirt

Potential saving is calculated under overcast sky conditions
Savings under clear sky conditions can be higher
Hours are standard time of the time zone
Occupancy is from 8:30 am to 5:30 pm

Laboratory Test Results: (Bare opening - No glass)

Daylight factor (%), obtained from testing the model								
	4.55	4.14	4.20	4.33	4.47	4.81	5.04	5.46 %
Points as designated in the model & on cross section	1	2	3	4	5	6	7	8 sensor number (see cross section)

Calculated predicted illuminance = oputdoor standard illuminance x DF x glass VT x LLF

June 21

Points as designated in the model & on cross section. Predicted illumination level in the space due to daylight (fc) = standard outside illuminance x DF x glass visible transmittance x di

	Outside illuminance	1	2	3	4	5	6	7	8
9 a.m.	1208	33	30	30	31	32	35	36	39
10 a.m.	1508	41	37	38	39	40	43	45	49
11 a.m.	1738	47	43	43	45	46	50	52	56
12 p.m.	1882	51	46	47	48	50	54	56	61
1 p.m.	1931	52	48	48	50	51	55	58	63
2 p.m.	1882	51	46	47	48	50	54	56	61
3 p.m.	1738	47	43	43	45	46	50	52	56
4 p.m.	1508	41	37	38	39	40	43	45	49
5 p.m.	1208	33	30	30	31	32	35	36	39

Solar noon @ 1:00 pm

Solar Noon Distribution		
Average IL :	53.1	fc
St.Dev :	5.2	fc
Maximum :	62.7	fc
Minimum :	47.6	fc
Max / Min :	1.31884058	

Potential daylight saving (%) = [actual illuminance from daylight / required illuminance] ≤ 100%

	1	2	3	4	5	6	7	8
9 a.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10 a.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11 a.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

June
Daily average saving
100.00%

March/Sept 21

Predicted illumination level in the space due to daylight (fc) = standard outside illuminance x DF x glass visible transmittance x di

	Outside illuminance	1	2	3	4	5	6	7	8
9 a.m.	809	22	20	20	21	22	23	24	26
10 a.m.	1135	31	28	28	29	30	32	34	37
11 a.m.	1386	38	34	35	36	37	40	42	45
12 p.m.	1544	42	38	39	40	41	44	46	50
1 p.m.	1597	43	39	40	41	42	46	48	52
2 p.m.	1544	42	38	39	40	41	44	46	50
3 p.m.	1386	38	34	35	36	37	40	42	45
4 p.m.	1135	31	28	28	29	30	32	34	37
5 p.m.	809	22	20	20	21	22	23	24	26

Solar noon @ 1:00 pm

Solar Noon Distribution		
Average IL :	43.9	fc
St.Dev :	4.3	fc
Maximum :	51.9	fc
Minimum :	39.3	fc
Max / Min :	1.31884058	

Potential daylight saving (%) = [actual illuminance from daylight / required illuminance] ≤ 100%

	1	2	3	4	5	6	7	8
9 a.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10 a.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11 a.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

March/Sept
Daily average saving
99.99%

December 21

Predicted illumination level in the space due to daylight (fc) = standard outside illuminance x DF x glass visible transmittance x di

	Outside illuminance	1	2	3	4	5	6	7	8
9 a.m.	595	16	15	15	15	16	17	18	19
10 a.m.	825	22	20	21	21	22	24	25	27
11 a.m.	970	26	24	24	25	26	28	29	32
12 p.m.	1019	28	25	25	26	27	29	31	33
1 p.m.	970	26	24	24	25	26	28	29	32
2 p.m.	825	22	20	21	21	22	24	25	27
3 p.m.	595	16	15	15	15	16	17	18	19
4 p.m.	296	8	7	7	8	8	8	9	10
5 p.m.	0	0	0	0	0	0	0	0	0

Solar noon @ 12:00 pm

Solar Noon Distribution		
Average IL :	28.0	fc
St.Dev :	2.7	fc
Maximum :	33.1	fc
Minimum :	25.1	fc
Max / Min :	1.31884058	

