2020

ECOmmunity

THE PENNSYLVANIA STATE UNIVERSITY

U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

Suburban Single-Family Home

Our Team

Supporting Organizations

PHRC
PENNSYLVANIA HOUSING RESEARCH CENTER

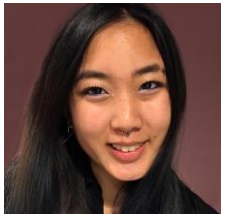
HAMER CENTER

EEHR
THE ENERGY EFFICIENT HOUSING RESEARCH GROUP

Faculty Advisors



Team Leaders

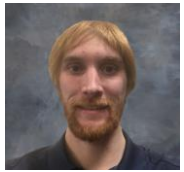






Team Members

















TEN CONTESTS

The occurance of these icons throughout the book indicates that the adjacent section includes information relevant to the noted contest. Some sections may have one or more icons associated with it.


Energy Performance


Engineering


Financial Feasibility and Affordability


Resilience


Architecture


Operations

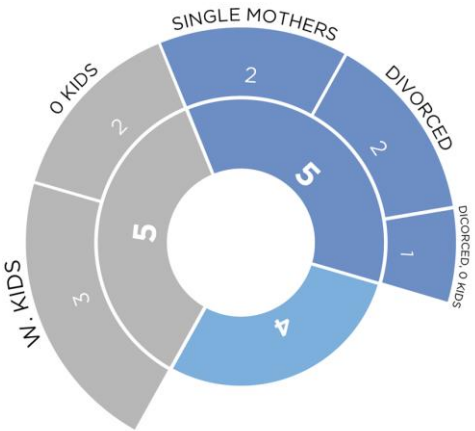

Market Potential


Comfort and Environmental Quality


Innovation


Presentation

CCHLT



CURRENT CCHLT HOUSEHOLDS

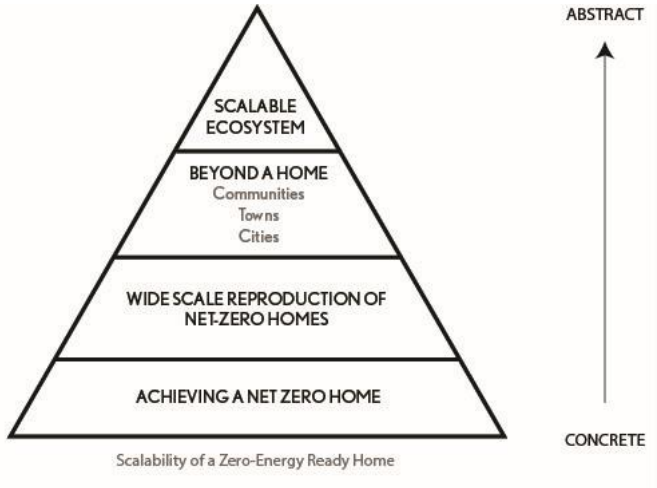
SINGLE

SINGLE PARENT

2 single mothers, both have 1 young child
2 divorced parents, one has a special needs child
1 disabled individual, divorced, adult children lived in home when young

MARRIED COUPLE

3 married with children/grand children, one has 2 teenagers, one has two grandchildrens, 1 has one has a special needs child
2 married with no kids



Scalability of a Zero-Energy Ready Home

CCHLT Mission Statement

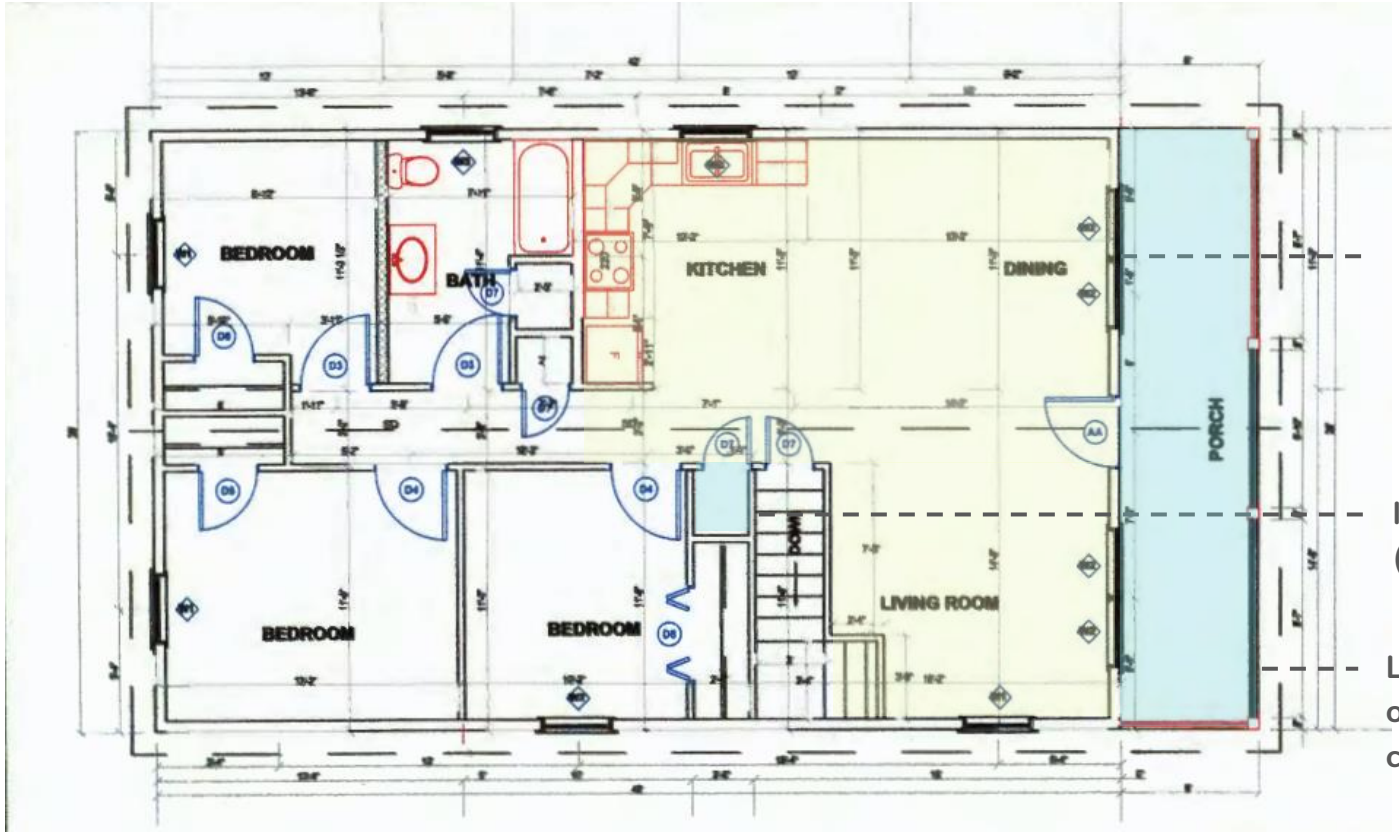
CCHLT

"At Centre County Housing and Land Trust, our mission is to strengthen communities through the development and stewardship of permanently, affordable homes for people of low- to moderate-income."

Existing Woodycrest Park

Thompson Place

Typical Thompson Place Floor Plan

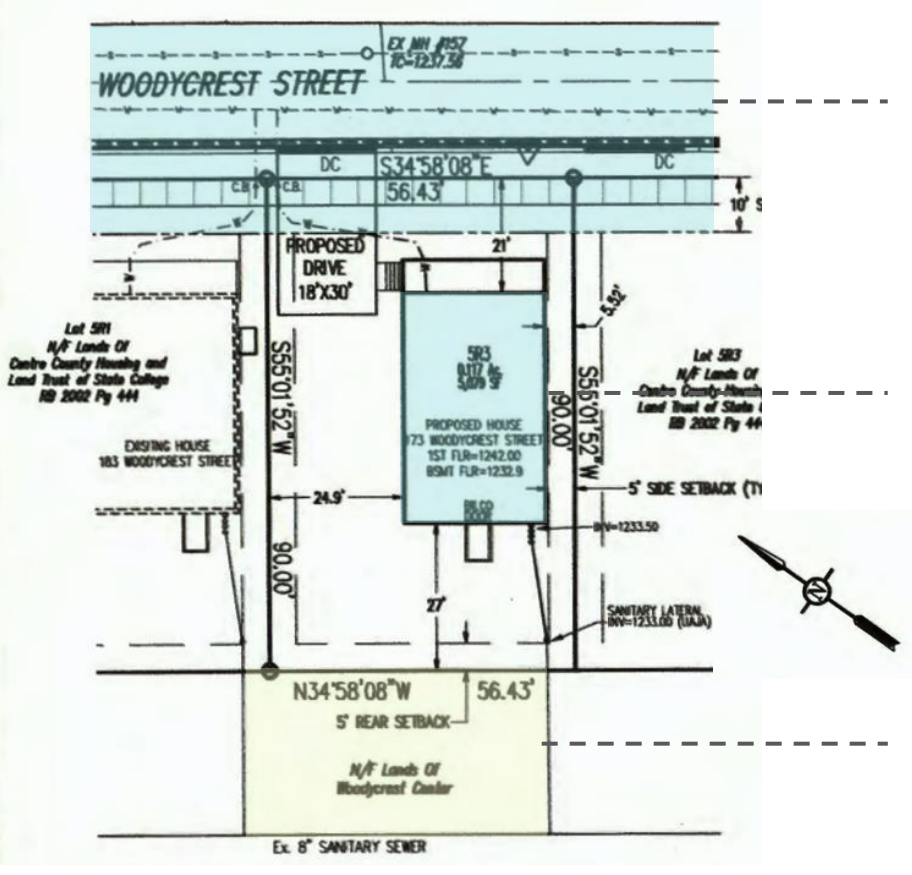


Great inclusion of kitchen, living, dining core

Inefficient systems used (Electric Baseboard)

Lack of connection to other homes or community spaces

Typical Thompson Place Lot



Lack of connection to other community, no interaction created

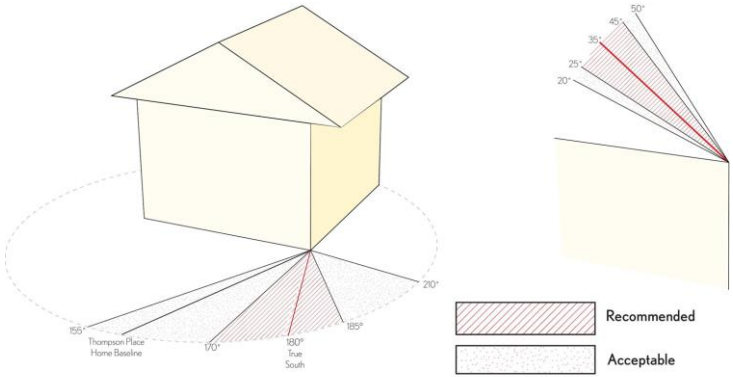
Home orientation creates inefficient energy production if Solar PV is added

