Passive Building Experts

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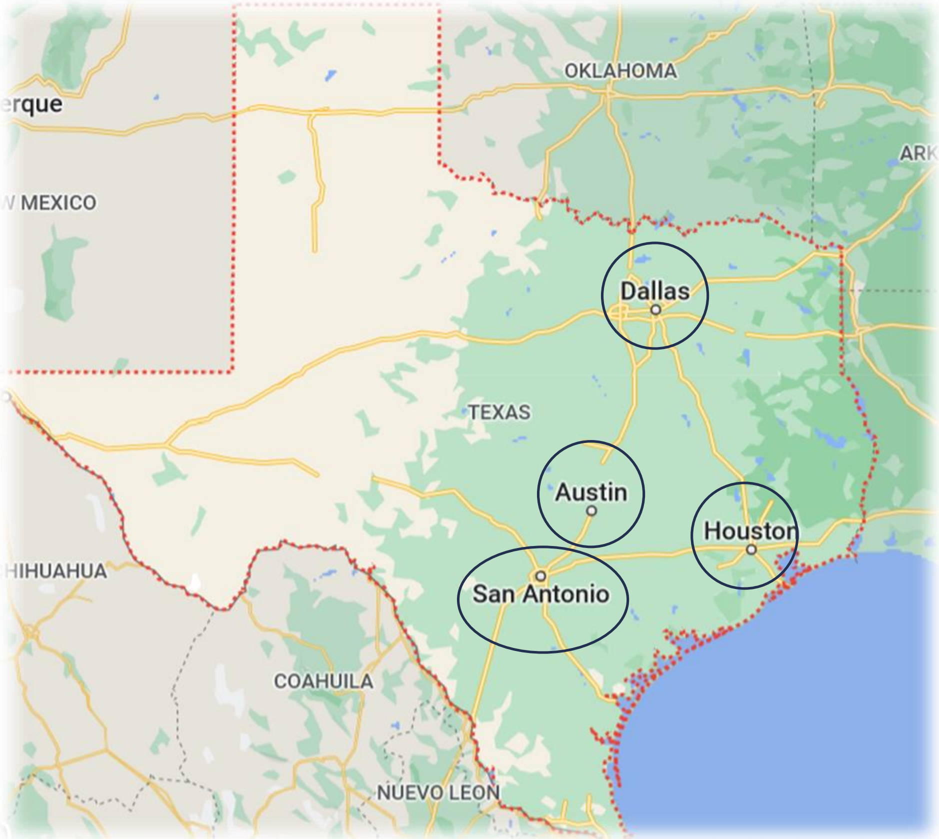
Build Zero Consulting

Hot and Humid Texas

- Texas

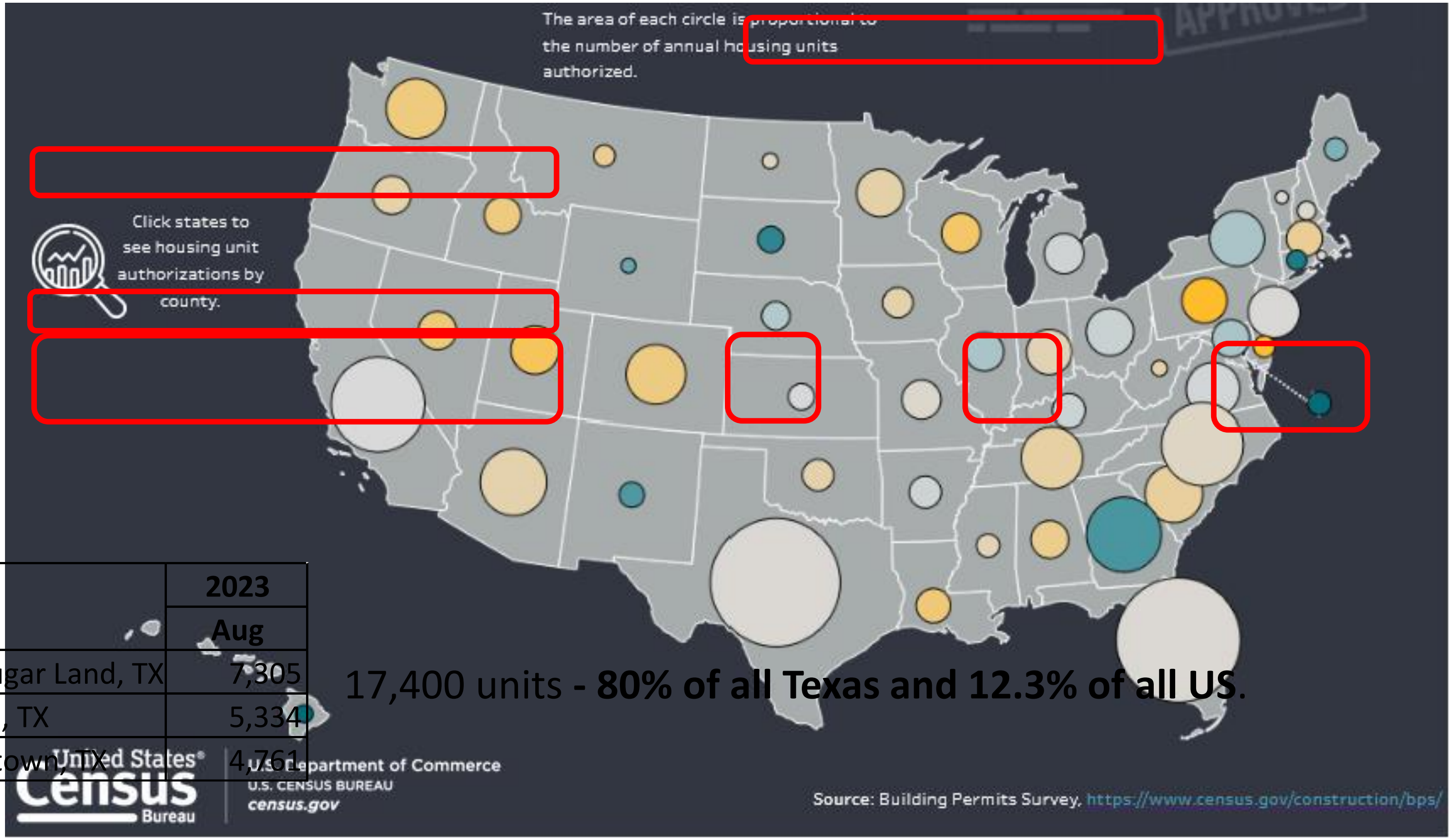


Texas – Fact Sheet

Cities	Population Metro area	Pop. growth (past 10 yrs)	Household growth (5 yrs)	$ Median House prices	Power Outages'08-'17	Small Building Rooftop Solar Potential in MW:
Austin	2.42 M					
Houston	7.34 M					
Dallas	7.94 M					
San Antonio	2.65M					
US Average	-					

Texas – Fact Sheet

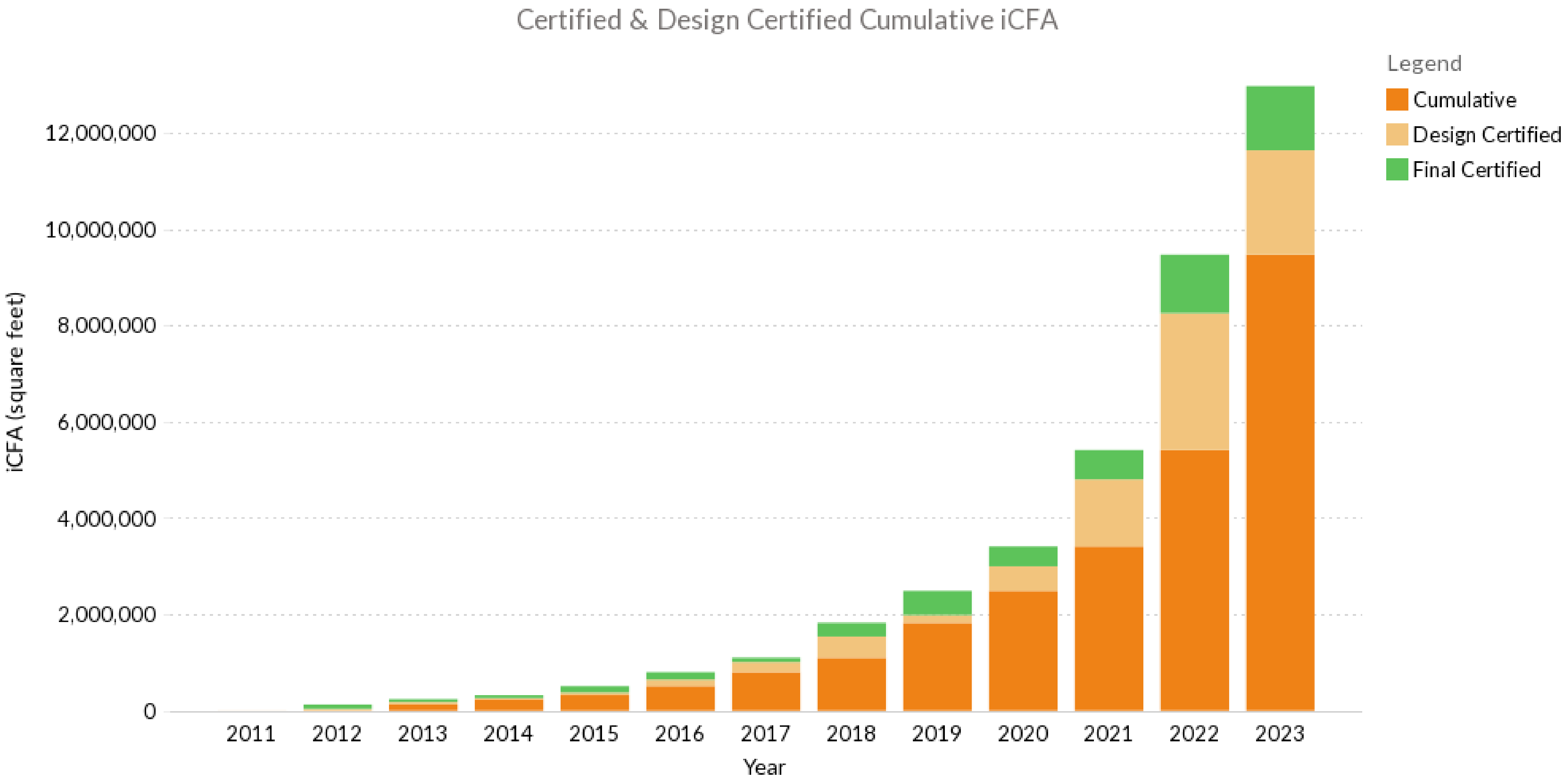
Annual **New Privately Owned Housing Units** Authorized by State:



Permits	2023
	Aug
Houston-The Woodlands-Sugar Land, TX	7,305
Dallas-Fort Worth-Arlington, TX	5,334
Austin-Round Rock-Georgetown, TX	4,761

17,400 units **- 80% of all Texas and 12.3% of all US**.