Potential daylight saving (%) = [actual illuminance from daylight / required illuminance] ≤ 100%

	1	2	3	4	5	6	7	8
9 a.m.	0.81	0.73	0.74	0.77	0.79	0.85	0.89	0.97
10 a.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11 a.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2 p.m.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3 p.m.	0.81	0.73	0.74	0.77	0.79	0.85	0.89	0.97
4 p.m.	0.40	0.36	0.37	0.38	0.39	0.42	0.44	0.48
5 p.m.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

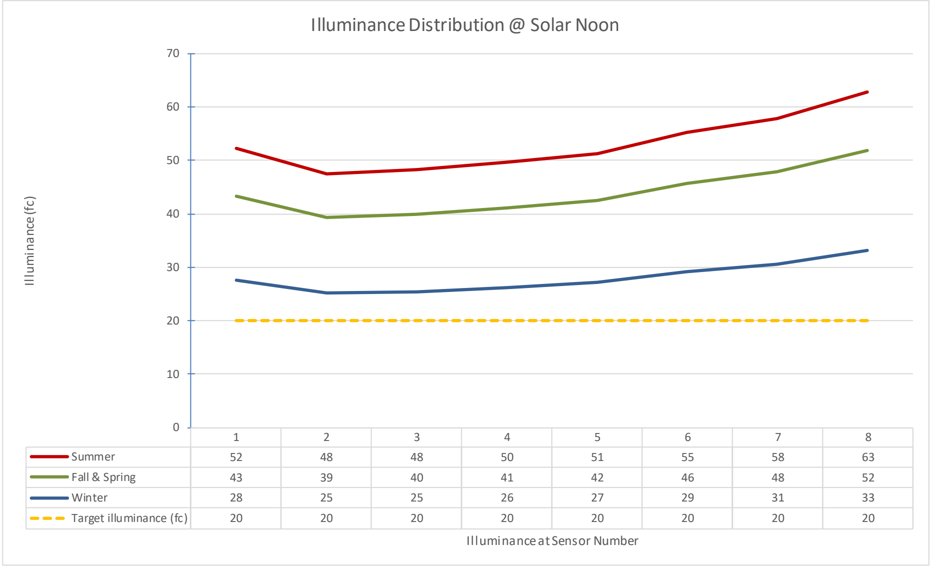
December
Daily average saving
78.27%

Daylight Analysis — Summary

Type of space: Sports Facility
Recommended illuminance: 20 (fc) according to IESNA
System designed: Assumption:
20 (fc) general lighting
0 (fc) task lighting
0.70 Glass visible transmittance
0.85 Glass transmittance depreciation for dirt

Laboratory Test Results: (Bare opening - No glass)

	Daylight factor (%), obtained from testing the model								
	4.55	4.14	4.20	4.33	4.47	4.81	5.04	5.46	%
	1	2	3	4	5	6	7	8	
Season	Predicted illumination level in the space due to daylight (fc) at solar noon								
Summer	52	48	48	50	51	55	58	63	fc
Fall & Spring	43	39	40	41	42	46	48	52	fc
Winter	28	25	25	26	27	29	31	33	fc
Target illuminance	20	20	20	20	20	20	20	20	fc



Illuminance Distribution
Max / Min : 1.31884058

Summer @ solar noon		
Average IL :	53.1	fc
St.Dev :	5.2	fc
Maximum :	62.7	fc
Minimum :	47.6	fc

Fall & Spring @ solar noon		
Average IL :	43.9	fc
St.Dev :	4.3	fc
Maximum :	51.9	fc
Minimum :	39.3	fc

Winter @ solar noon		
Average IL :	28.0	fc
St.Dev :	2.7	fc
Maximum :	33.1	fc
Minimum :	25.1	fc