Great Backyard Space

Design Constraints

State College Climate Zone: 5A

Houses are within 20° off True South to maximize solar gains



CCHLT

80-120% Centre County MFI

$60,759-$91,138

Ownership spans 7-25+ years

No foreclosures

Typical CCHLT Family

-2 adults, 28 years old

-College degrees

-1-2 young children

-First time homeowner

Design Priorities

(1) Sense of Community

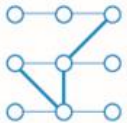
CCHLT
ECOmmunity

(2) Quality of Life

CCHLT Solar Decathlon
ECOmmunity

(3) Affordability

CCHLT
Solar Decathlon



(4) Flexibility

CCHLT
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(5) Operational and Embodied Energy

ECOmmunity Solar Decathlon

(6) Constructability and Material Life Cycle

CCHLT Solar Decathlon

(7) Innovation

Solar Decathlon
ECOmmunity

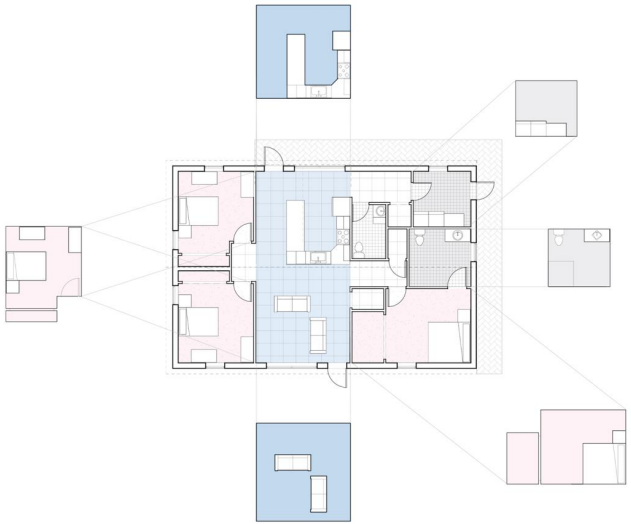
(8) Aesthetics

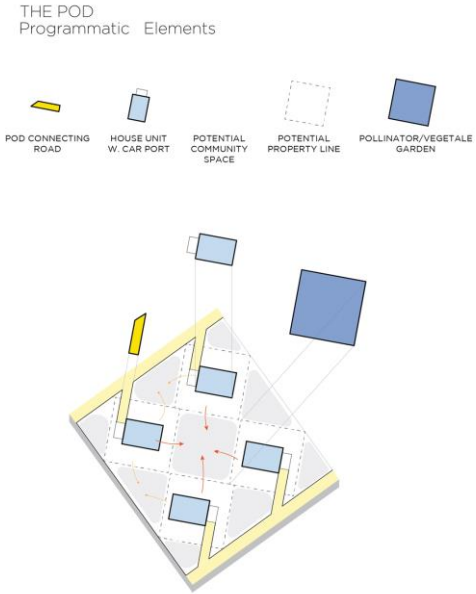
ECOmmunity

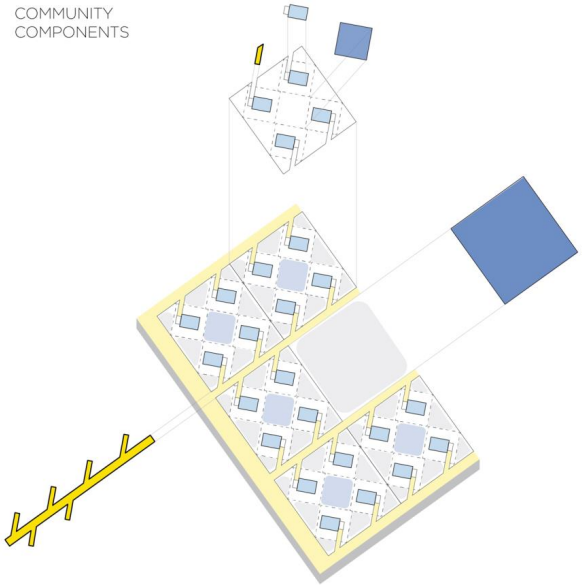
(9) Resilience

Solar Decathlon