Certification Growth



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Certification Growth

Certification Growth

- Final Certified
  - Theresa Passive House; Single-Family Addition 2A, 2218 sq. ft. (Austin)
  - Casa La Vista, Single-Family New Construction 2A 2990 sq. ft. (Spicewood)
  - Blaise House, Single-Family Retrofit 2A, 1473 sq. ft. (Austin)

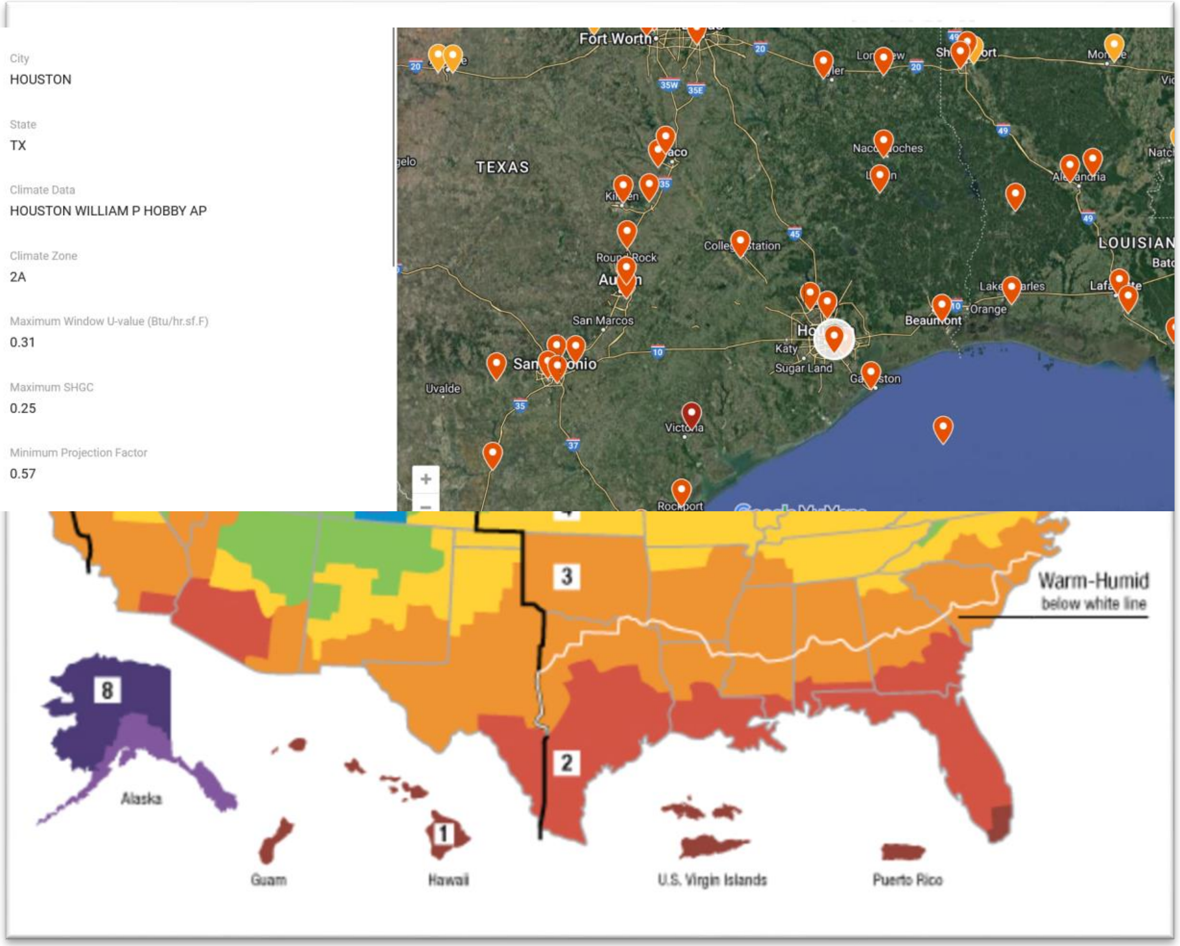
- Design Certified
  - Abbate House, Single-Family New Construction 2A, 1130 sq. ft. (Austin)

- Registered
  - Lareina Guesthouse, Single-Family New Construction 2A, 1033 sq. ft. (Austin)
  - 1118 W 7th, Single-Family New Construction 2A, 5000 sq. ft. (Austin)
  - Clutch City, Multi Family (Jesse Hunt) New Construction 2A, 4674 sq. ft. (Houston)
  - Raimer Guest House, Single-Family New Construction 3A, 898 sq. ft. (Celeste)
  - Ocean Front Villas, Single-Family New Construction 2A, (Galveston)
  - Kananbatch Residence, Single-Family New Construction 2399 sq. ft. (Porter)
  - Positive Impact Homes, Single-Family New Construction 2500 sq. ft. (Santa Fe)