Potential annual energy savings (all seasons) **94.56%**

Potential annual energy savings (excluding summer) **92.75%**

Cross Section

insert a digital copy of the space cross section inside this box

Summarized Model Inputs

	Ekotrope												Open Studio
	Model 1			Model 2			Model 3			Model 4			Model 5
	A1	A2	Total	A1	A2	Total	A1	A2	Total	A1	A2	Total	Total
HERS	70	73		50	55		21	27		26	27		-
Site EUI	31.7	41.6	**34.0**	19.7	8.2	**27.9**	8.8	4.1	**12.9**	11.7	18.0	**13.1**	**Before PV = 9.64 | After PV = -2.81**
Energy Demand													
Total kWh	21718	8394	**30112**	17479	7255	**24734**	7796	3665	**11461**	7973	3639	**11612**	**Before PV = 8540 | After PV = -2489**
Heating E Demand	9083	2606	**11689**	4496	1328	**5824**	441	70	**511**	577	52	**629**	**141**
Cooling E Demand	2327	880	**3207**	1970	800	**2770**	1099	474	**1573**	1140	466	**1606**	**800**
Hot Water E Demand	3938	1666	**5604**	3938	1666	**5604**	0	0	**0**	0	0	**0**	**0**
Lights + Appliances E Demand	6371	3243	**9614**	7076	3461	**10537**	6256	3122	**9378**	6256	3122	**9378**	**7619**
Renewables													
Photovoltaic Panels	-	-	-	-	-	-	-	-	-	-	-	-	7 kw DC system (22 panels)
Heating	Furnace			Furnace			Ductless Mini-Split			Ductless Mini-Split			Water to Water Heat Pump
Heating Efficiency - HSPF	7.7			9.2			15.8			15.8			15.4
Cooling	AC Unit			AC Unit			Ductless Mini-Split			Ductless Mini-Split			Air to Water Heat Pump
Cooling Efficiency - SEER	13			16			18.35			18.35			19.92
Hot Water	Standard (Electric)			Standard (Electric)			Solar (+ Electric Backup)			Solar (+ Electric Backup)			Solar (+ Electric Backup)
Tank Size (gallons)	80			80			80			80			80
Ventilation	Infiltration Only			Balanced			ERV			ERV			ERV
Ventilation (cfm)				115	36	151	126	36	162	126	36	162	162
Wattage				115	36	151	29	8.3	37.3	29	8.3	37.3	37.3
Lights + Appliances													
Lights	100% Fluorescent			100% Fluorescent			100% LED			100% LED			100% LED + Improvements
Appliances	HERS Reference			HERS Reference			HERS Reference			HERS Reference			Energy Star + Improvements
Envelope													
Roof R-Value	R-32			R-60			R-62			R-65			R-65
Wall R-Value	R-15			R-32			R-35			R-43			R-43
Glazing U-Value	U-0.50			U-0.30			U-0.19			U-0.20			U-0.20
Glazing SHGC	0.3			0.4			0.4			0.37			0.37
Slab R-Value	R-1			R-10			R-13			R-14			R-14

Site vs. Source Energy

$$Energy_{source} = Energy_{site} * Conversion\ Factor_{site\ to\ source}$$

$$Energy_{source,\ Final} = 11{,}541\ kWh/yr * 2.21 = 25{,}506\ kWh/yr$$

$$Energy_{source,\ Final+} = 8{,}540\ kWh/yr * 2.21 = 18{,}874\ kWh/yr$$

	Baseline 1		Baseline 2		Baseline 3		Final		Final +	
Unit	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2
HERS	70	73	50	55	21	27	26	27	n/a	n/a

	Baseline 1	Baseline 2	Baseline 3	Final	Final +
Unit	A1 + A2	A1 + A2	A1 + A2	A1 + A2	A1 + A2
Site EUI	34.0	27.9	12.9	13.1	9.64
Source EUI	75.1	61.7	28.5	29.0	21.3

HERS Ratings

HERS® Index Score:

26

Your home's HERS score is a relative performance score. The lower the number, the more energy efficient the home. To learn more, visit www.hersindex.com

Annual Savings

$3,749

*Relative to an average U.S. home

Home:

Hillsdale, OK 73743

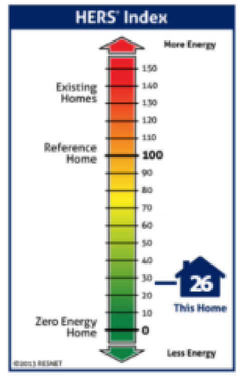
Builder:

Your Home's Estimated Energy Use:

	Use [MBtu]	Annual Cost
Heating	7.5	$264
Cooling	3.3	$116
Hot Water	0.0	$0
Lights/Appliances	21.4	$756
Service Charges		$0
Generation (e.g. Solar)	0.0	$0
Total:	**32.1**	**$1,136**

This home meets or exceeds the criteria of the following:

2021 International Energy Conservation Code



Home Feature Summary:

Home Type:	Townhouse, end unit
Model:	N/A
Community:	N/A
Conditioned Floor Area:	2,333 ft²
Number of Bedrooms:	5
Primary Heating System:	Custom • Electric • 15.8 HSPF
Primary Cooling System:	Custom • Electric • 28.35 SEER
Primary Water Heating:	Solar Water Heater • Electric • 0.99 Energy Factor
House Tightness:	0.6 ACH50 (Adjusted Infiltration: 5.55 ACH50)
Ventilation:	126 CFM (unmeasured) • 29 Watts • ERV
Duct Leakage to Outside:	Forced Air Ductless
Above Grade Walls:	R-40
Ceiling:	Attic, R-62
Window Type:	U-Value: 0.2, SHGC: 0.37
Foundation Walls:	N/A
Framed Floor:	N/A

Rating Completed by:

Energy Rater: Molly Hoback
RESNET ID:

Rating Company: OSU SDC

Rating Provider:

Molly Hoback, Certified Energy Rater
Date: 3/30/24 at 9:12 PM

ekotrope

Ekotrope RATER - Version:4.2.1.3368
The Energy Rating Disclosure for this home is available from the Approved Rating Provider.

HERS® Index Score:

27

Your home's HERS score is a relative performance score. The lower the number, the more energy efficient the home. To learn more, visit www.hersindex.com

Annual Savings

$1,275

*Relative to an average U.S. home

Home:

Hillsdale, OK 73743

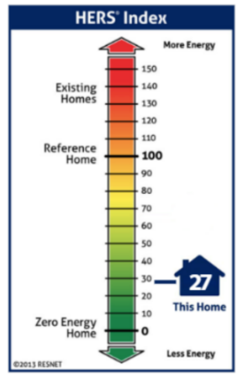
Builder:

Your Home's Estimated Energy Use:

	Use [MBtu]	Annual Cost
Heating	0.1	$5
Cooling	1.1	$39
Hot Water	0.0	$0
Lights/Appliances	10.7	$377
Service Charges		$0
Generation (e.g. Solar)	0.0	$0
Total:	**11.9**	**$421**

This home meets or exceeds the criteria of the following:

2021 International Energy Conservation Code



Home Feature Summary:

Home Type:	Townhouse, inside unit
Model:	N/A
Community:	N/A
Conditioned Floor Area:	688 ft²
Number of Bedrooms:	1
Primary Heating System:	Custom • Electric • 15.8 HSPF
Primary Cooling System:	Custom • Electric • 28.35 SEER
Primary Water Heating:	Solar Water Heater • Electric • 0.99 Energy Factor
House Tightness:	0.6 ACH50 (Adjusted Infiltration: 0.46 ACH50)
Ventilation:	36 CFM • 8.3 Watts • ERV
Duct Leakage to Outside:	Forced Air Ductless
Above Grade Walls:	R-40
Ceiling:	Attic, R-62
Window Type:	U-Value: 0.2, SHGC: 0.37
Foundation Walls:	N/A
Framed Floor:	N/A

Rating Completed by:

Energy Rater: Molly Hoback
RESNET ID:

Rating Company: OSU SDC

Rating Provider:

Molly Hoback, Certified Energy Rater
Date: 3/30/24 at 10:42 PM

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Ekotrope RATER - Version:4.2.1.3368
The Energy Rating Disclosure for this home is available from the Approved Rating Provider.