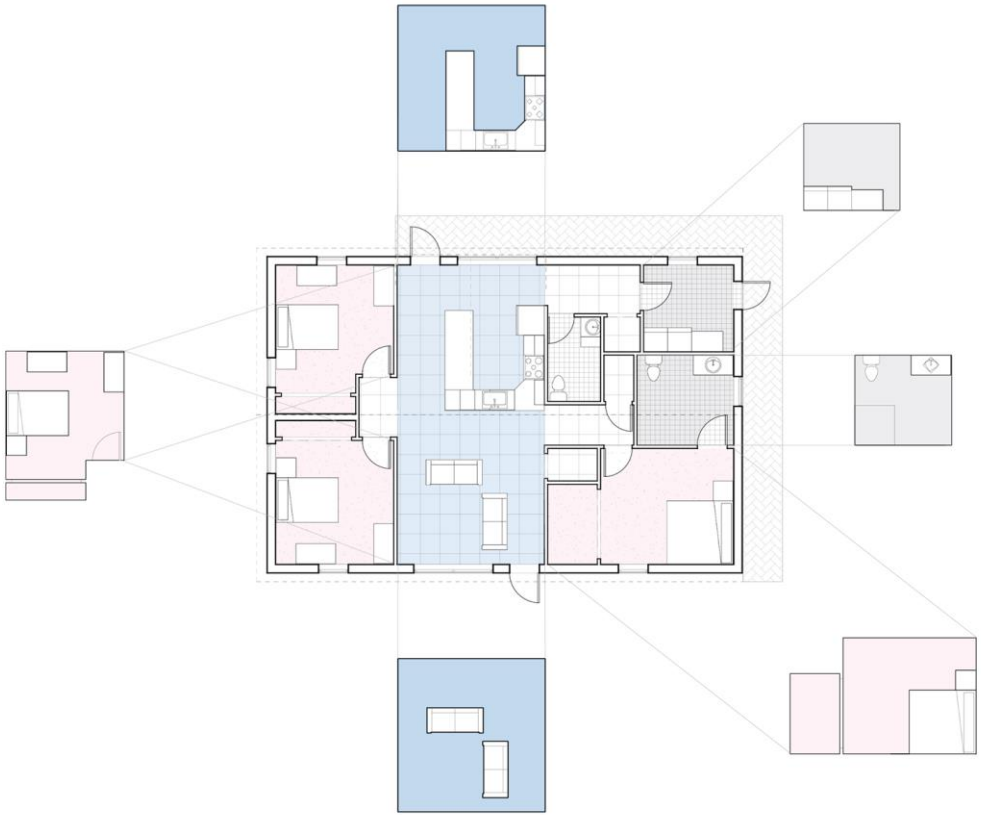
The Social Core



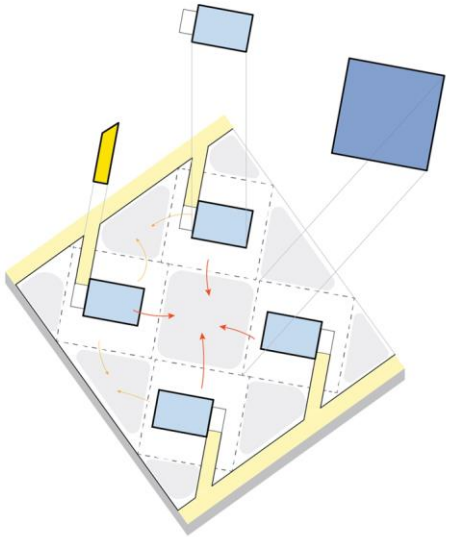


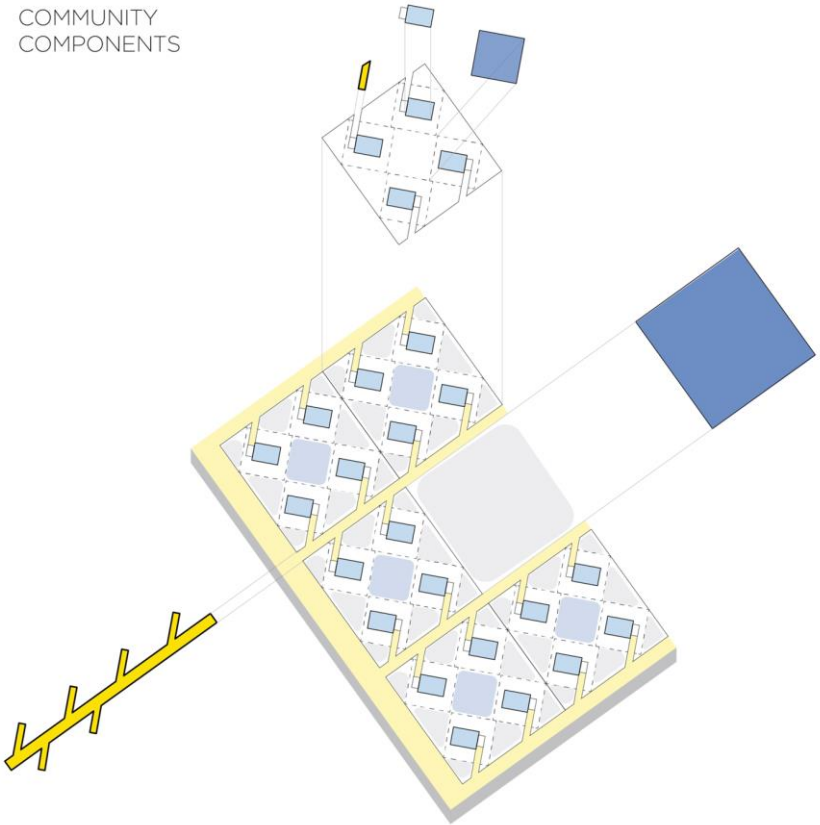


Architecture

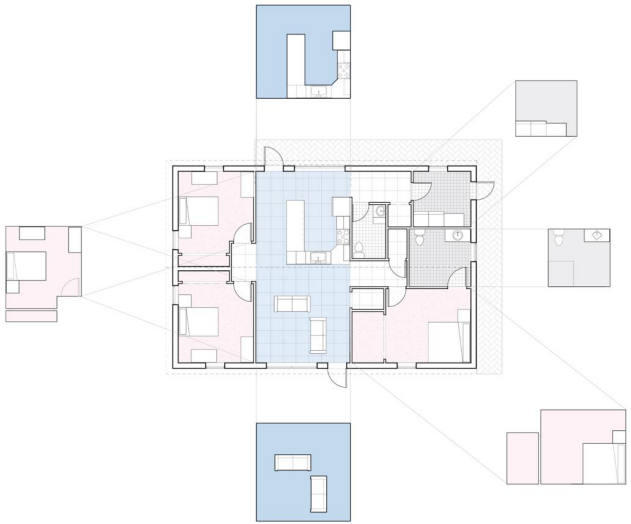


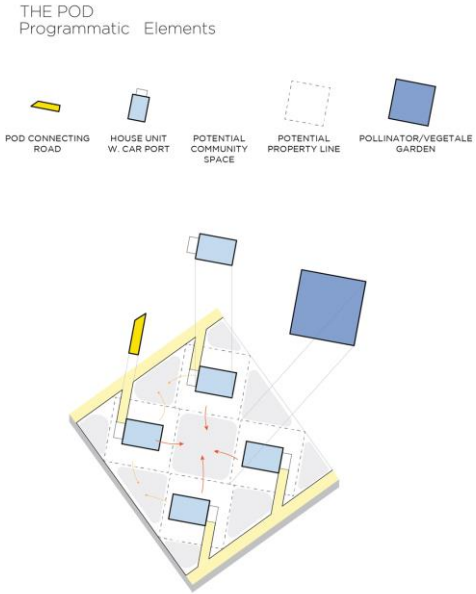
THE POD
Programmatic Elements

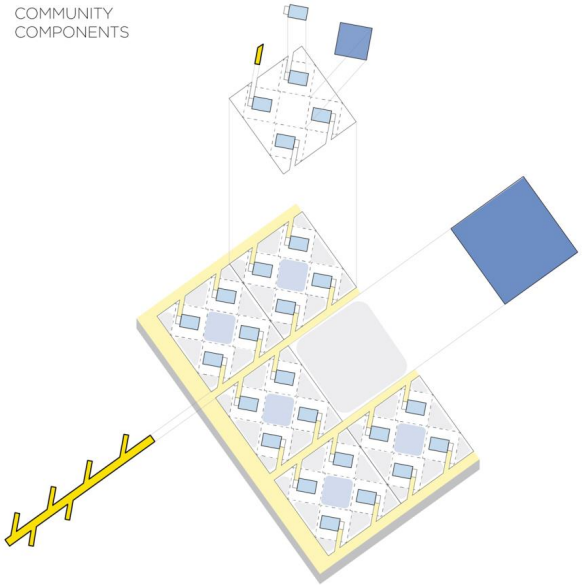



COMMUNITY
COMPONENTS

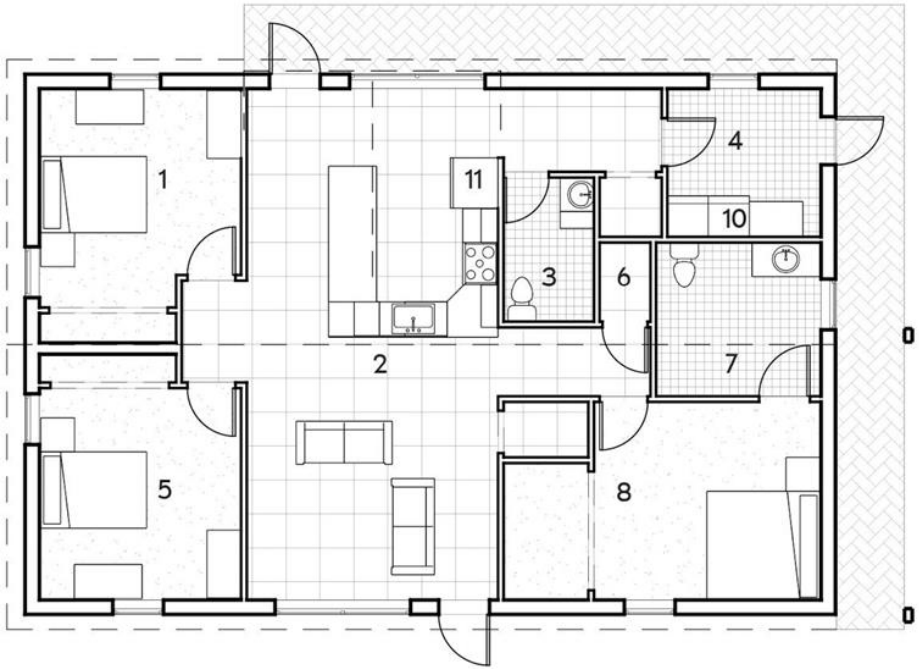
The Social Core





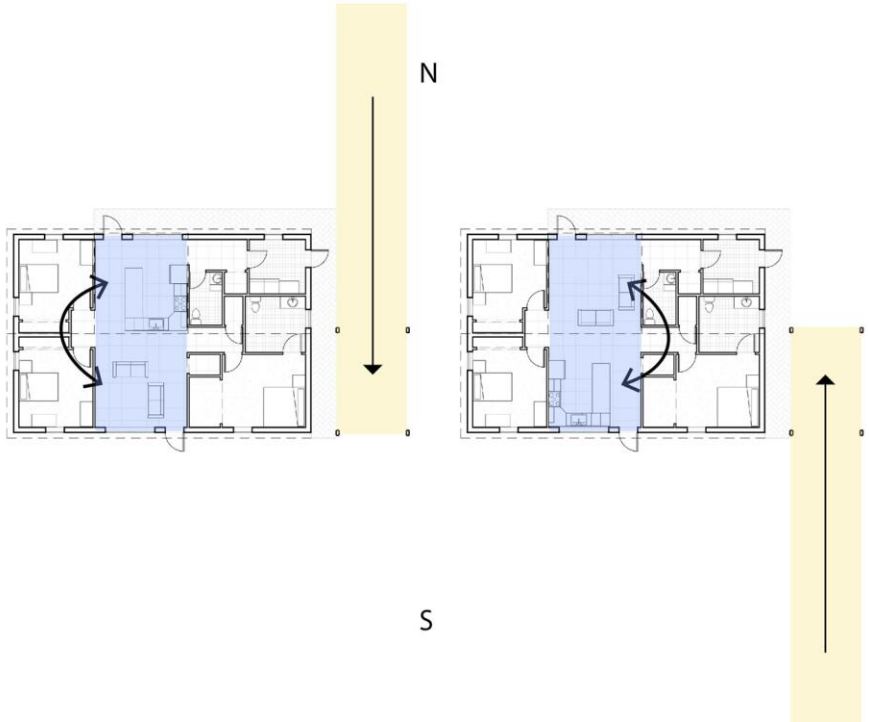


Floor Plan

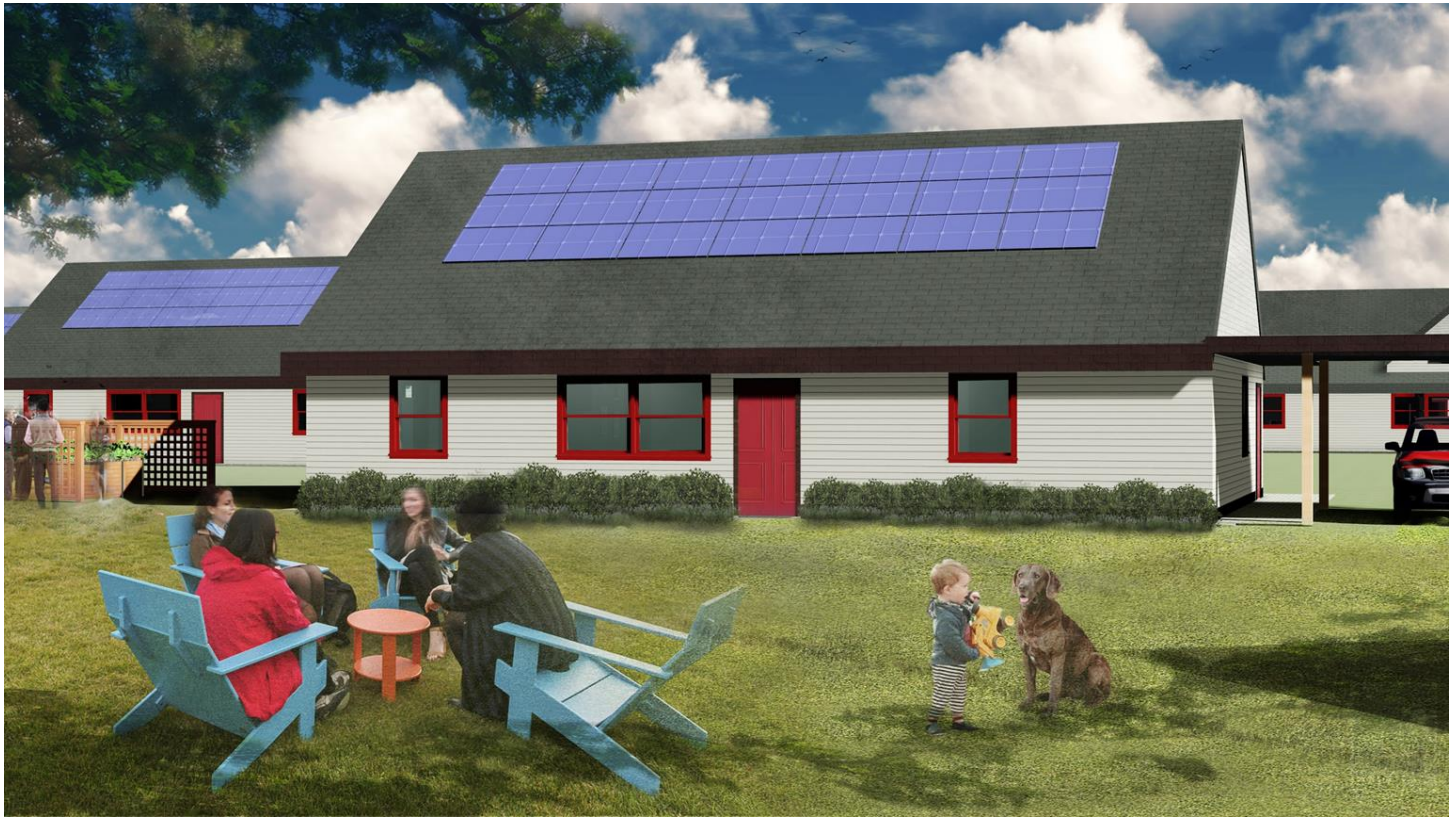


1	bedroom	146 sf
2	kitchen/living	554 sf
3	bathroom	40 sf
4	mudroom	79 sf
5	bedroom	149 sf
6	mechanical room	14 sf
7	master bath	88 sf
8	master bedroom	157 sf
9	carport	240 sf
10	washer/dryer	
11	refrigerator	

Diagram of Flexible Modules



Backyard



Park View

Living Room Interior

Kitchen Interior

Design Consideration

(3) Affordability

CCHLT

Solar Decathlon

(5) Operational and Embodied Energy

ECOmmunity Solar Decathlon

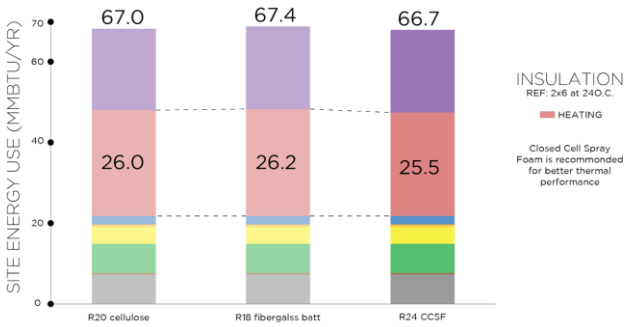
(6) Constructability and Material Life Cycle