- Application: 3 Projects

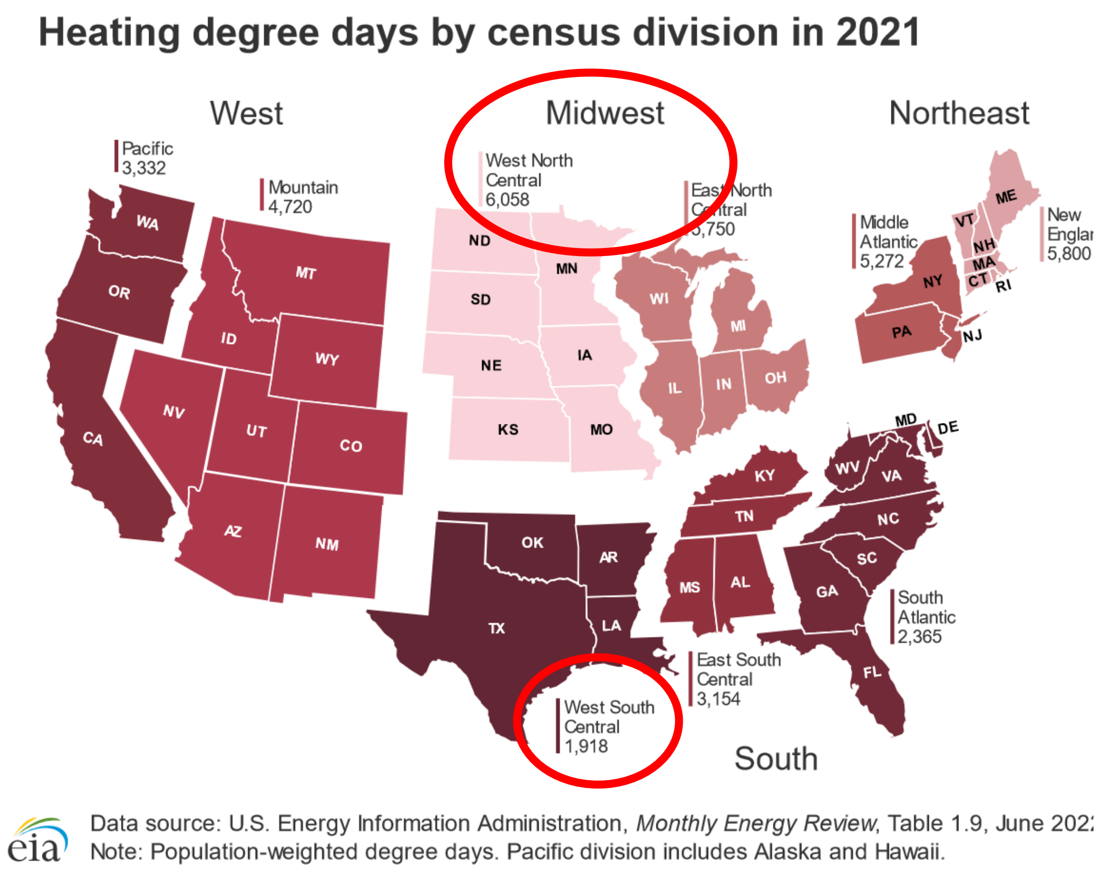
Hot and Humid Texas

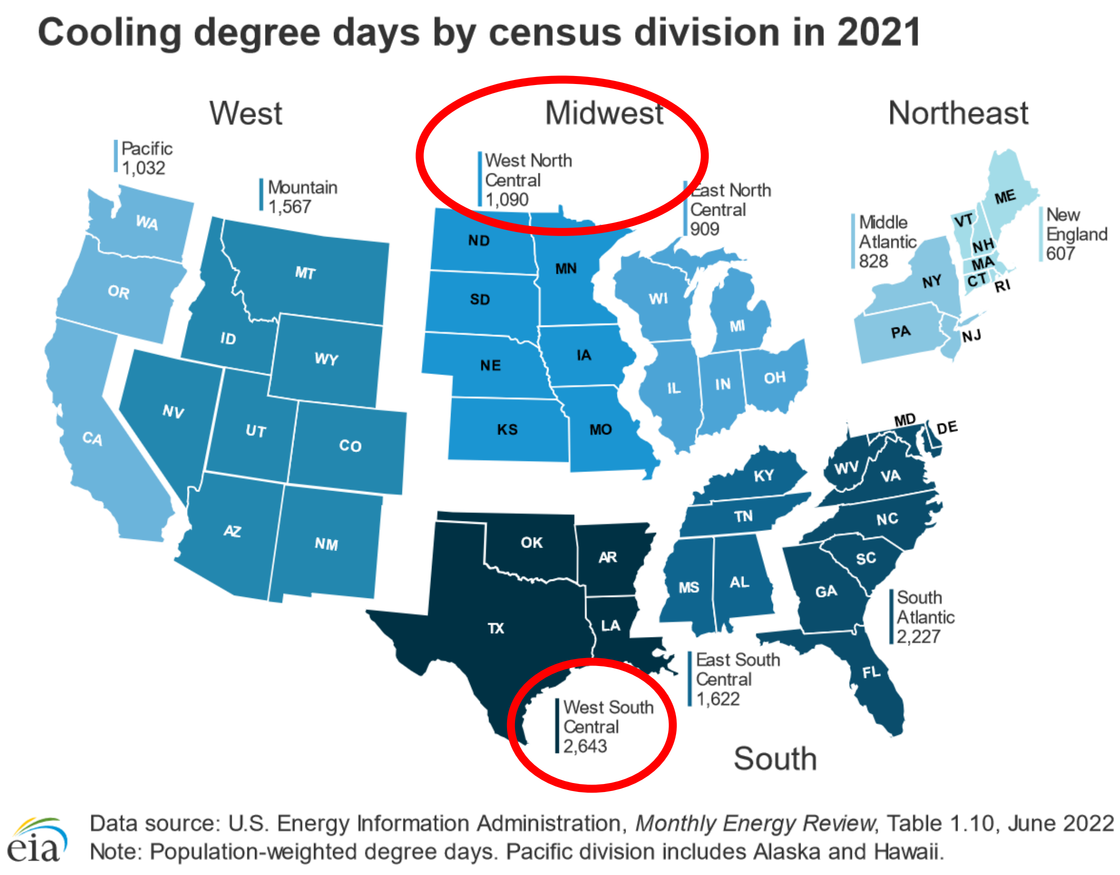
- Houston, TX



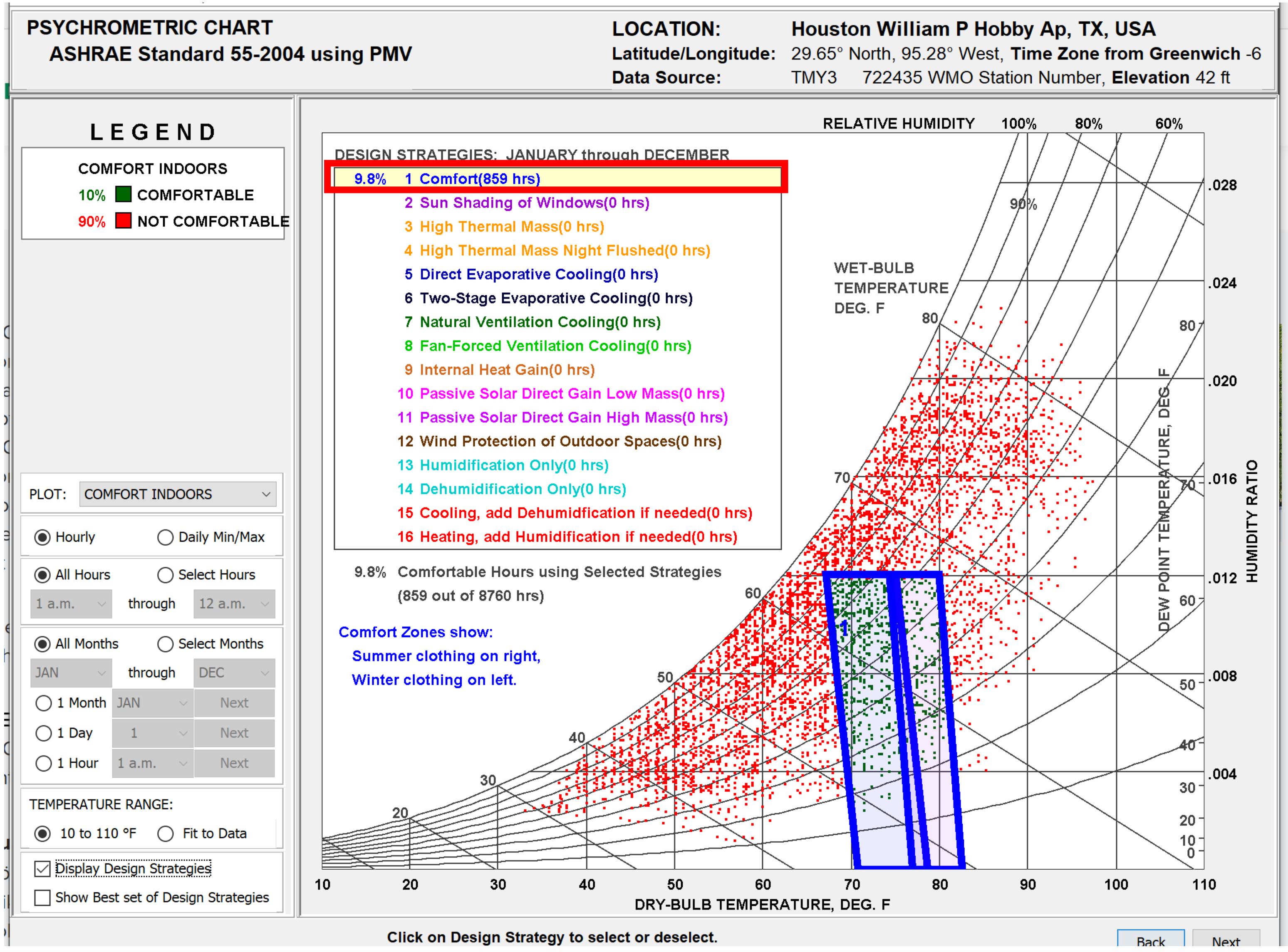
Hot and Humid Texas

- Houston, TX

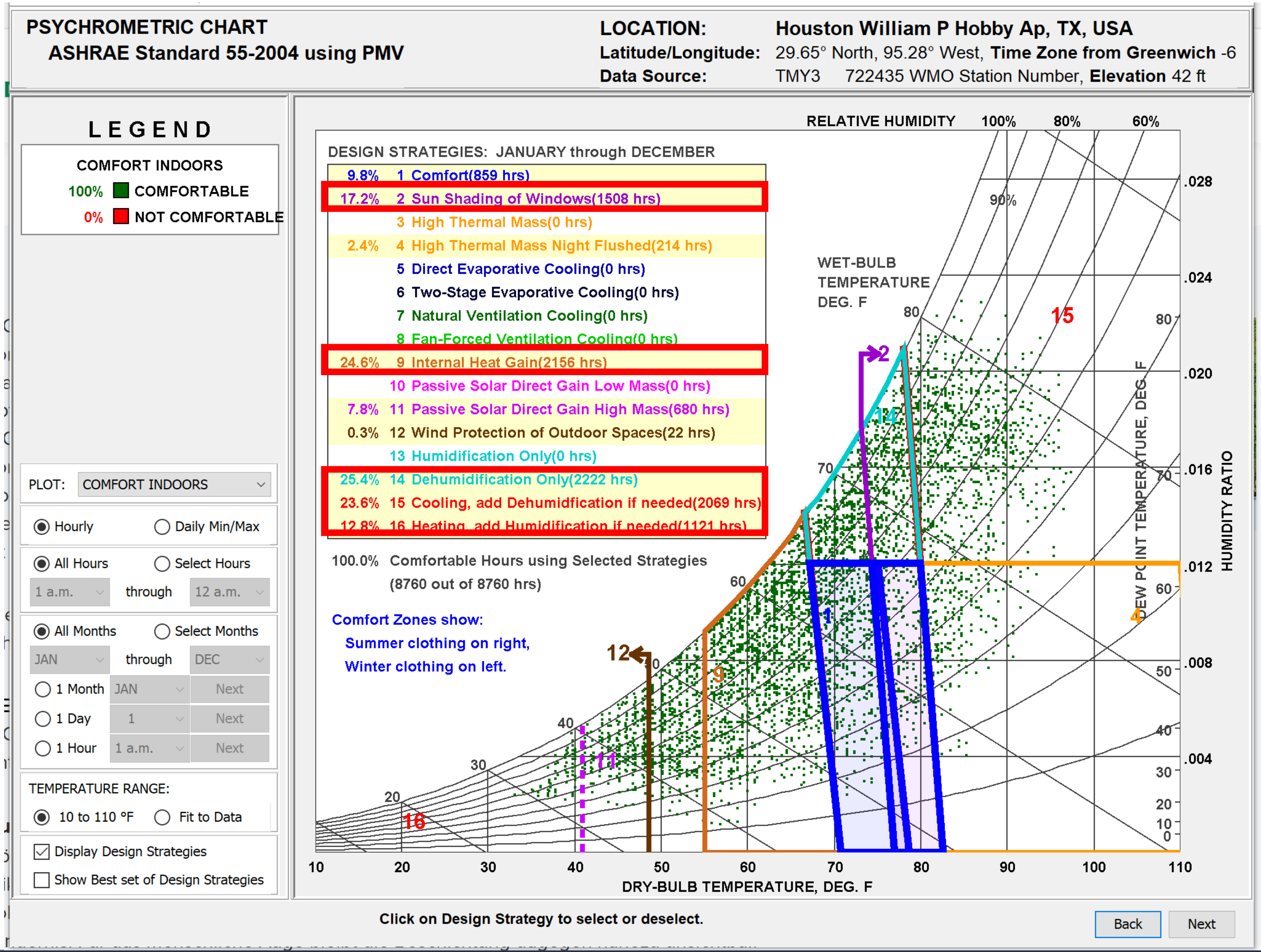


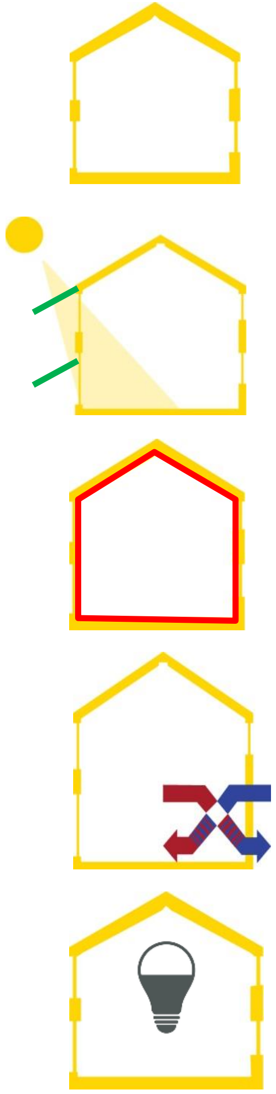


Hot and Humid Texas



Hot and Humid Texas





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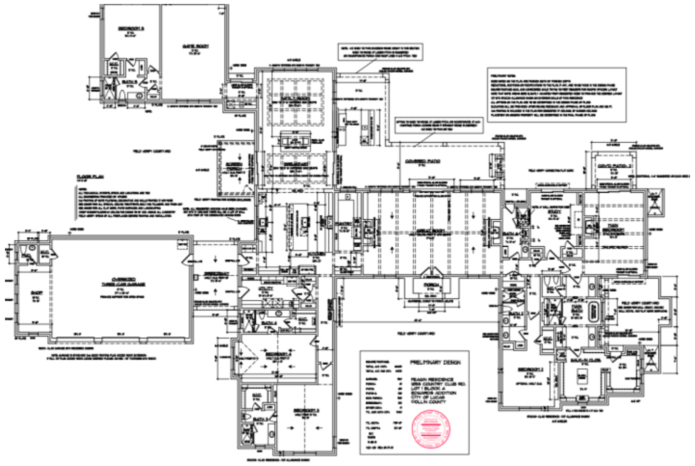
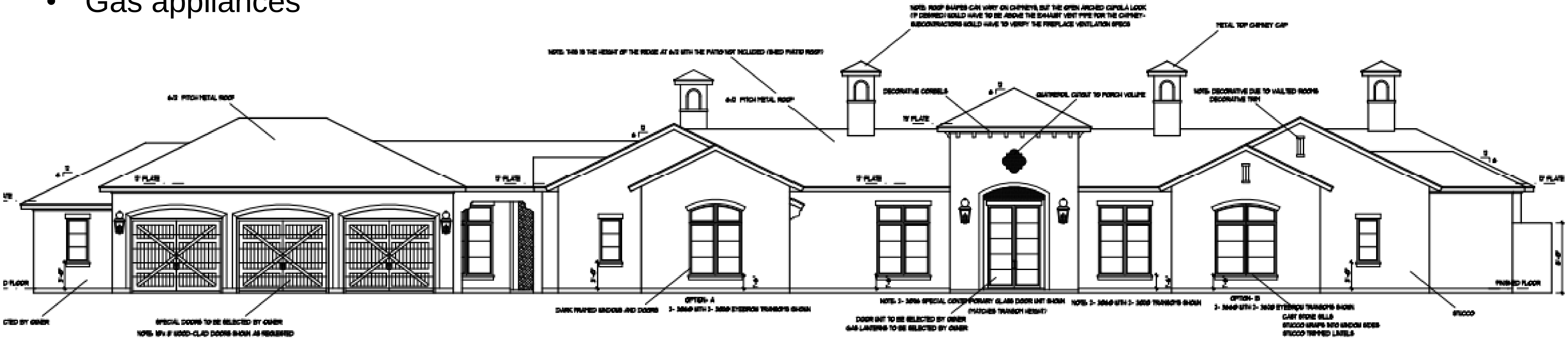
Texas Building Typologies

“Everything is bigger in Texas”

- Single Family 1 Story
- ~ 6000 sq ft
- 5 bed/7 bath
- 3 car garage
- Large envelope size and multiple wings
- Distributed nature of hot water use
- Combustion safety – 5 fireplaces
- Gas appliances





Phius 2021 – Prescriptive

Houston

5	Thermal Enclosure			
5.1.1a	Fenestration / Openings	Maximum Whole U-Value	0.31	(BTU/h.ft^2.°F)
5.1.1b	Walls & Overhang Floors - Effective R-value	Minimum Effective R-Value	23	(ft^2.°F.h/BTU)
5.1.1c	Roofs / Ceilings	Minimum Effective R-Value	53	(ft^2.°F.h/BTU)
5.1.1d	Whole Slab Foundations, Below-Grade Walls, Floors of Conditioned Basements & Crawl Spaces	Minimum Effective R-Value	8	(ft^2.°F.h/BTU)
5.1.1e	Ceilings of Unconditioned Basements or Crawl Spaces & Pier and Beam Floors	Minimum Effective R-Value	13	(ft^2.°F.h/BTU)

Austin

5	Thermal Enclosure			
5.1.1a	Fenestration / Openings	Maximum Whole U-Value	0.26	(BTU/h.ft^2.°F)
5.1.1b	Walls & Overhang Floors - Effective R-value	Minimum Effective R-Value	25	(ft^2.°F.h/BTU)
5.1.1c	Roofs / Ceilings	Minimum Effective R-Value	55	(ft^2.°F.h/BTU)
5.1.1d	Whole Slab Foundations, Below-Grade Walls, Floors of Conditioned Basements & Crawl Spaces	Minimum Effective R-Value	9	(ft^2.°F.h/BTU)
5.1.1e	Ceilings of Unconditioned Basements or Crawl Spaces & Pier and Beam Floors	Minimum Effective R-Value	14	(ft^2.°F.h/BTU)

Dallas

5	Thermal Enclosure			
5.1.1a	Fenestration / Openings	Maximum Whole U-Value	0.24	(BTU/h.ft^2.°F)
5.1.1b	Walls & Overhang Floors - Effective R-value	Minimum Effective R-Value	26	(ft^2.°F.h/BTU)
5.1.1c	Roofs / Ceilings	Minimum Effective R-Value	56	(ft^2.°F.h/BTU)
5.1.1d	Whole Slab Foundations, Below-Grade Walls, Floors of Conditioned Basements & Crawl Spaces	Minimum Effective R-Value	9	(ft^2.°F.h/BTU)
5.1.1e	Ceilings of Unconditioned Basements or Crawl Spaces & Pier and Beam Floors	Minimum Effective R-Value	14	(ft^2.°F.h/BTU)