HERS® Index Score:

-1

Your home's HERS score is a relative performance score. The lower the number, the more energy efficient the home. To learn more, visit www.hersindex.com

Annual Savings

$4,885

*Relative to an average U.S. home

Home:

Hillsdale, OK 73743

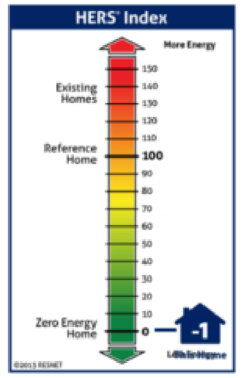
Builder:

Your Home's Estimated Energy Use:

	Use [MBtu]	Annual Cost
Heating	7.5	$264
Cooling	3.3	$116
Hot Water	0.0	$0
Lights/Appliances	21.4	$756
Service Charges		$0
Generation (e.g. Solar)	33.3	-$1,136
Total:	**32.1**	**$0**

This home meets or exceeds the criteria of the following:

2021 International Energy Conservation Code



Home Feature Summary:

Home Type:	Townhouse, end unit
Model:	N/A
Community:	N/A
Conditioned Floor Area:	2,333 ft²
Number of Bedrooms:	5
Primary Heating System:	Custom • Electric • 15.8 HSPF
Primary Cooling System:	Custom • Electric • 28.35 SEER
Primary Water Heating:	Solar Water Heater • Electric • 0.99 Energy Factor
House Tightness:	0.6 ACH50 (Adjusted Infiltration: 5.55 ACH50)
Ventilation:	126 CFM (unmeasured) • 29 Watts • ERV
Duct Leakage to Outside:	Forced Air Ductless
Above Grade Walls:	R-40
Ceiling:	Attic, R-62
Window Type:	U-Value: 0.2, SHGC: 0.37
Foundation Walls:	N/A
Framed Floor:	N/A

Rating Completed by:

Energy Rater: Molly Hoback
RESNET ID:

Rating Company: OSU SDC

Rating Provider:

Molly Hoback, Certified Energy Rater
Date: 3/30/24 at 9:05 PM

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Ekotrope RATER - Version:4.2.1.3368
The Energy Rating Disclosure for this home is available from the Approved Rating Provider.

HERS® Index Score:

-3

Your home's HERS score is a relative performance score. The lower the number, the more energy efficient the home. To learn more, visit www.hersindex.com

Annual Savings

$1,696

*Relative to an average U.S. home

Home:

Hillsdale, OK 73743

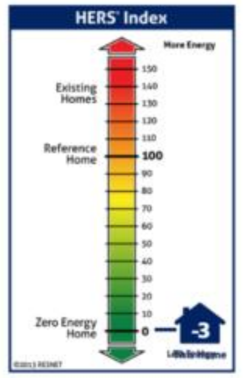
Builder:

Your Home's Estimated Energy Use:

	Use [MBtu]	Annual Cost
Heating	0.1	$5
Cooling	1.1	$39
Hot Water	0.0	$0
Lights/Appliances	10.7	$377
Service Charges		$0
Generation (e.g. Solar)	13.3	-$421
Total:	**11.9**	**$0**

This home meets or exceeds the criteria of the following:

2021 International Energy Conservation Code



Home Feature Summary:

Home Type:	Townhouse, inside unit
Model:	N/A
Community:	N/A
Conditioned Floor Area:	688 ft²
Number of Bedrooms:	1
Primary Heating System:	Custom • Electric • 15.8 HSPF
Primary Cooling System:	Custom • Electric • 28.35 SEER
Primary Water Heating:	Solar Water Heater • Electric • 0.99 Energy Factor
House Tightness:	0.6 ACH50 (Adjusted Infiltration: 0.46 ACH50)
Ventilation:	36 CFM • 8.3 Watts • ERV
Duct Leakage to Outside:	Forced Air Ductless
Above Grade Walls:	R-40
Ceiling:	Attic, R-62
Window Type:	U-Value: 0.2, SHGC: 0.37
Foundation Walls:	N/A
Framed Floor:	N/A

Rating Completed by:

Energy Rater: Molly Hoback
RESNET ID:

Rating Company: OSU SDC

Rating Provider:

Molly Hoback, Certified Energy Rater
Date: 3/30/24 at 9:08 PM

ekotrope

Ekotrope RATER - Version:4.2.1.3368
The Energy Rating Disclosure for this home is available from the Approved Rating Provider.