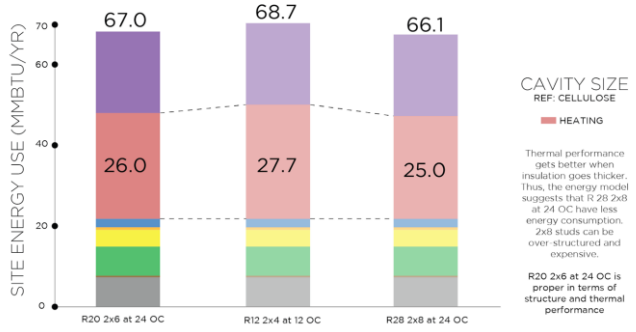
CCHLT Solar Decathlon

Research

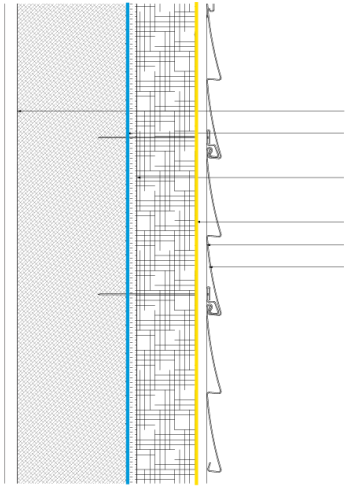
Insulation Type	R-Value	Density	Embodied Energy	Embodied Carbon	Blowing Agent (GWP)	Constructibility	Affordability
	R/in	*lb/ft^3*	*MJ/kg*	*kgCO2/kg*	Type	*Simple 1 - 5 Technical*	$/ft^2/R
Fiberglass Batt	3.3 per inch	1	2.8	0.0165	None	1	$0.12
Dense-Pack Cellulose	3.7 per inch	3	2.1	0.0033	None	4	$0.16
Closed-Cell Spray Foam	5 per inch	2	72	0.0387	Water (GWP=1)	5	$0.12
Open-Cell Spray Foam	3.7 per inch	0.5	72	0.0154	Water (GWP=1)	5	$0.26
Rockwool Batt	4	2.8	16.8		None	2	$0.07
XPS	5 per inch	2	89	0.0379	HFC-134a (GWP=1,430)	2	$0.23
EPS	3.9 per inch	1	89	0.0307	Pentane (GWP=7)	2	$0.21
Rigid Rockwool	4 per inch	4	17	0.0455	None	3	$0.20
Polyisocyanurate	6.0 per inch	1.5	72	0.0284	Pentane (GWP=7)	2	$0.11
Expanded Cork Board	3.6 per inch	7.5	4		None	3	$0.29

"Avoiding the Global Warming Impact of Insulation" Alex Wilson, Scott Gibson / Fine Homebuilding





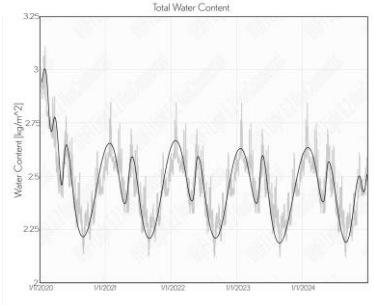
Wall Construction



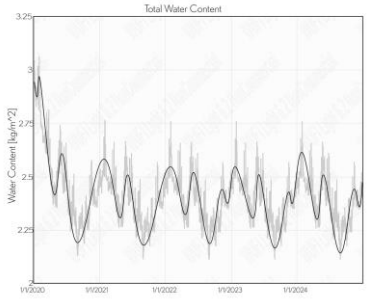
Wall (R-32)

5/8" GWB
2x6 Advanced Framing with
5 1/2" R-3.7 per Inch Dense-Pack Cellulose (Thermal Barrier)
1/2" ZIP Sheathing with Taped Joints
(Air/Vapor Barrier and Drainage Plane)
3" R-4 per Inch Rigid Rockwool Insulation (Thermal Barrier)
1/2" Furring Strips for Rain Screen and Drainage
1/2" Lapped Vinyl Siding with 4" Nails
into the Studs and Sealant Applied (to maintain continuous air barrier)

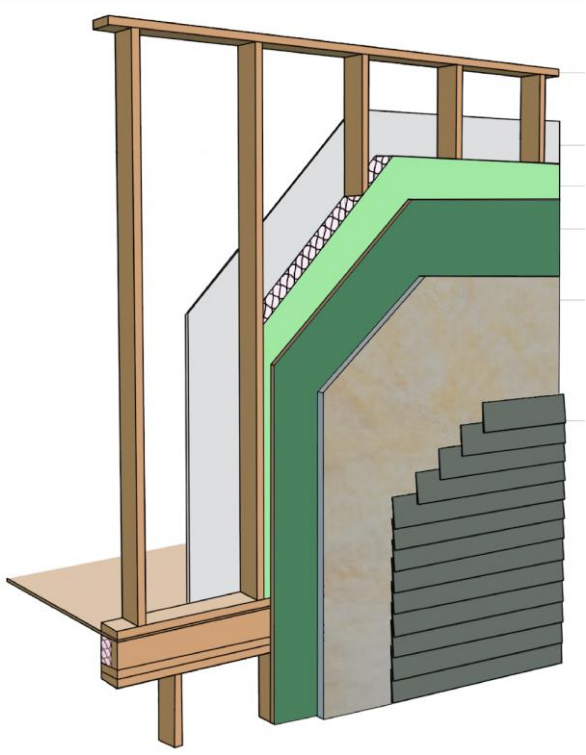
Continuous Thermal Barrier
Continuous Air/Vapor Barrier