San Antonio

5	Thermal Enclosure			
5.1.1a	Fenestration / Openings	Maximum Whole U-Value	0.28	(BTU/h.ft^2.°F)
5.1.1b	Walls & Overhang Floors - Effective R-value	Minimum Effective R-Value	24	(ft^2.°F.h/BTU)
5.1.1c	Roofs / Ceilings	Minimum Effective R-Value	54	(ft^2.°F.h/BTU)
5.1.1d	Whole Slab Foundations, Below-Grade Walls, Floors of Conditioned Basements & Crawl Spaces	Minimum Effective R-Value	8	(ft^2.°F.h/BTU)
5.1.1e	Ceilings of Unconditioned Basements or Crawl Spaces & Pier and Beam Floors	Minimum Effective R-Value	13	(ft^2.°F.h/BTU)

Positive Impact Homes

- Single Family 1 story
- Sqft: approx. 2,500
- Project Status: Permitting
- Positive Impact Homes

POSITIVE IMPACT HOMES
FOR VETERANS BATTLING PTSD & SPECIAL NEEDS

Images by Stella Maris Architecture

Positive Impact Homes: Criteria vs Results

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Phius 2021
Performance Criteria Calculator v3.2

UNITS:	IMPERIAL (IP)
BUILDING FUNCTION:	RESIDENTIAL
PROJECT TYPE:	NEW CONSTRUCTION
STATE/ PROVINCE	TEXAS
CITY	HOUSTON WILLIAM P HC

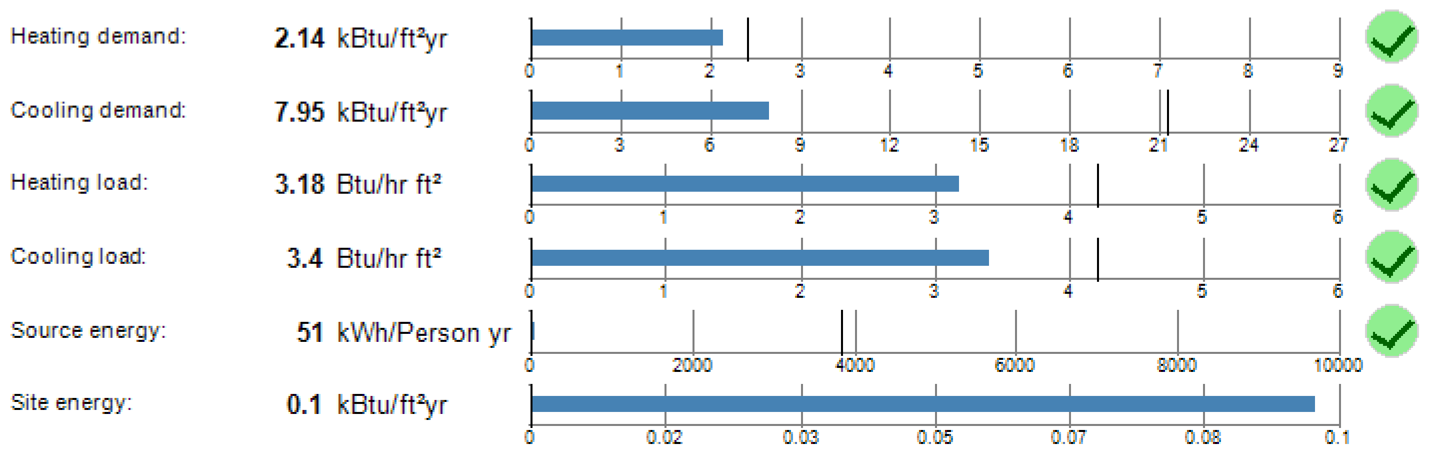
Envelope Area (ft²)	12,905.6
iCFA (ft²)	3,200.0
Dwelling Units (Count)	1
Total Bedrooms (Count)	4

Space Conditioning Criteria

Annual Heating Demand	2.8	kBtu/ft²yr
Annual Cooling Demand	19.3	kBtu/ft²yr
Peak Heating Load	3.2	Btu/ft²hr
Peak Cooling Load	4.2	Btu/ft²hr

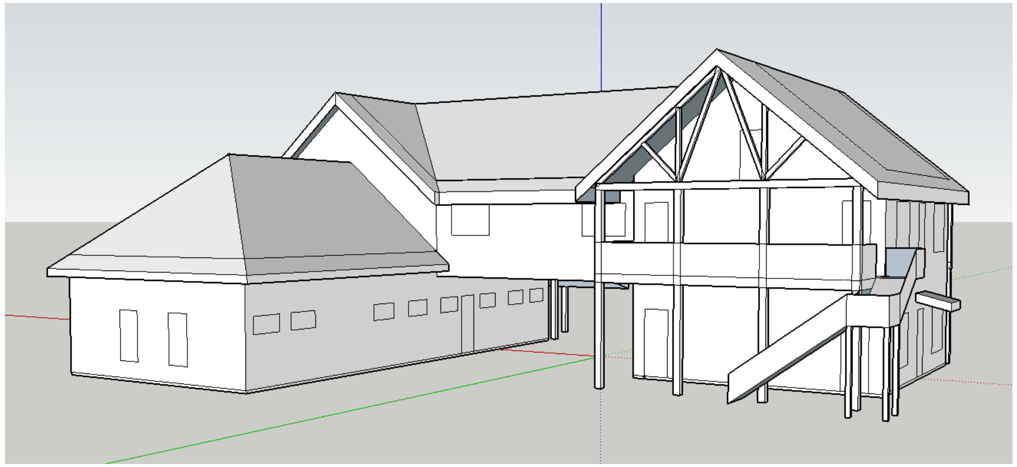
Source Energy Criteria

Phius CORE	5000	kWh/person.yr
Phius ZERO	0	kWh/person.yr



Palm Street Development

- Two Unit Residence
- Sqft: Unit 1 1,950; Unit 2 3,600
- Project Status: Permitting
- SunRoof USA PV System offering 24.96 kWp (29.6k lbs/yr CO_2 reduction)
- Emphasis on carbon neutral, energy positive construction practices
- Bridge above easement that connects the two residences
- Two additional 1st floor bedrooms w/ exterior entrances



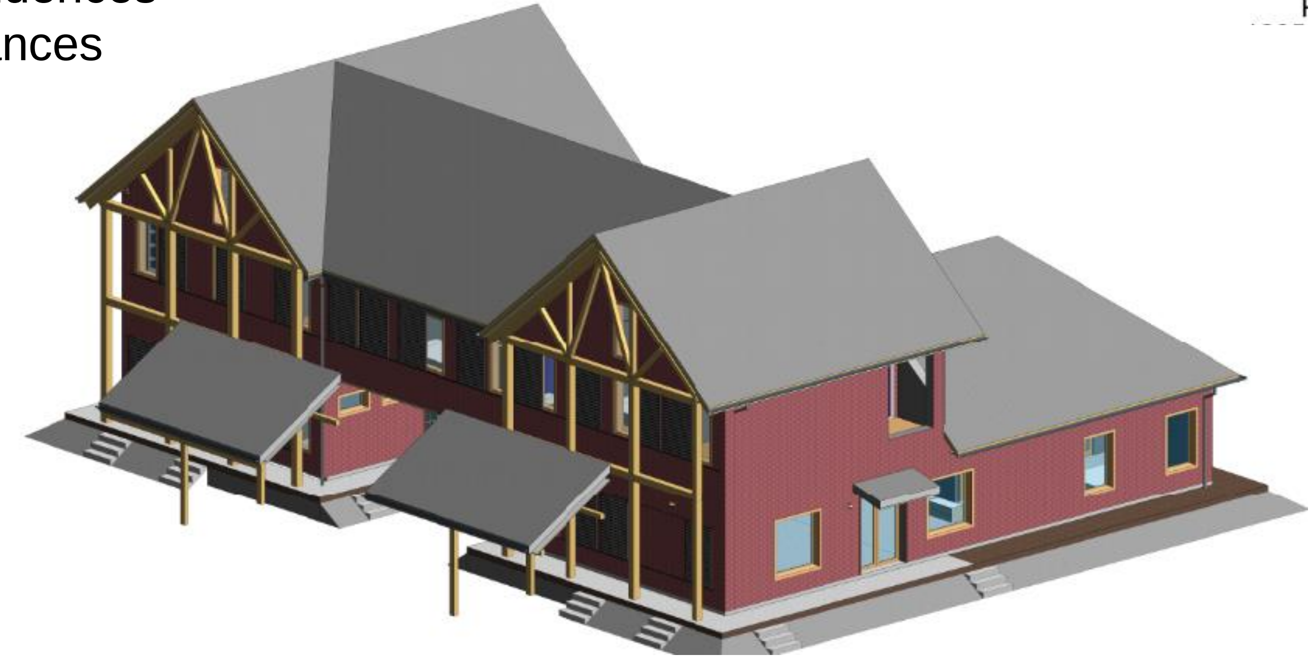


Image courtesy of Mint Homes / Raj Development Corporation

Palm Street: Criteria vs Results

Phius 2021
Performance Criteria Calculator v3.2

UNITS:	IMPERIAL (IP)
BUILDING FUNCTION:	RESIDENTIAL
PROJECT TYPE:	NEW CONSTRUCTION
STATE/ PROVINCE	TEXAS
CITY	HOUSTON WILLIAM P HC

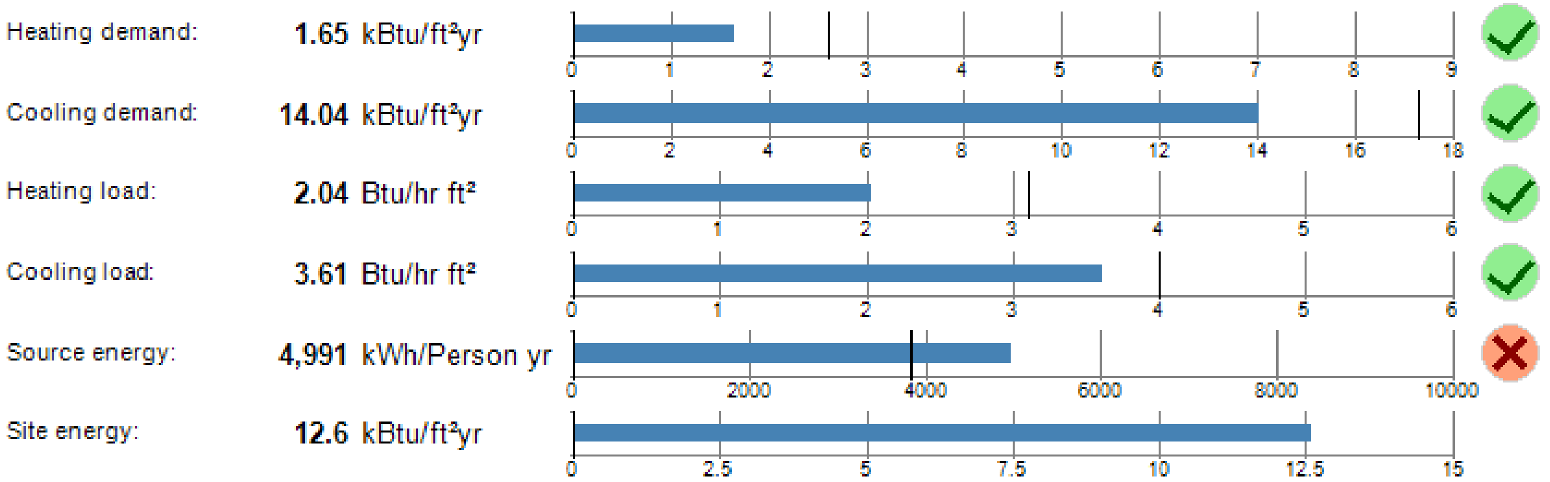
Envelope Area (ft²)	16,032.0
iCFA (ft²)	5,254.0
Dwelling Units (Count)	2
Total Bedrooms (Count)	5

Space Conditioning Criteria

Annual Heating Demand	2.7	kBtu/ft²yr
Annual Cooling Demand	19.1	kBtu/ft²yr
Peak Heating Load	3.1	Btu/ft²hr
Peak Cooling Load	4.1	Btu/ft²hr