EUI Performance Summary

House Parents Attached Housing Schedules									Guest Room	
	Occupancy		Occupancy		Equipment		Lighting		Occupancy	
	Living & Kitchen		Bedrooms		Living & Kitchen		ving & Kitch	Bedrooms	Living & Kitchen	
Hours	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	Weekends	Weekends	Weekday	Weekend
0	0	0	1	1	0.02	0.02	0.1	0.1	0	1
1	0	0	1	1	0.02	0.02	0.1	0.1	0	1
2	0	0	1	1	0.02	0.02	0.1	0.1	0	1
3	0	0	1	1	0.02	0.02	0.1	0.1	0	1
4	0	0	1	1	0.02	0.02	0.1	0.1	0	1
5	0	0	1	1	0.02	0.02	0.1	0.1	0	1
6	0	0	1	1	0.02	0.02	0.1	0.1	0	1
7	1	1	0	1	0.1	0.02	0.1	0.1	0	0
8	0	1	0	0	0.02	0.1	0.1	0	0	0
9	0	1	0	0	0.02	0.04	0.4	0	0	0
10	0	0.7	0	0	0.02	0.04	0.4	0	0	0
11	0	0.7	0	0	0.02	0.15	0.4	0	0	0
12	0	1	0	0	0.02	0.15	0.4	0	0	0
13	0	0.5	0	0	0.02	0.15	0.4	0	0	0
14	0	0.5	0	0	0.02	0.04	0.4	0	0	0
15	0	0.5	0	0.4	0.02	0.04	0.4	0	0	1
16	0	0.5	0.27	0.4	0.02	0.04	1	0	0	1
17	0	0.5	0.27	0.4	0.02	0.04	1	0.4	0	0
18	1	0.5	0.27	0.27	0.04	0.04	1	0.4	0	0
19	1	1	0.27	0.27	0.15	0.15	1	0.4	0	0
20	1	1	0.27	0.27	0.2	0.2	0.4	1	0	0
21	0.5	0.5	0.27	0.27	0.02	0.02	0.1	0.1	0	0
22	0	0	1	1	0.02	0.02	0.1	0.1	0	1
23	0	0	1	1	0.02	0.02	0.1	0.1	0	1

Maternity House Schedules					
	Occupancy	Occupancy	Equipment	Lighting	
	Living & Kitchen	Bedrooms	Living & Kitchen	Living & Kitchen	Bedrooms
Hours	All Days	All Days	All Days	All days	All days
0	0	1	0.02	0.1	0.1
1	0	1	0.02	0.1	0.1
2	0	1	0.02	0.1	0.1
3	0	1	0.02	0.1	0.1
4	0	1	0.02	0.1	0.1
5	0	1	0.02	0.1	0.1
6	0	1	0.02	0.1	0.1
7	0	1	0.02	0.1	0.1
8	0.6	0.2	0.1	0.1	0.1
9	0.6	0.2	0.02	0.4	0.1
10	0.6	0.2	0.2	0.4	0.1
11	0.6	0.2	0.2	0.4	0.1
12	0.6	0	0.2	0.4	0.1
13	0.8	0	0.04	0.4	0.1
14	0.8	0	0.04	0.4	0.1
15	0.6	1	0.04	0.4	0.1
16	0.6	1	0.04	1	0.1
17	0.8	0.2	0.04	1	0.1
18	0.8	0.2	0.2	1	0.4
19	0.8	0.2	0.15	1	0.4
20	0.8	1	0.2	0.4	1
21	0.8	1	0.1	0.1	1
22	0.1	1	0.02	0.1	0.1
23	0	1	0.02	0.1	0.1