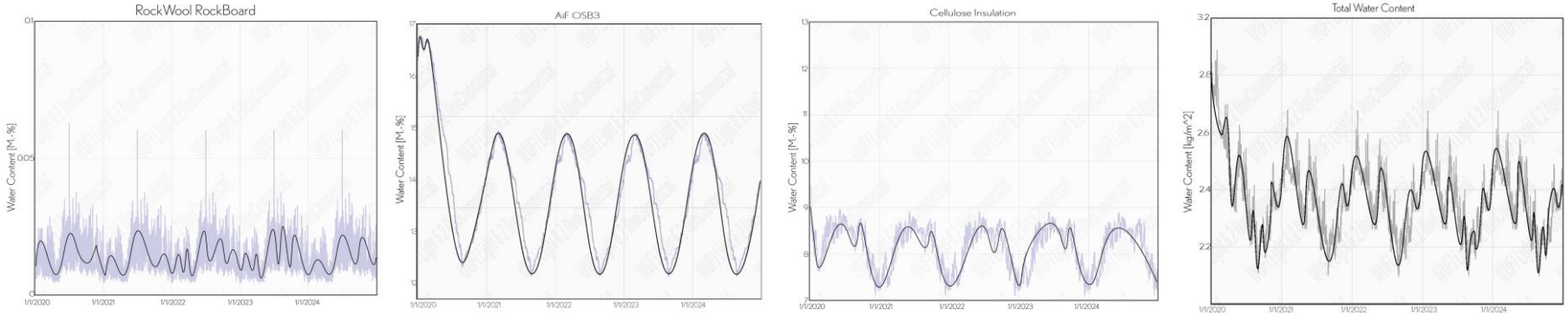
Rockwool Insulation



XPS Insulation

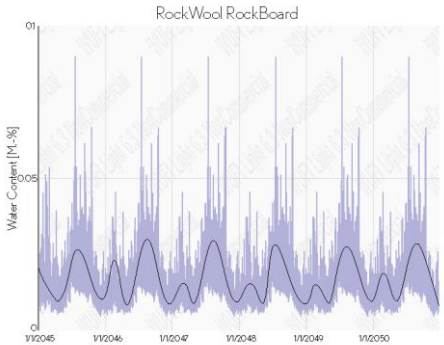


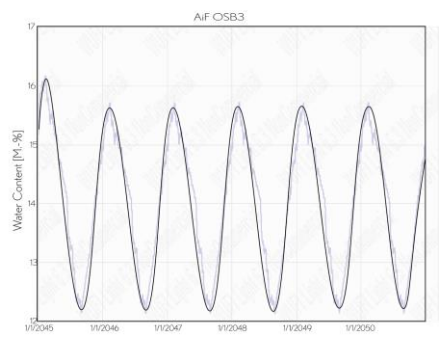
Wall Construction

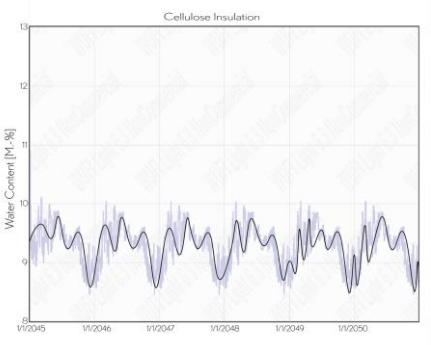


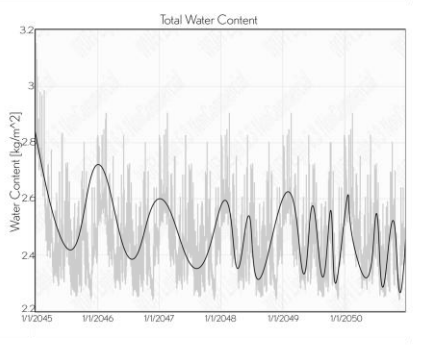
WUFI Hygrothermal Analysis

Building Envelope Resiliency



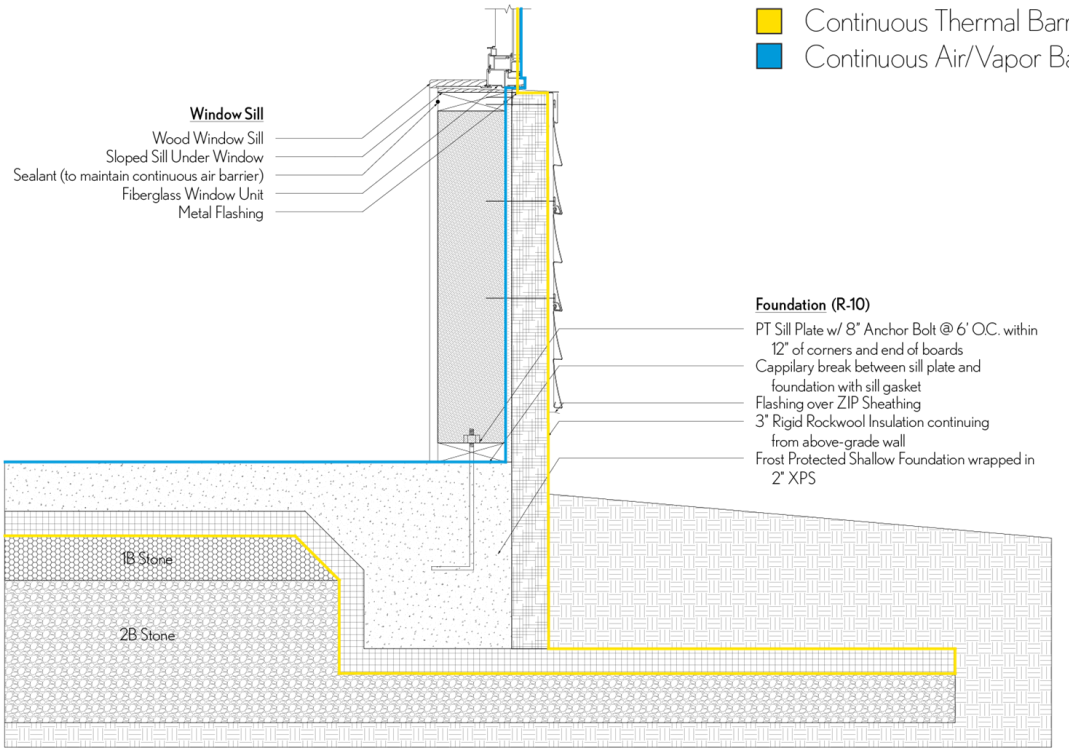


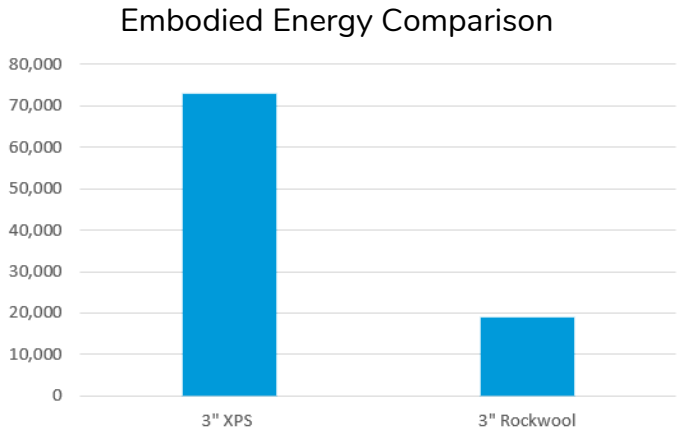




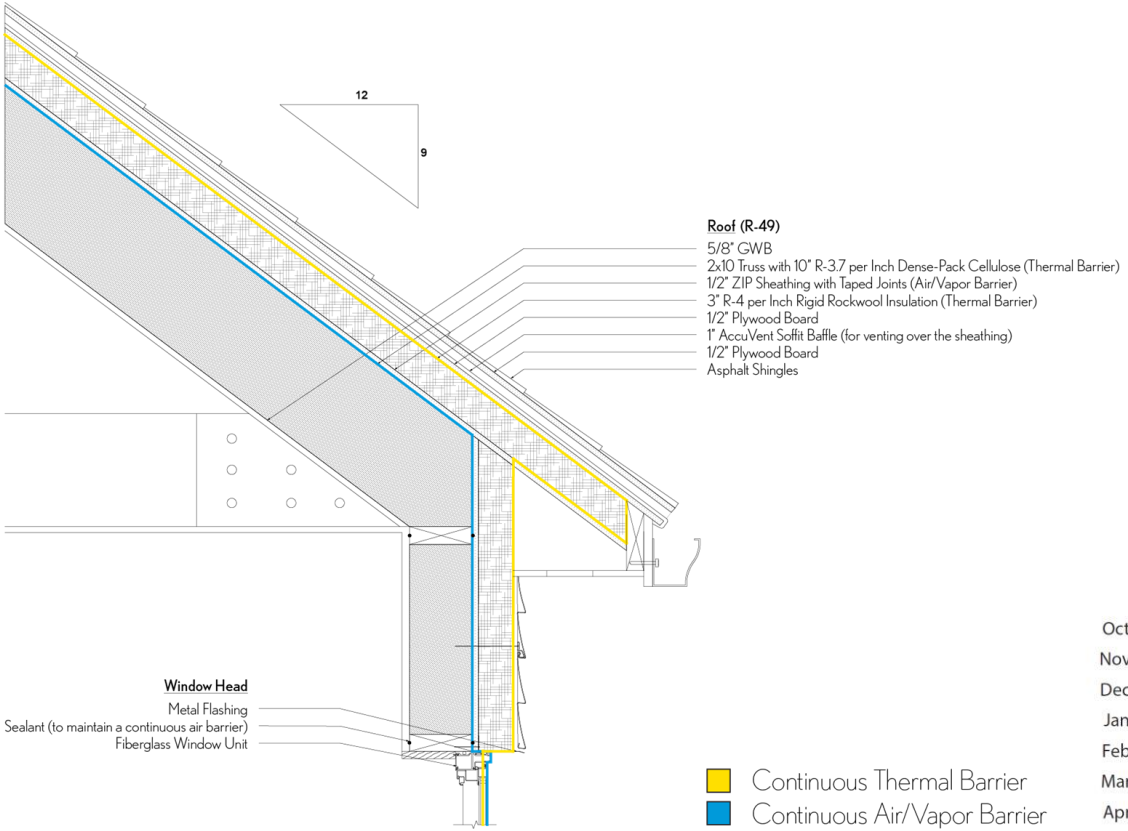
2050 WUFI Hygrothermal Analysis

Foundation Construction





Roof Construction



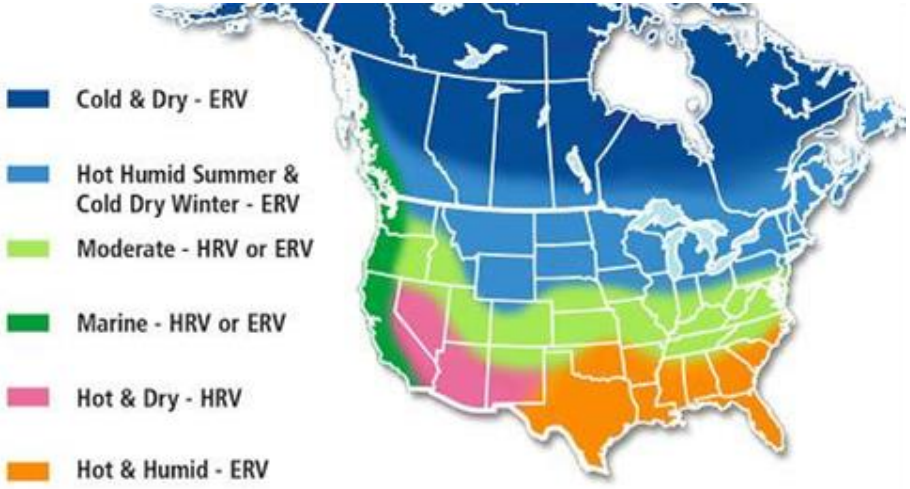
Unvented Roof - Rigid Insulation Ratio Analysis

Temp. of Condensing Surface = [ΔT x R-Value Ratio] + Monthly Mean Exterior Temperature

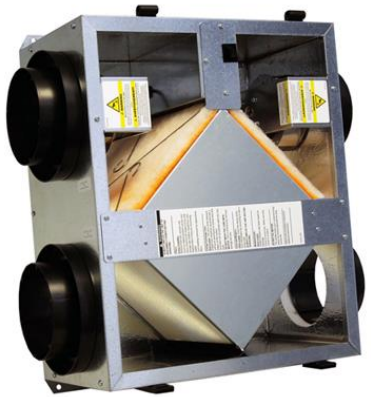
	Inside Temp.	Monthly Mean Exterior Temp.	ΔT	Temp. of Condensing Surface
Oct.	70°F	51.5°F	18.5°F	56°F
Nov.	70°F	42°F	28°F	49°F
Dec.	70°F	31.5°F	38.5°F	41°F
Jan.	70°F	35°F	35°F	44°F
Feb.	70°F	36°F	34°F	44°F
Mar.	70°F	39°F	31°F	47°F
Apr.	70°F	44.5°F	22.5°F	51°F