Source Energy Criteria

Phius CORE	5600	kWh/person.yr
Phius ZERO	0	kWh/person.yr



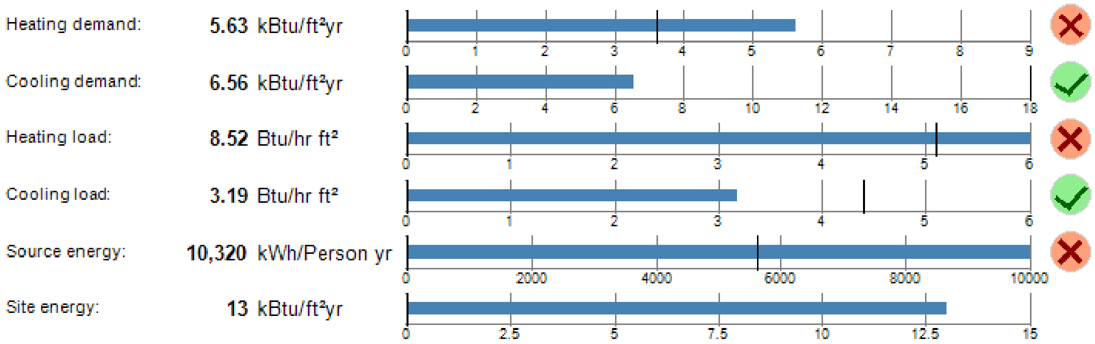
Austin Development

- Single Family 1 Story
- Sqft: Unit 1 9,600
- Project Status: Construction Documents
- Windows and Air Tightness (acc. ASTM E283 @75Pa – Industry standard limits is at 0.3cfm/sq.ft.)
  - **Casements**: Results between 0.03 cfm/sq.ft. - 0.06 cfm/sq.ft – manufacturer lists 1.1 cfm/sq.
  - **Double Hung**: Results between 0.1 - 0.24 cfm/sq.ft.
- Cost Effectiveness

Austin Development

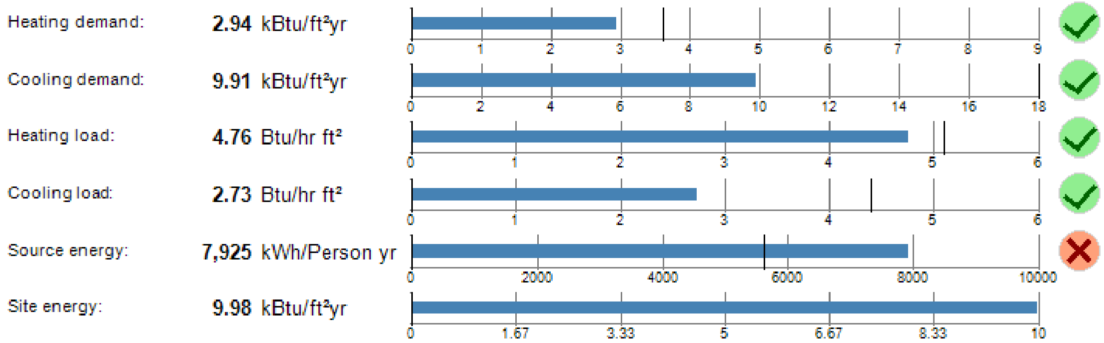
	Climate Zone	Fenestration U-Factor[b, i]	Skylight[b] U-Factor	Glazed Fenestration SHGC[b, e]	Ceiling R-Value	Wood Frame Wall R-Value[g]	Mass Wall R-Value[h]	Floor R-Value	Basement[c,g] Wall R-Value	Slab[d] R-Value & Depth	Crawl Space[c,g] Wall R-Value
IECC 2021	2	0.40	0.65	0.25	49	13 or 0& 10ci	4/6	13	0	0	0
Austin TX Code Compliant (ish)		0.25	0.25	.25 cog	38	18.1	n/a	n/a	n/a	.42	n/a
Austin TX Optimum (ish)		0.25	0.25	.25 cog	49	24.3	n/a	n/a	n/a	4.42	n/a

Austin TX Code Compliant (ish)



Air Infiltration Limit:
0.215 cfm_{50}/ft^2
3.00 ACH_{50}

Austin TX Optimum (ish)



Air Infiltration Limit:
0.06 cfm_{50}/ft^2
0.83 ACH_{50}

Austin Development

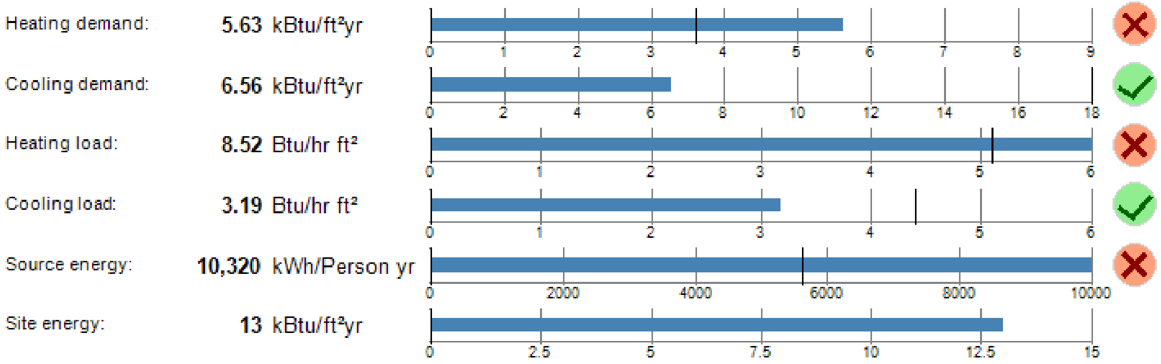
Assembly	Case 1 Minimum
Slab	Uninsulated 4” Concrete Slab = R 0.42
Walls	R13 (2x4 w/ Batt Insulation)
Roof	R38 (Not including framing)
Windows	U-Value 0.4 BTU/ft^2 h F SHGC 0.25
Airtightness	ACH50: 5 per hour CFM50: 0.36 per ft^2 (Envelope Area)

	Case 1
Energy Use	38993.07 kWh
Energy Cost (Monthly in $)	$454.92
PV Required for Zero	39,000 kWh
Estimated DC System Size	26.4 kW
Estimated Number of Panels	72

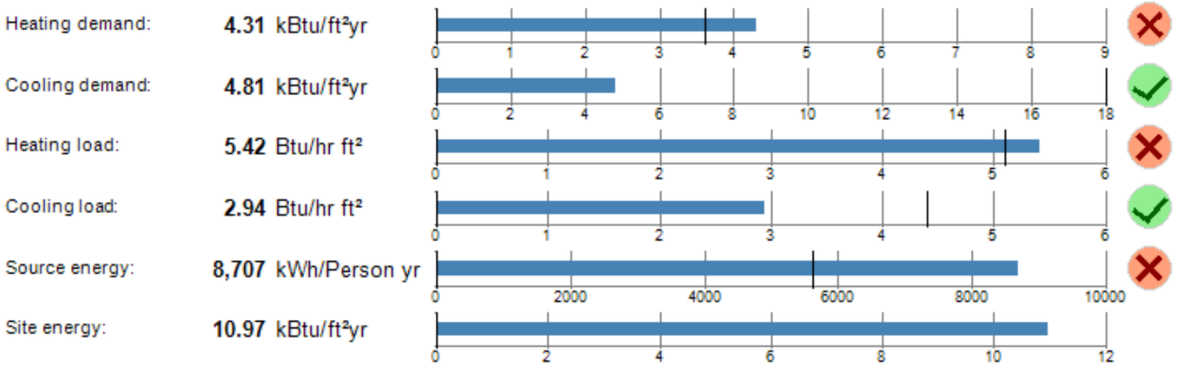
Austin Development

	CLIMATE ZONE	FENESTRATION *U*-FACTOR[b, i]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE[g]	MASS WALL *R*-VALUE[h]	FLOOR *R*-VALUE	BASEMENT[c,g] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c,g] WALL *R*-VALUE
IECC 2021	2	0.40	0.65	0.25	49	13 or 0& 10ci	4/6	13	0	0	0
Austin TX Code Compliant (ish)		0.25	0.25	.25 cog	38	18.1	n/a	n/a	n/a	.42	n/a

Air Infiltration Limit:
0.215 cfm_{50}/ft^2
3.00 ACH_{50}



Air Infiltration Limit:
0.06 cfm_{50}/ft^2
0.83 ACH_{50}



Energy savings due to Air Tightness: 5376 kwh/year of site energy

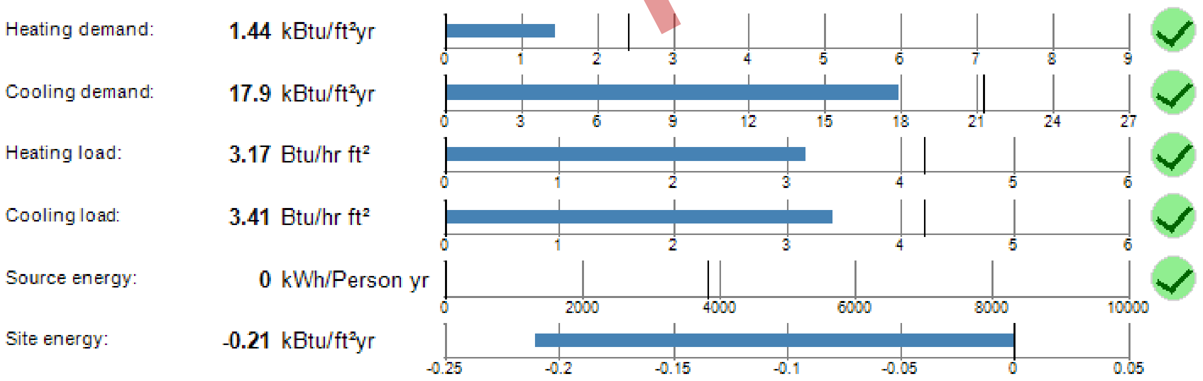
Results in a 15.6% energy savings for the building and a cost savings of $806.40/year or $67.20/month @ $0.15/kwh

Slab Insulation

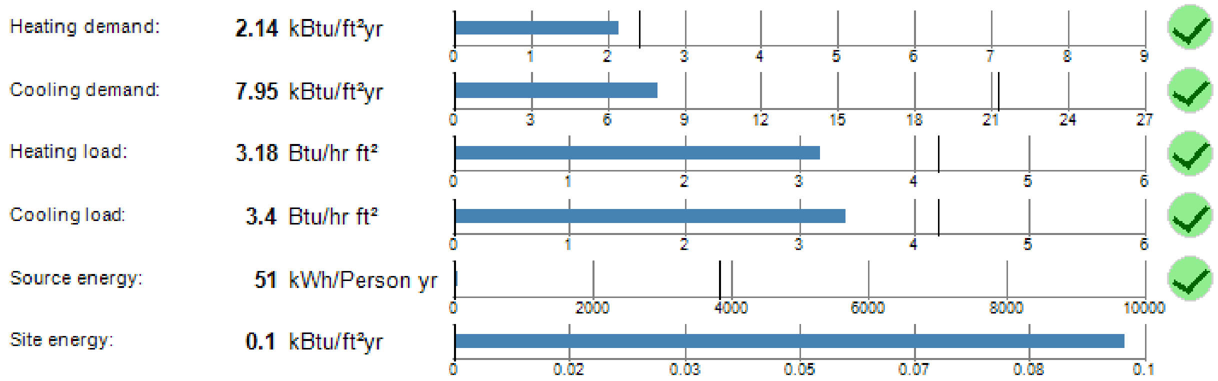
- In many cases, insulation continuous under the slab is not required or even recommended.
- There are some cases where approximately R-8 would provide meaningful results.
  See Phius Prescriptive Requirements

- Situations where this is the case:
  1. Where the building has lower internal and solar gains (benefits less from free ground contact)
  2. In climates where the ground temperature is lower
     *For example: Houston vs Dallas

Positive Impact Homes: With R8 Slab Insulation



Positive Impact Homes: Without Slab Insulation



Slab Insulation Revisited

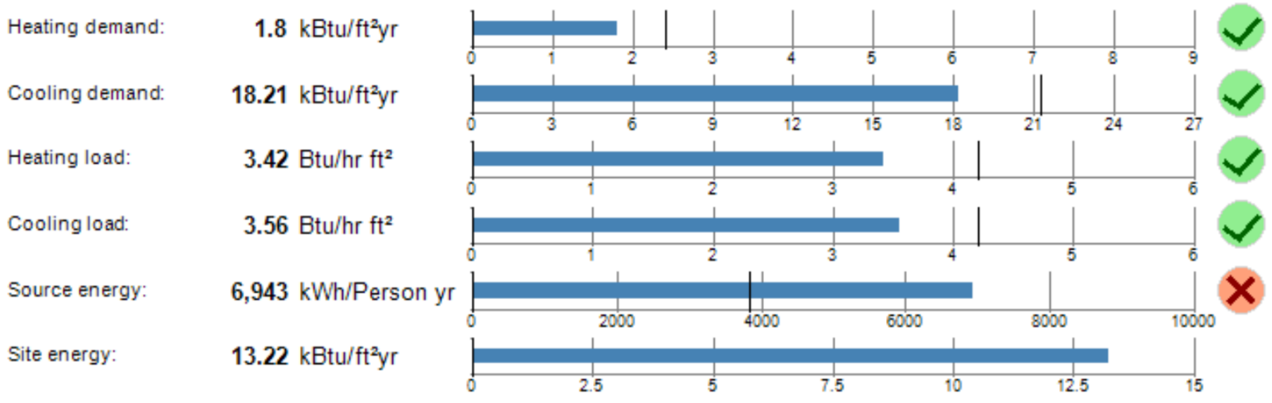
What happens when a slab is insulated?

Heat loss through the slab is reduced

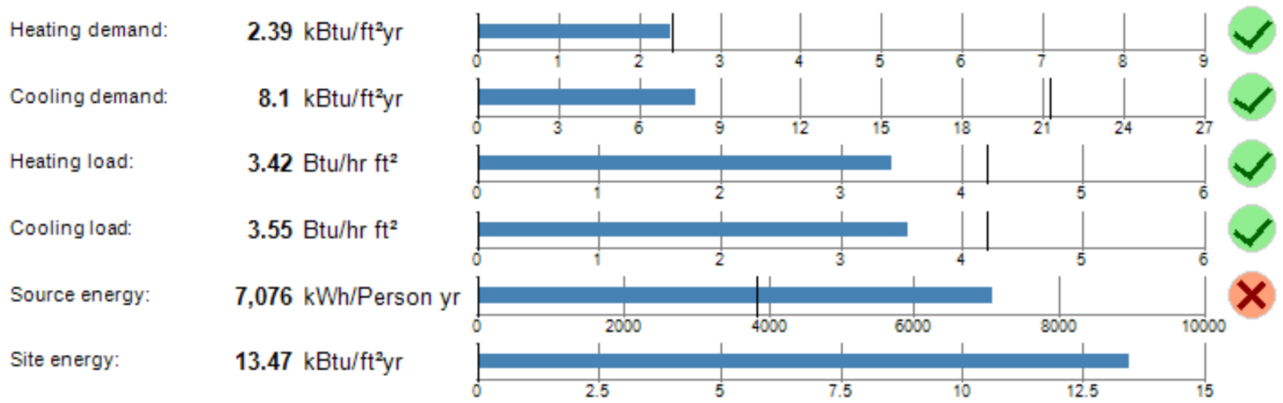
- In the winter, this heat loss to the ground adds to the heating demand
- In the summer, this heat loss to the cool ground is beneficial

These effects can look balanced!
Note the relative similarity between the source energy in kwh.

Positive Impact Homes: With R4 Slab Insulation



Positive Impact Homes: Without Slab Insulation



Slab Insulation: Austin

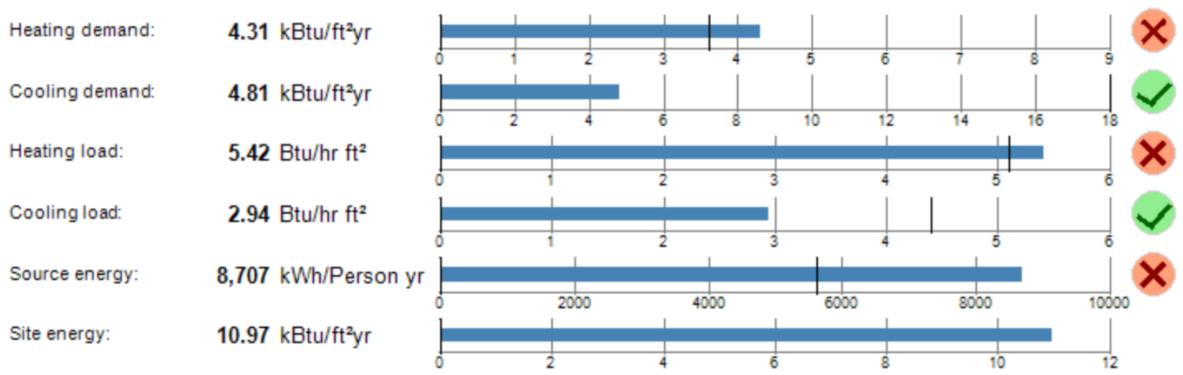
IECC 2021

CLIMATE ZONE	FENESTRATION U-FACTOR[b, i]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE[g]	MASS WALL R-VALUE[h]	FLOOR R-VALUE	BASEMENT[c,g] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c,g] WALL R-VALUE
2	0.40	0.65	0.25	49	13 or 0& 10ci	4/6	13	0	0	0

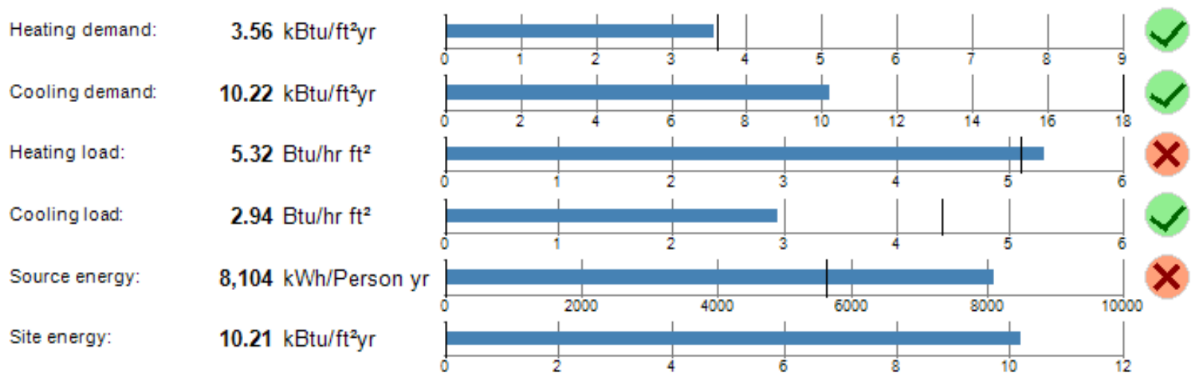
Baseline:
Slab R = .42
Wall R = 18.1
Roof R = 38
Slab Per. = R5, 2'

Window U = 0.25
Window SHGC= 0.25
Airtightness = 0.06 cfm_{50}/ft^2

Slab R-Value: None (.42)



Slab R-Value: 4.42



Energy savings due to increased R-value: 2007.8 kwh/year of site energy

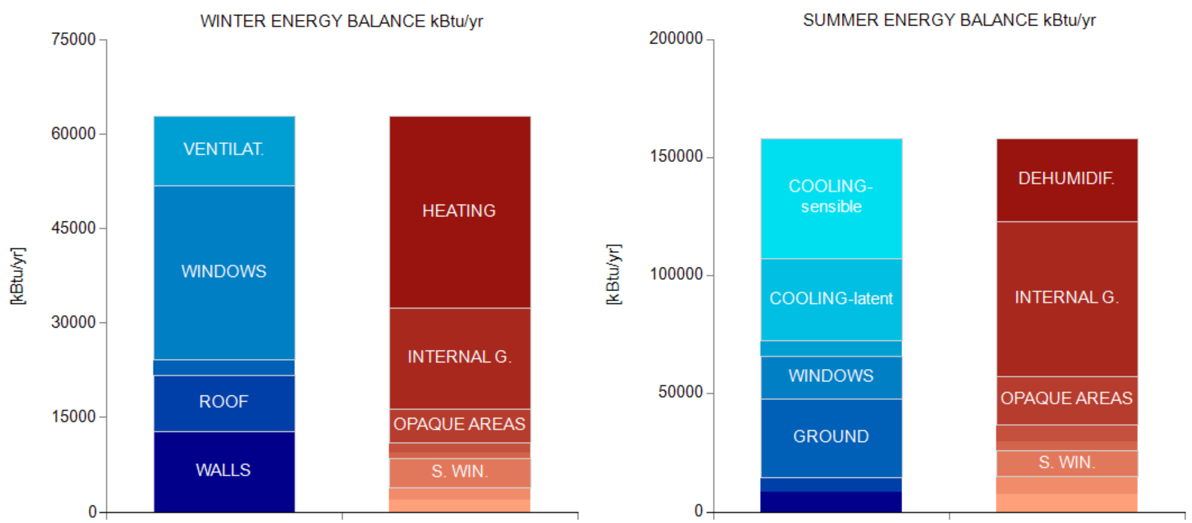
Results in a 6.92% energy savings for the building and a cost savings of $301.17/year or $25.10/month @ $0.15/kwh

Slab Insulation

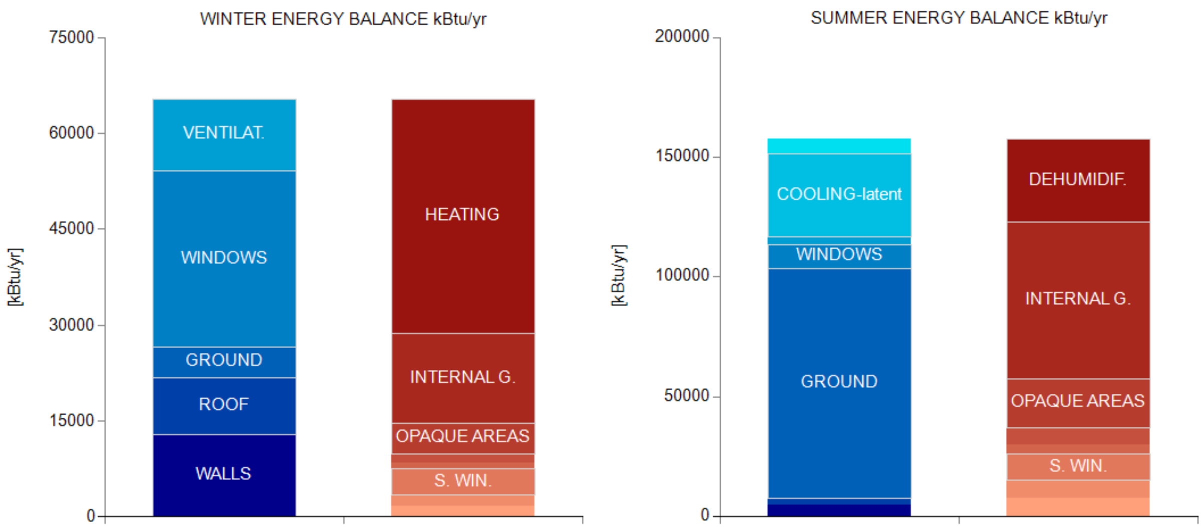
What happens when a slab is insulated?

Heat loss through the slab is reduced

- In the winter, this heat loss to the ground adds to the heating demand
- In the summer, this heat loss to the cool ground is beneficial
- The heat loss to the ground is sensible heat loss
- The latent heat demand stays the same, but sensible has been cut dramatically
- The demands are similar, but the efficiency of the mechanical system determines the annual source energy use!!