Rigid Insulation R-Value: 12
Total Assembly R-Value: 49
R-Value Ratio: 0.245

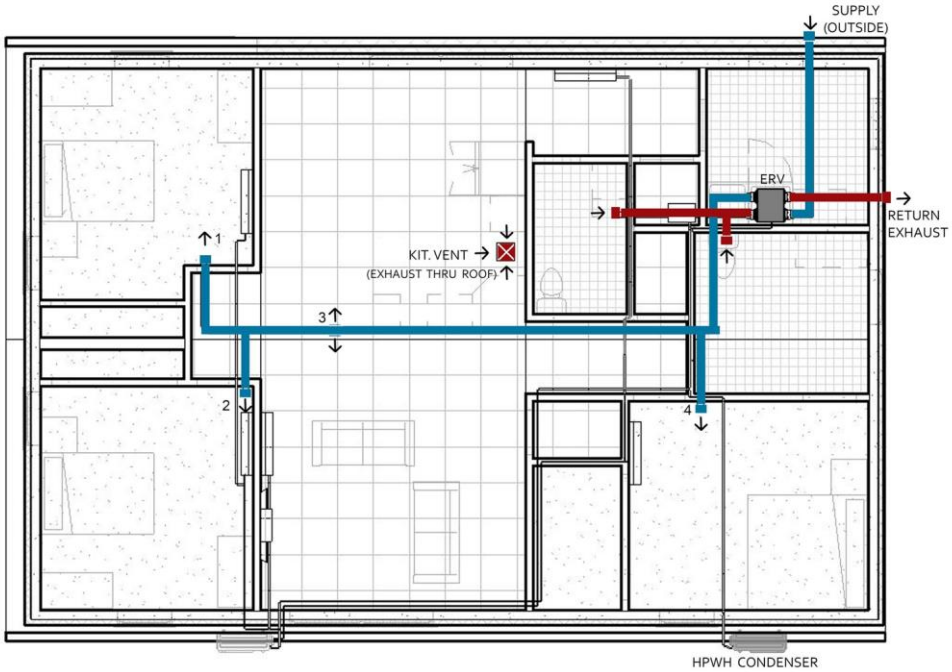
Ventilation



RenewAire - GR 90 ERV

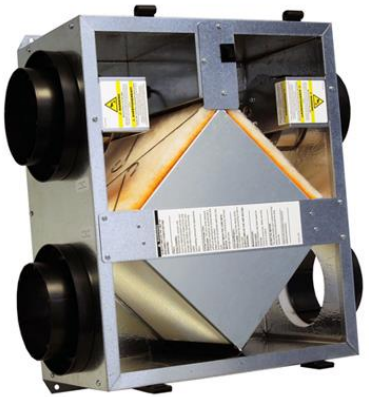


Ventilation



Ventilation Plan w/ ERV Location

RenewAire - GR 90 ERV

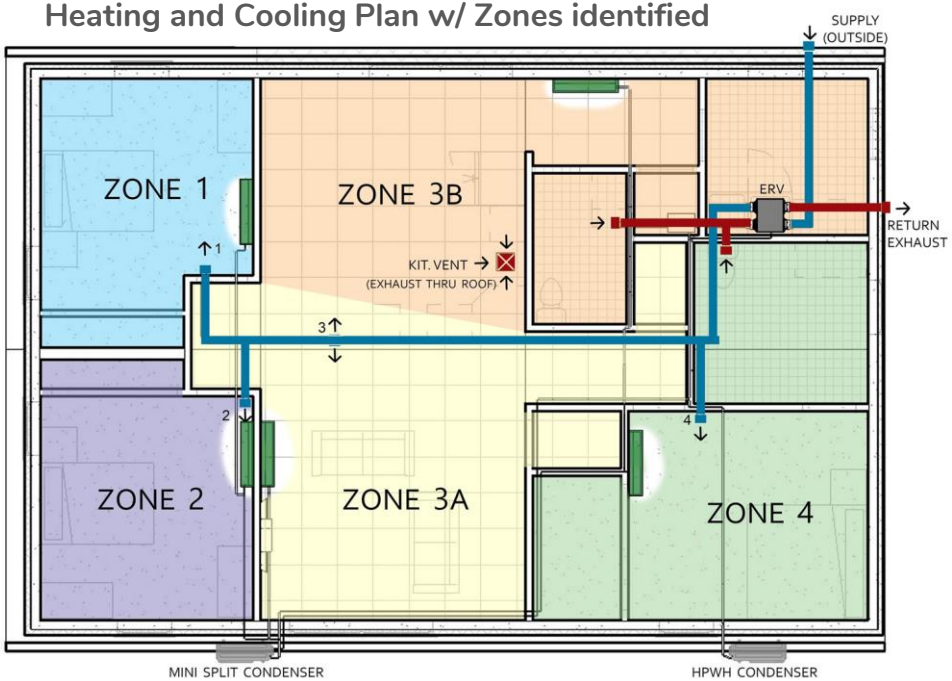


Heating and Cooling

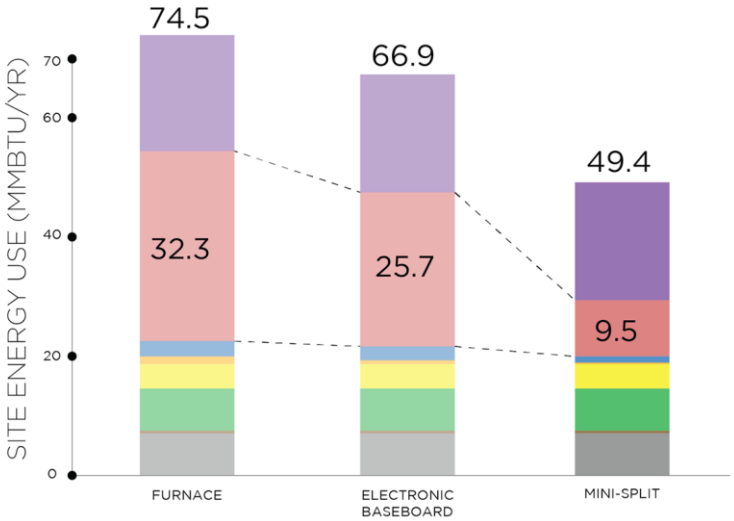
LG Condenser Model
LMU480HV

LG Mini Split Model
LMN079HVT

Heating and Cooling Plan w/ Zones identified



Heating and Cooling

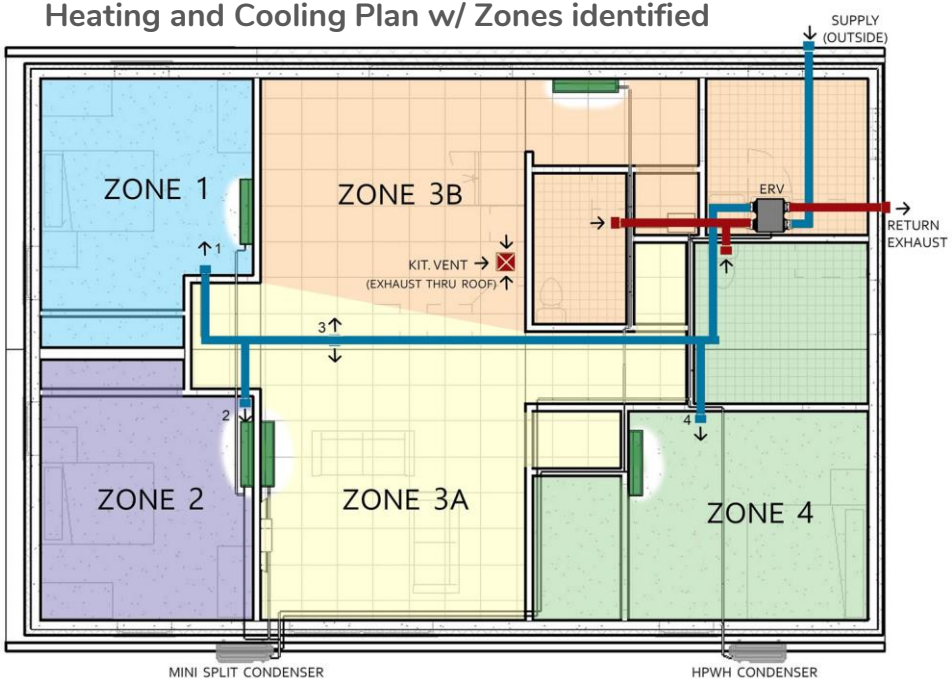


SPACE CONDITIONING

Heating
Cooling

Mini-split space conditioning system reduced energy usage the most

Heating and Cooling Plan w/ Zones identified



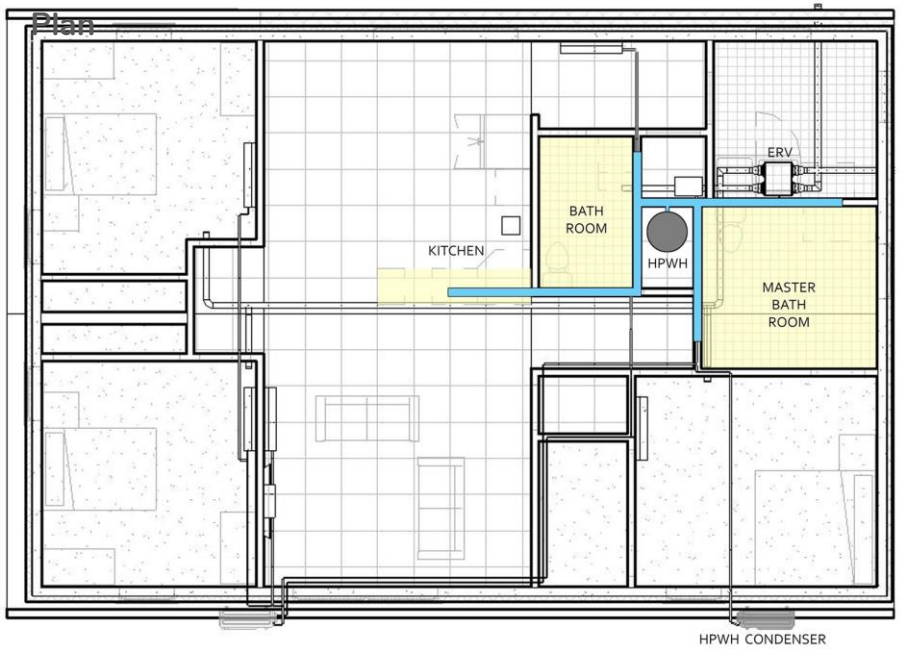
Plumbing

Sanden SANCO2
Heat Pump Water Heater

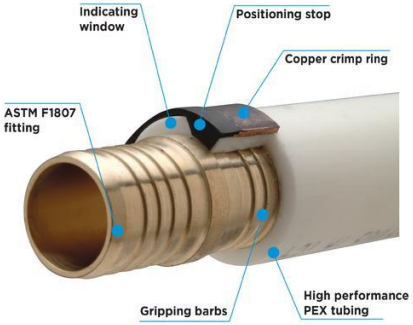
Water Tank (Indoor)
Model SAN-83SSAQA

Condenser Unit (Outdoor)
Model GS3-45HPA

Highlighted “Wet Core” Walls in Plan



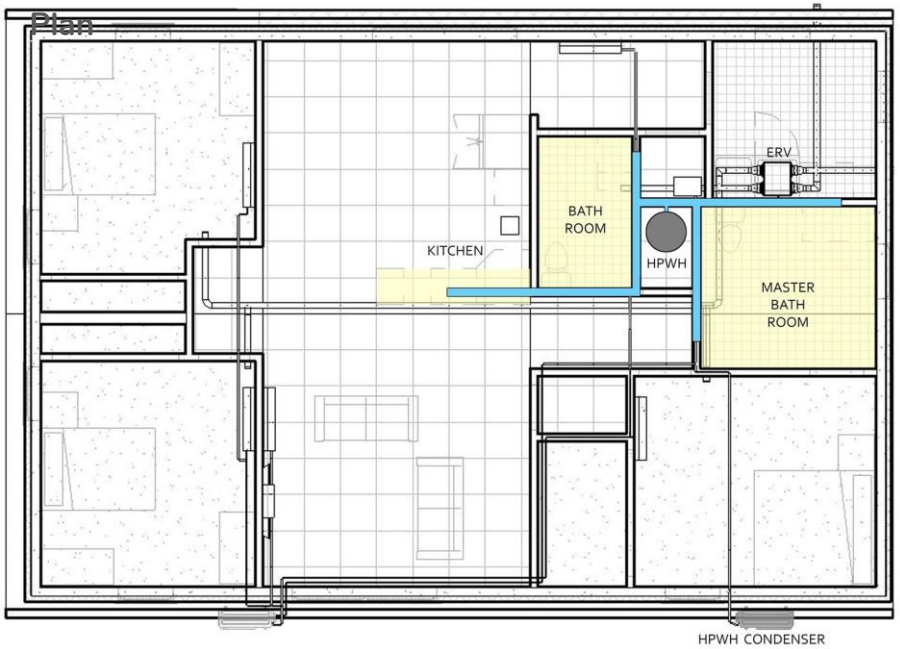
Plumbing



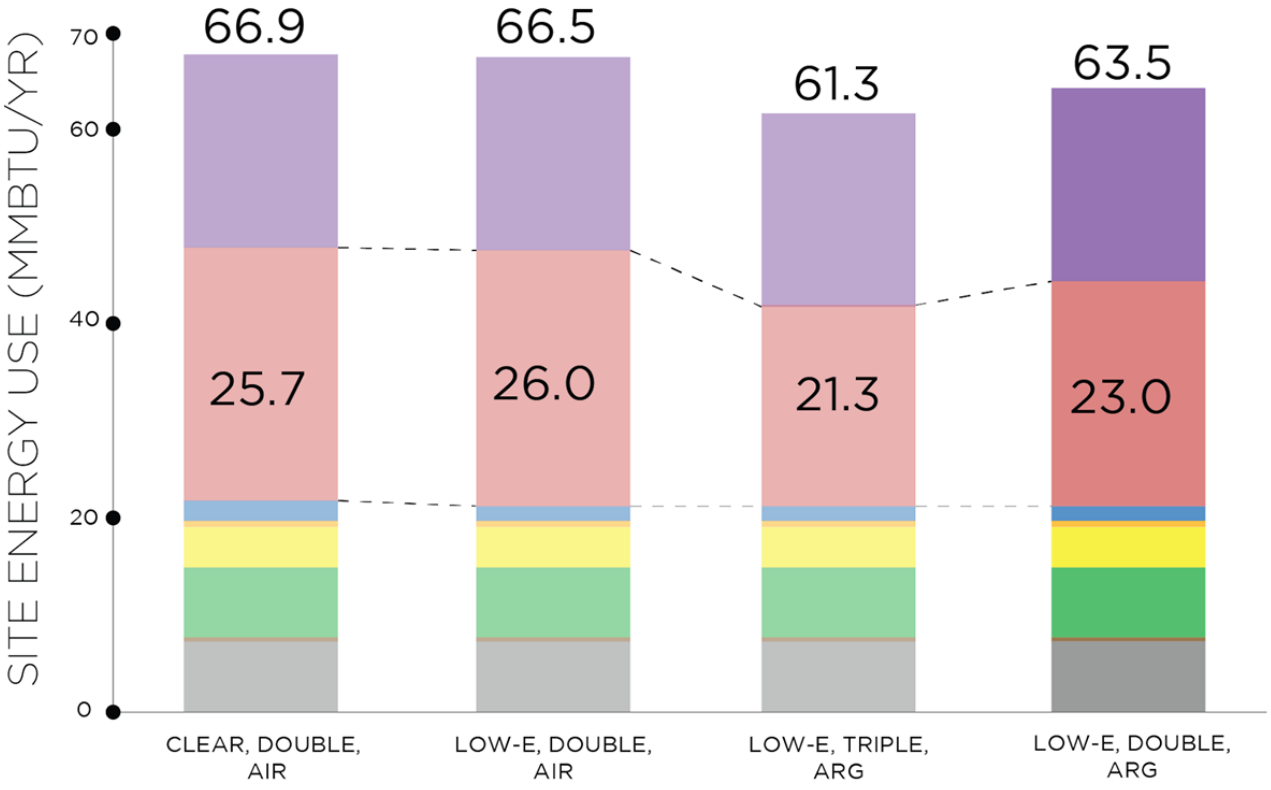
PEX-A Supply Piping

PVC Waste piping

Highlighted “Wet Core” Walls in Plan



Window Types



WINDOW PANE

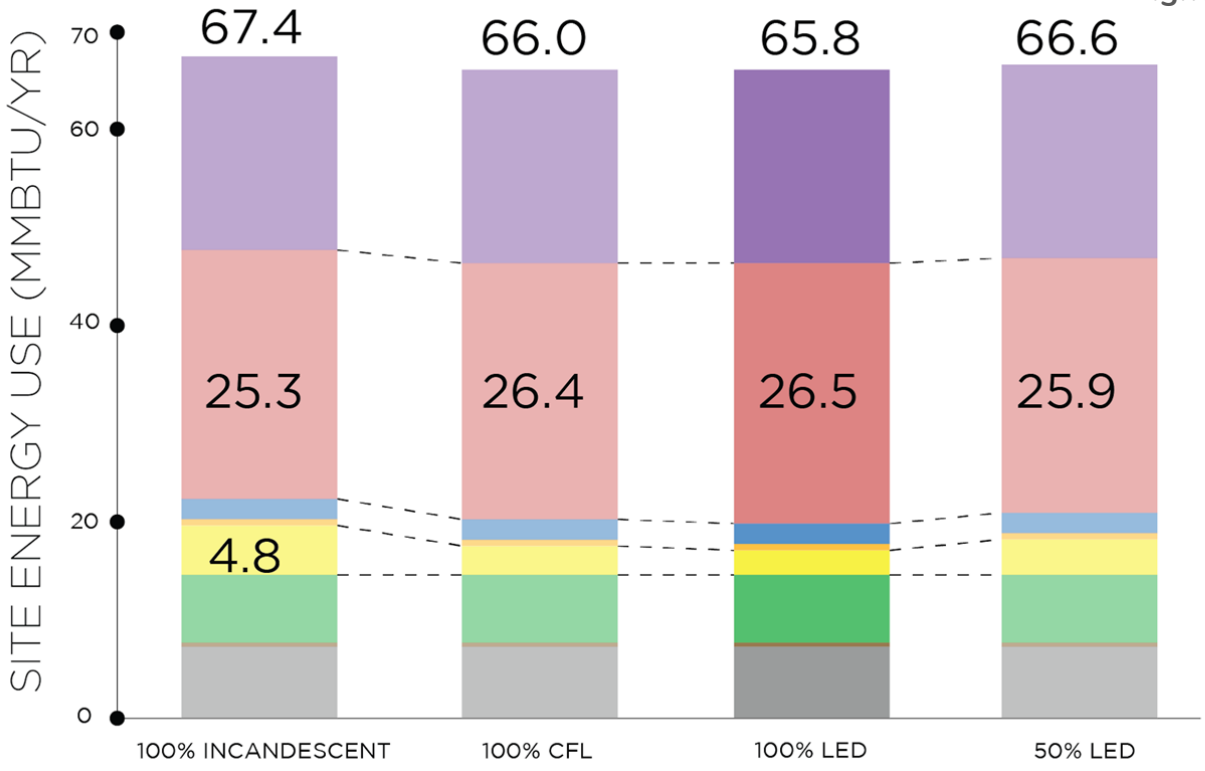
Heating

Window panes have impact on heating energy use. Key factor is to reduce heat leaking in cooling days

The energy model suggests Triple-pane glass filled with Argon, but it might not be cost-effective.

Double-pane w. Argon is recommonded for acceptable therman performance and lower cost

Lighting Energy



LIGHTING

Heating

LIGTING

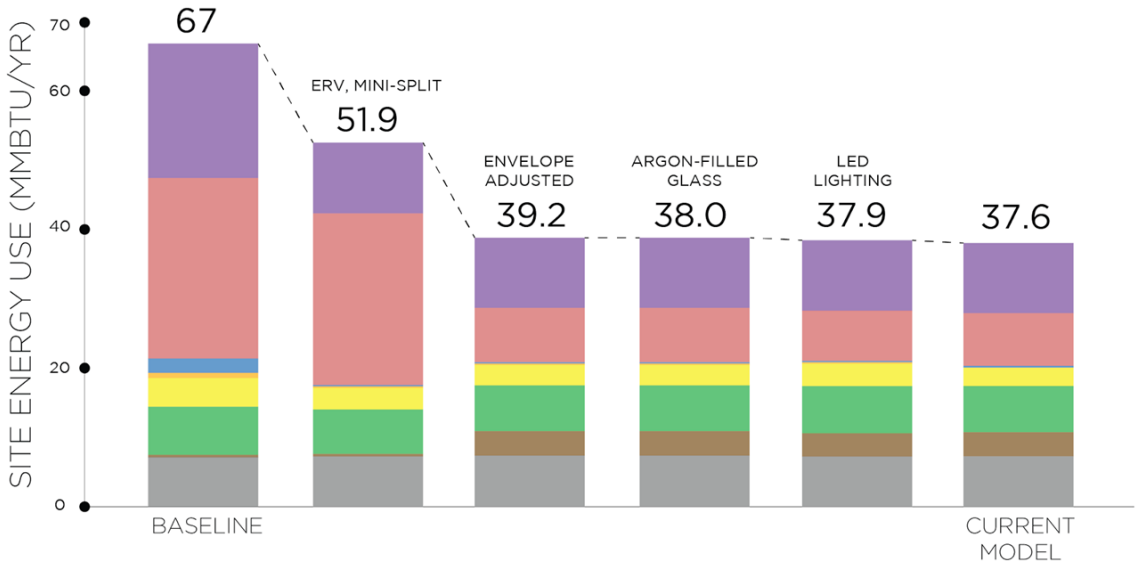
100% LED is suggested for less energy cost on lighting

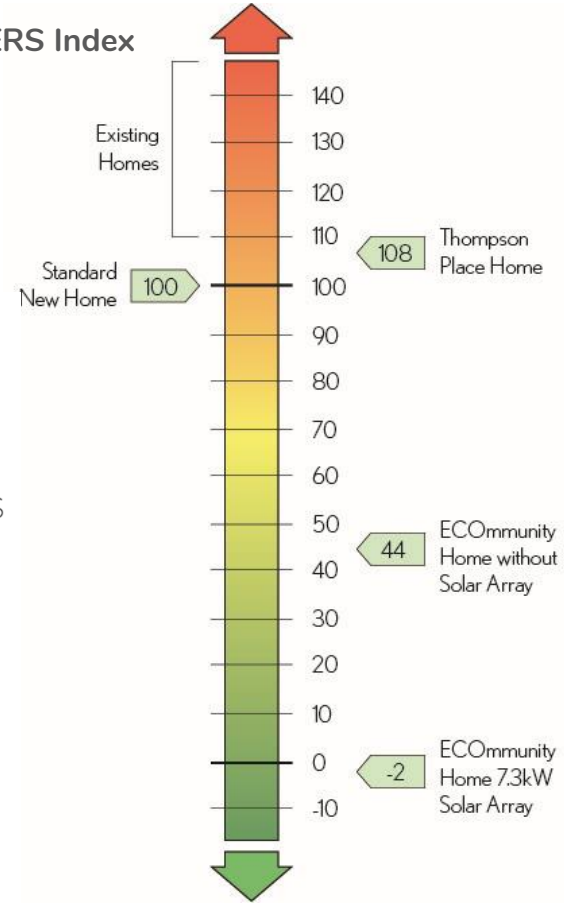
Lithonia - LTIKSQ LED Linear Track Light