With R4 Slab Insulation

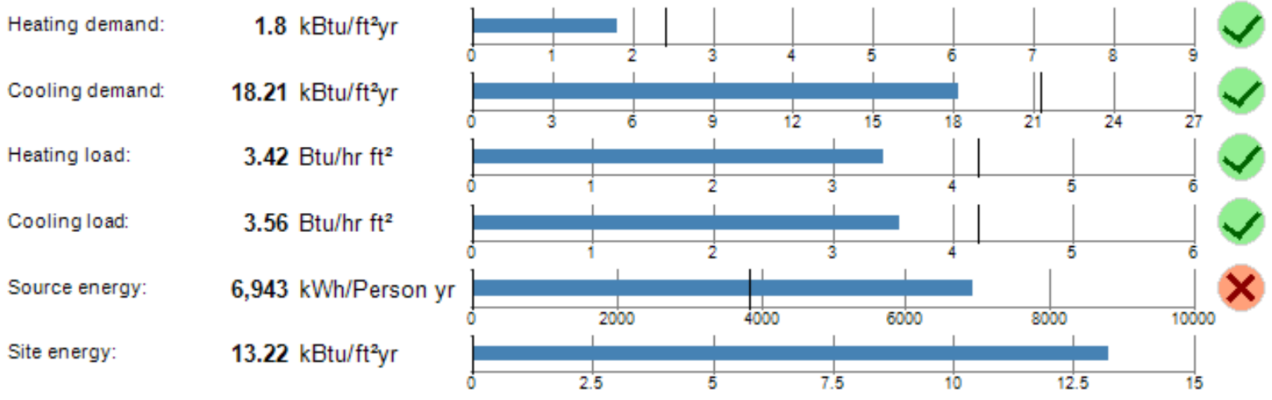


Without Slab Insulation

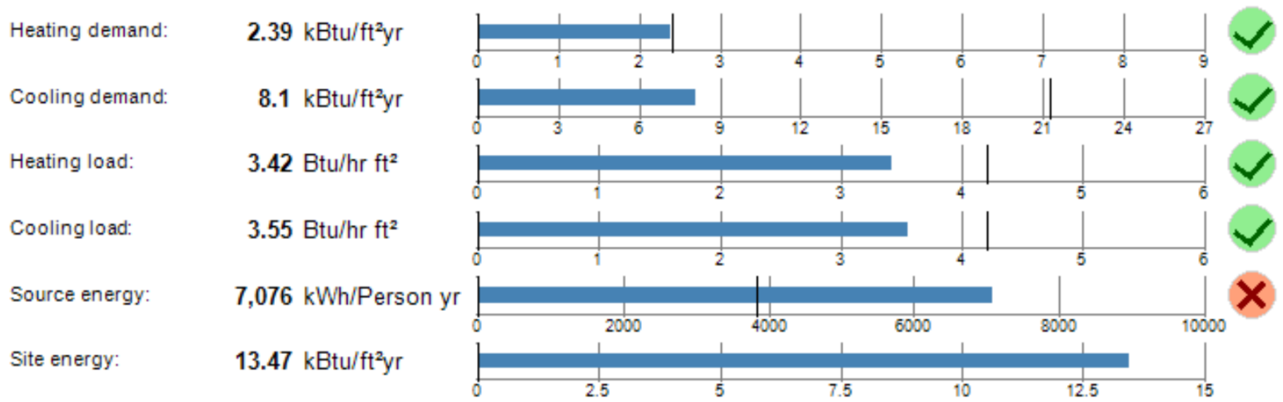
Slab Insulation Revisited

Dehumidification COP at 2

Positive Impact Homes: With R4 Slab Insulation

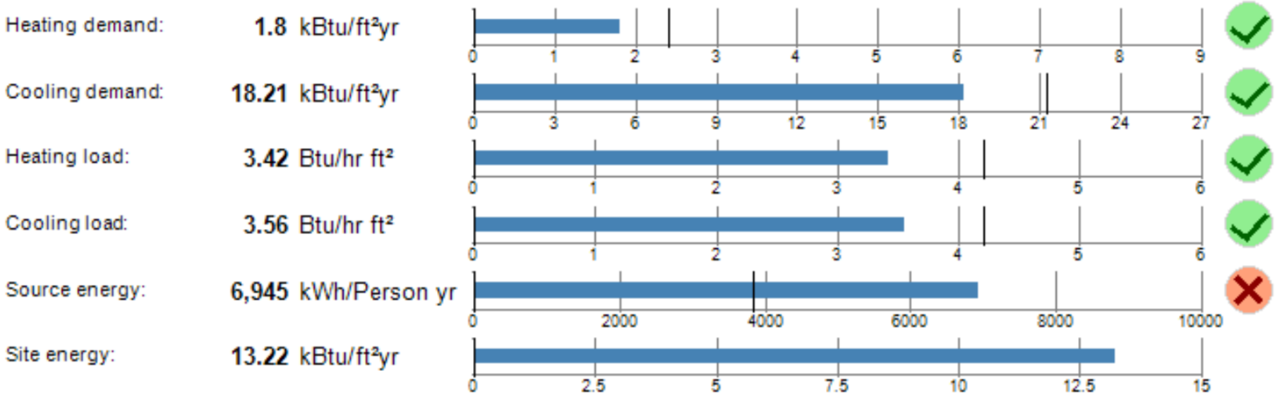


Positive Impact Homes: Without Slab Insulation

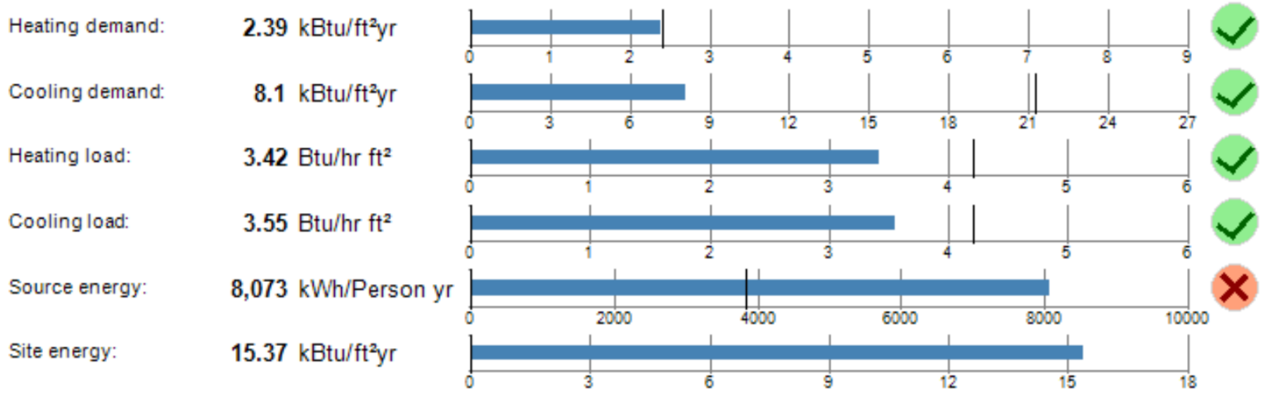


Dehumidification COP at 1.2

Positive Impact Homes: With R4 Slab Insulation



Positive Impact Homes: Without Slab Insulation



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Slab Insulation: Austin

IECC 2021

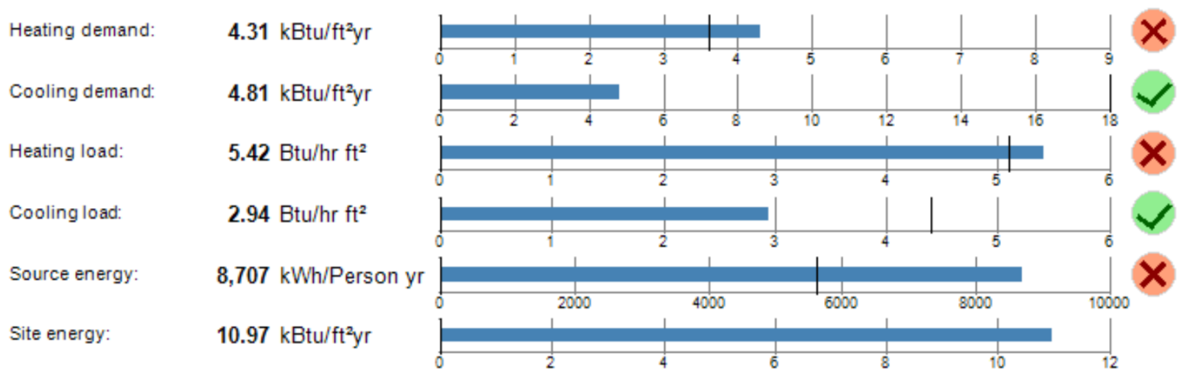
CLIMATE ZONE	FENESTRATION U-FACTOR[b, i]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE[g]	MASS WALL R-VALUE[h]	FLOOR R-VALUE	BASEMENT[c,g] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c,g] WALL R-VALUE
2	0.40	0.65	0.25	49	13 or 0& 10ci	4/6	13	0	0	0

Baseline:
Slab R = .42
Wall R = 18.1
Roof R = 38
Slab Per. = R5, 2'

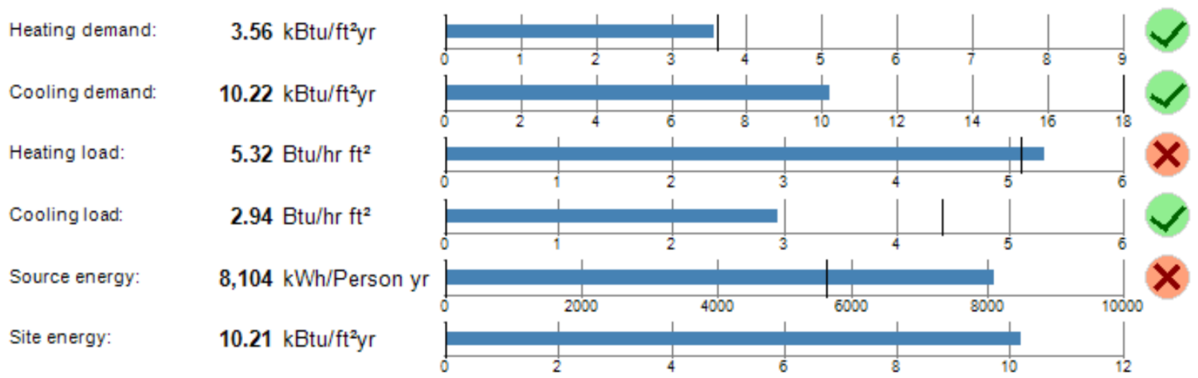
Window U = 0.25
Window SHGC= 0.25
Airtightness = 0.06 cfm_{50}/ft^2

Energy savings are due to substituting a COP of 1.2 for Dehumidification with a COP of 5.28 for Cooling

Slab R-Value: None (.42)