Commercial Electric - LED Recessed Light

Feit Electric - Exterior LED Wall Light

Site Energy Usage

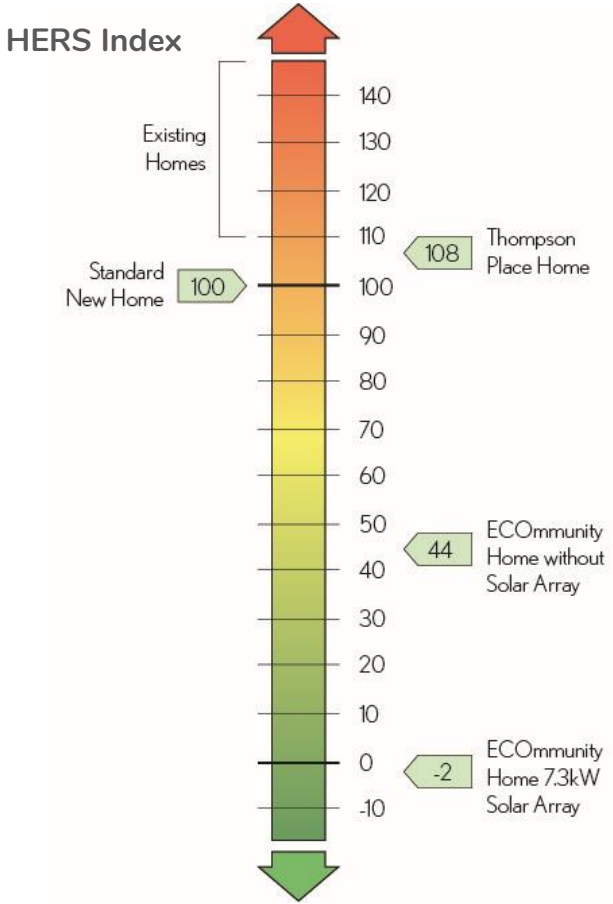


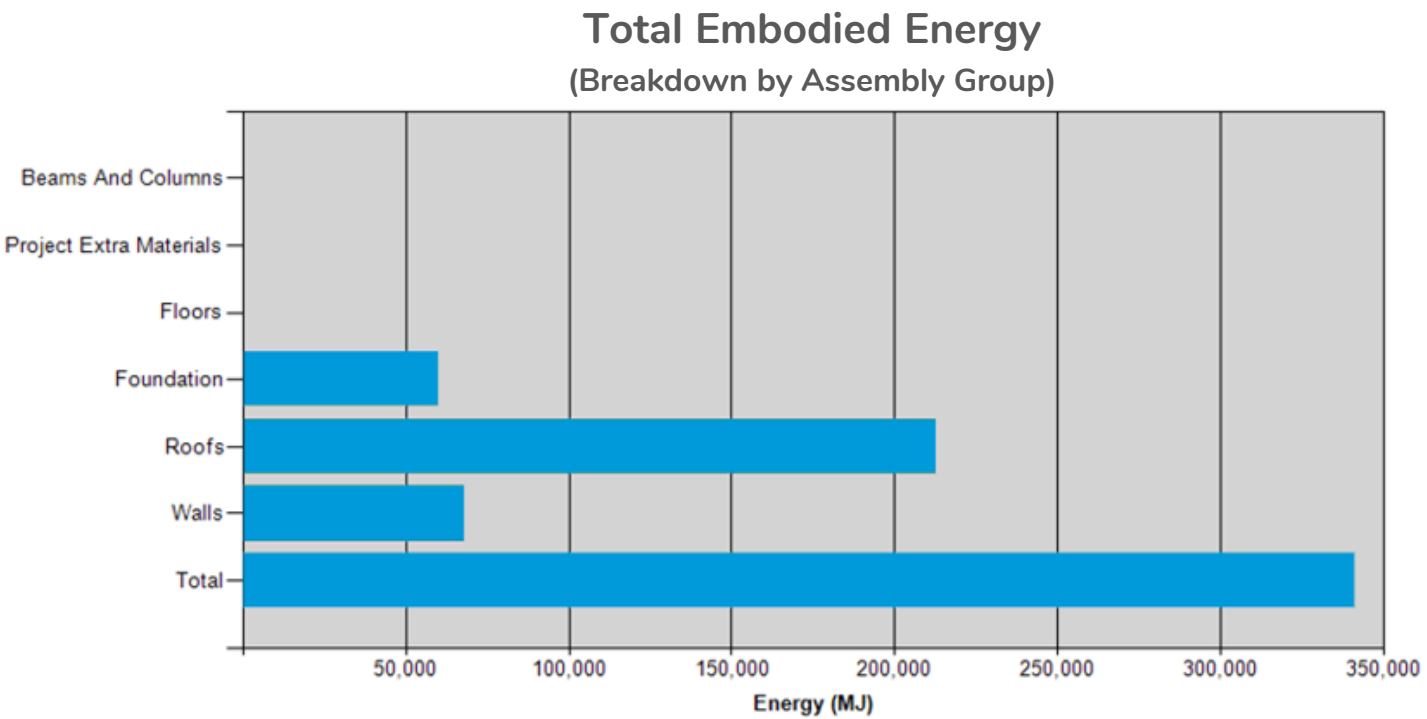


Energy Resilience and Future Proofing

LG Chem RESU10H
Back-up Battery

Sunpower X21-350-BLK-D-AC
Solar Panels




Total Embodied Energy
(Breakdown by Assembly Group)
Beams And Columns
Project Extra Materials
Floors
Foundation
Roofs
Walls
Total
50,000
100,000
150,000
200,000
250,000
300,000
350,000
Energy (MJ)

Design Priorities

- Affordability
- Quality of Life
- Resilience
- Flexibility

CCHLT Land Trust Model

CCHLT works with 80-120% Median Family Income(MFI)

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MFI in PA is $75,949

CCHLT Land Trust Model

CCHLT works with 80-120% Median Family Income(MFI)

MFI in PA is $75,949

CCHLT works with people who make between $60,759 and $91,138

Cost Breakdown

	Cost Without Add-On	Cost With Add-On
Construction	$103,287.04	$137,095.98
Labor	$33,719.14	$57,219.14
Total	**$137,006.18**	$194,315.12
Cost Per Square Foot	$86.71	$122.98

Cost Breakdown

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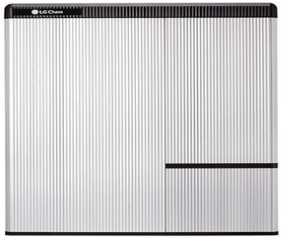
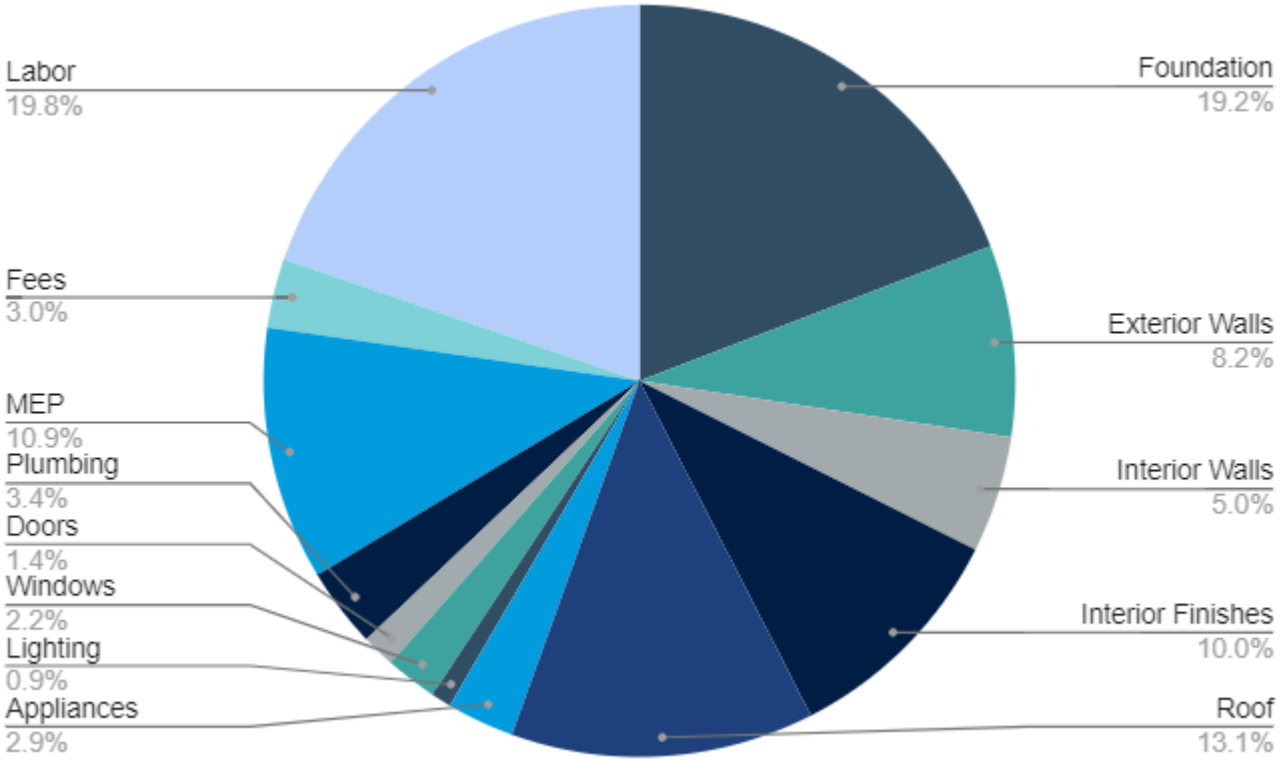
Back-up Battery



Sunpower X21-350-BLK-D-AC Solar Panels

Cost Breakdown



Cost Breakdown	
Foundation	$32,714.44
Exterior Walls	$14,037.20
Interior Walls	$8,557.66
Interior Finishes	$17,142.56
Roof	$22,274.67
Appliances	$4,960.00
Lighting	$1,484.00
Windows	$3,794.00
Doors	$2,446.00
Plumbing	$5,846.00
MEP	$18,597.65
Fees	$5,077.00
Labor	$33,719.14

Monthly Payment

Cost of Home without Add-ons

Salary at 80% MFI	$60,759
House Cost without add-ons	$137,006.19
Mortgage Term	30 years
Interest Rate	3.94
Down Payment	$4,110
Monthly Mortgage Payment	$629.00
Monthly Energy Cost	$58
Real Estate Taxes	$200.00
Insurance	$50.00
Private Mortgage Insurance	$114.17
CCHLT Land Lease	$15.00
Total Monthly Payment	**$1,066.17**
Debt to Income Ratio	**21.06%**

Cost of Home with Add-ons

Salary at 80% MFI	$60,759
House Cost with add-ons	$194,315.13
Mortgage Term	30 years
Interest Rate	3.94
Down Payment	$5,829
Monthly Mortgage Payment	$892.00
Monthly Energy Cost	$3
Real Estate Taxes	$200.00
Insurance	$50.00
Private Mortgage Insurance	$161.93
CCHLT Land Lease	$15.00
Total Monthly Payment	**$1,321.93**
Debt to Income Ratio	**27.19%**

CCHLT Mission Statement

CCHLT

At Centre County Housing and Land Trust, our mission is to strengthen communities through the development and stewardship of permanently, affordable homes for people of low- to moderate-income.

Conclusion

ECO mmunity

Create a Sense of Community

Improve the Quality of Life

Work to Create Affordable Local Housing for Members of the Penn State Community

Optimize CCHLT Output