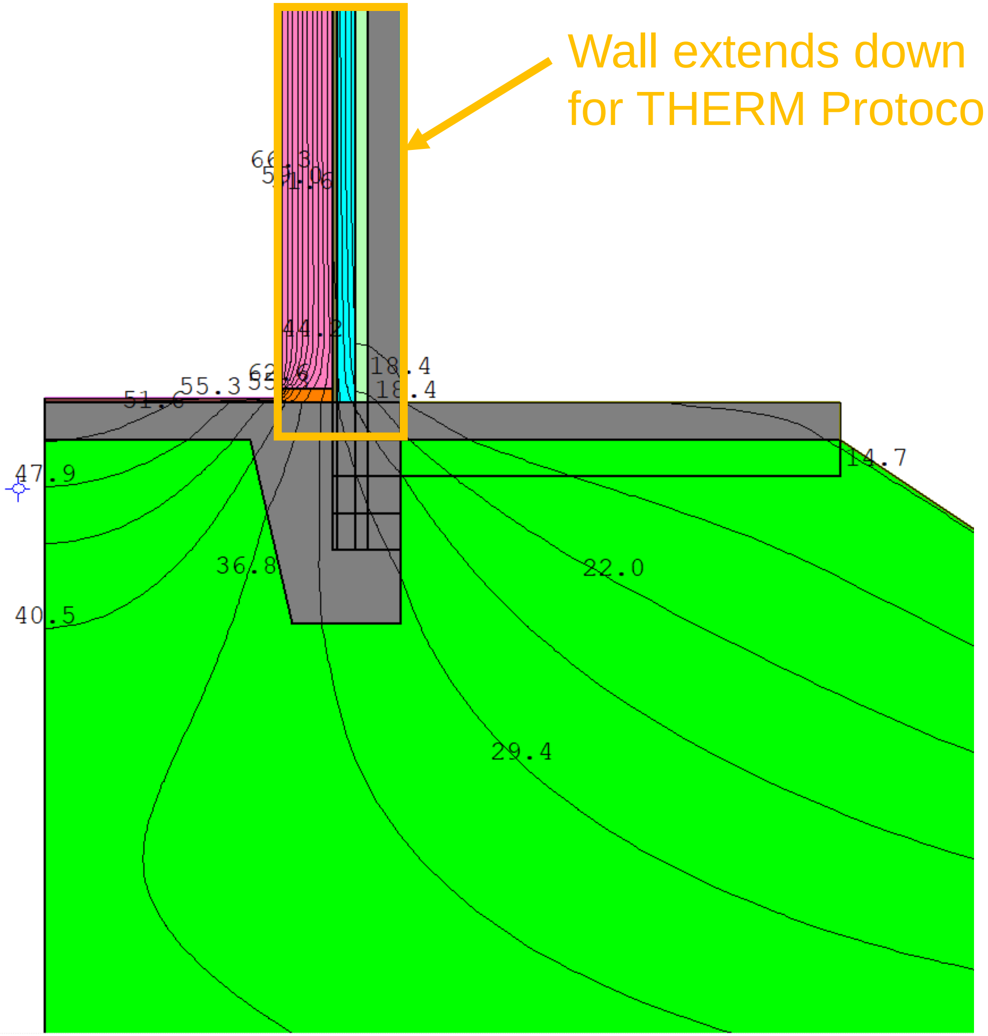
Slab R-Value: 4.42



Energy savings due to increased R-value: 2007.8 kwh/year of site energy

Results in a 6.92% energy savings for the building and a cost savings of $301.17/year or $25.10/month @ $0.15/kwh

Slab Insulation: Perimeter



Wall extends down for THERM Protocol

No Slab Edge Insulation

WHAT? / WHY!

- Uninsulated slabs have very little thermal resistance.
- The overlap of the wall and slab at the corner creates what is typically called double counting" of the heat loss, but in this case, it replaces concrete with additional insulation.

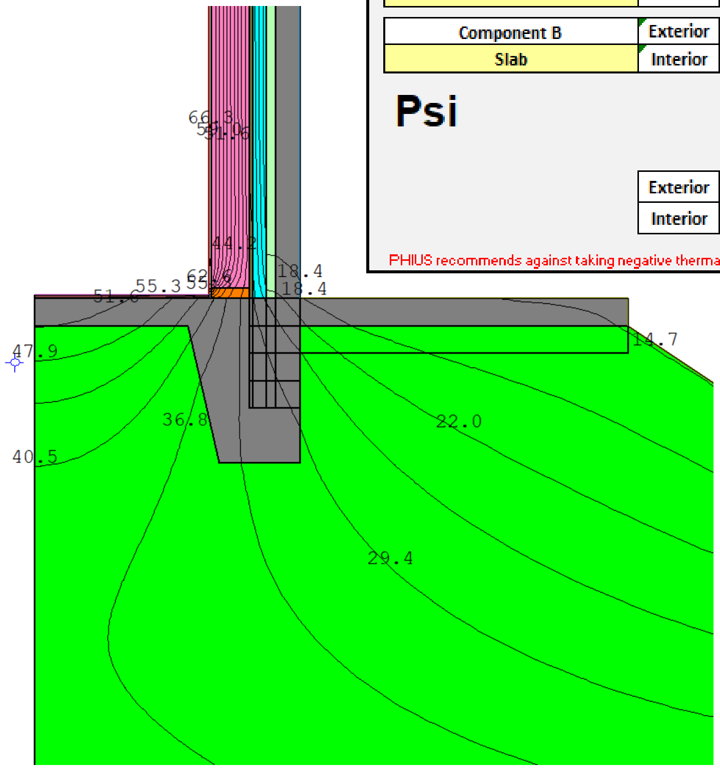
2D model		U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
	Exterior	0.016	54	468.27	33.72	3.36%
	Interior	0.1029	54	73.00	33.80	3.36%

Component		U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
Component A	Exterior	0.0282	54	52.00	6.60	0.00%
Wall	Interior	0.028	54.00	52.00	6.60	0.00%
Component B	Exterior	0.5823	27	39	51.10	1.36%
Slab	Interior	0.5823	27.00	39.00	51.10	1.36%

Psi	PsidT (btu/hr.ft)	dT (F)	Psi (btu/hr.ft.F)	Psi for WUFI (btu/hr.ft.F)
Exterior	-23.98	54.00	-0.444	-0.443
Interior	-23.89	54.00	-0.442	

PHIUS recommends against taking negative thermal bridges in the design phase. See Thermal Bridges section in Certification Guidebook.

Slab Insulation: Perimeter



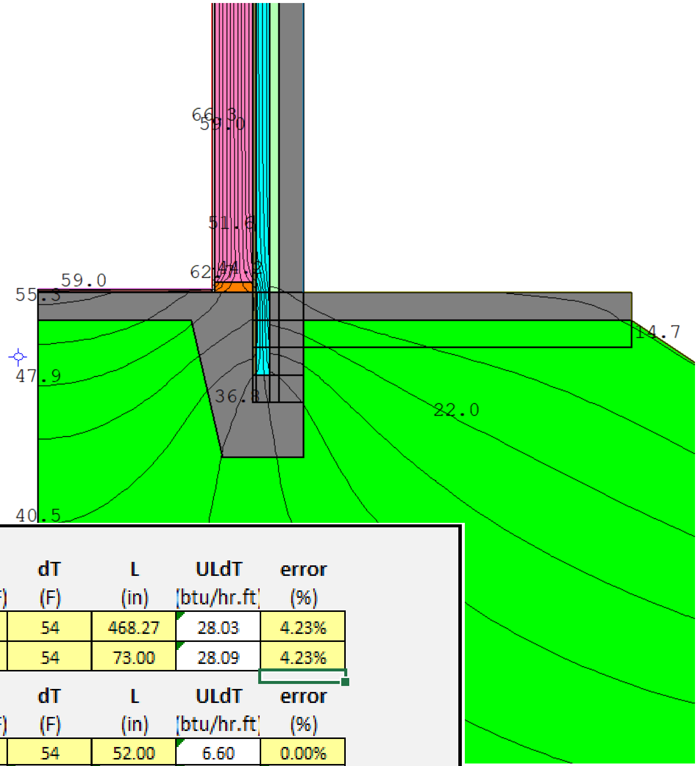
2D model		U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
	Exterior	0.016	54	468.27	33.72	3.36%
	Interior	0.1029	54	73.00	33.80	3.36%

Component		U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
Component A	Exterior	0.0282	54	52.00	6.60	0.00%
Wall	Interior	0.028	54.00	52.00	6.60	0.00%
Component B	Exterior	0.5823	27	39	51.10	1.36%
Slab	Interior	0.5823	27.00	39.00	51.10	1.36%

Psi	PsidT (btu/hr.ft)	dT (F)	Psi (btu/hr.ft.F)	Psi for WUFI (btu/hr.ft.F)
Exterior	-23.98	54.00	-0.444	-0.443
Interior	-23.89	54.00	-0.442	

PHIUS recommends against taking negative thermal bridges in the design phase. See Thermal Bridges section in Certification Guidebook.

No Slab Edge Insulation



2D model		U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
	Exterior	0.0133	54	468.27	28.03	4.23%
	Interior	0.0855	54	73.00	28.09	4.23%

Component		U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
Component A	Exterior	0.0282	54	52.00	6.60	0.00%
Wall	Interior	0.028	54.00	52.00	6.60	0.00%
Component B	Exterior	0.5823	27	39	51.10	1.36%
Slab	Interior	0.5823	27.00	39.00	51.10	1.36%

Psi	PsidT (btu/hr.ft)	dT (F)	Psi (btu/hr.ft.F)	Psi for WUFI (btu/hr.ft.F)
Exterior	-29.67	54.00	-0.549	-0.549
Interior	-29.61	54.00	-0.548	

PHIUS recommends against taking negative thermal bridges in the design phase. See Thermal Bridges section in Certification Guidebook.

2” CI Continued Down Past Slab Edge

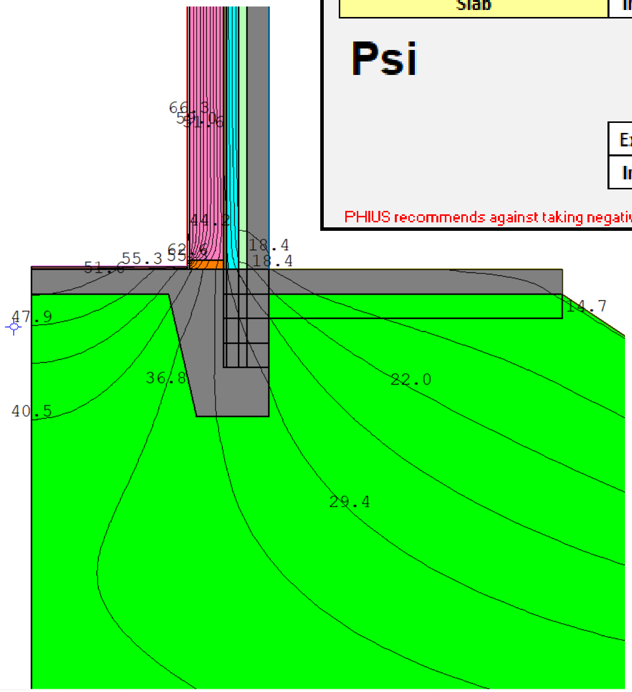
Slab Insulation: Perimeter

2D model		U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
	Exterior	0.016	54	468.27	33.72	3.36%
	Interior	0.1029	54	73.00	33.80	3.36%

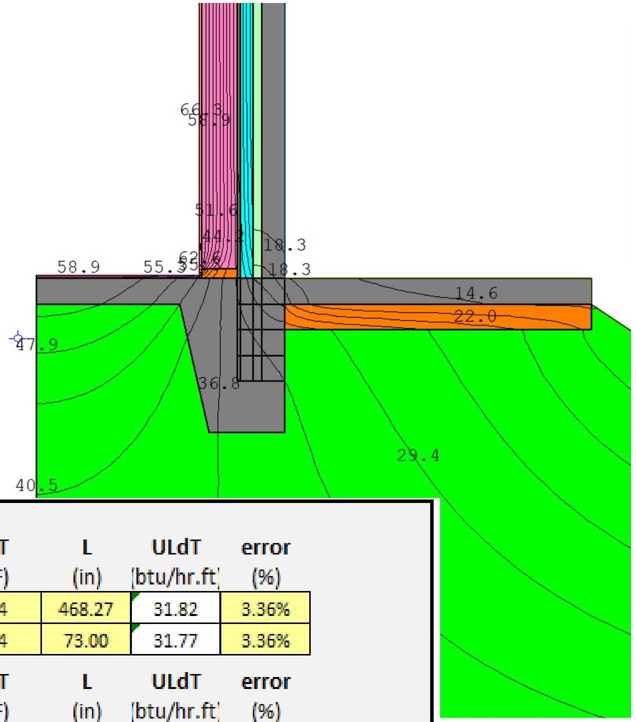
Component		U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
Component A	Exterior	0.0282	54	52.00	6.60	0.00%
Wall	Interior	0.028	54.00	52.00	6.60	0.00%
Component B	Exterior	0.5823	27	39	51.10	1.36%
Slab	Interior	0.5823	27.00	39.00	51.10	1.36%

Psi	PsidT (btu/hr.ft)	dT (F)	Psi (btu/hr.ft.F)	Psi for WUFI (btu/hr.ft.F)
Exterior	-23.98	54.00	-0.444	-0.443
Interior	-23.89	54.00	-0.442	

PHIUS recommends against taking negative thermal bridges in the design phase. See Thermal Bridges section in Certification Guidebook.



No Slab Edge Insulation



2D model		U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
	Exterior	0.0151	54	468.27	31.82	3.36%
	Interior	0.0967	54	73.00	31.77	3.36%

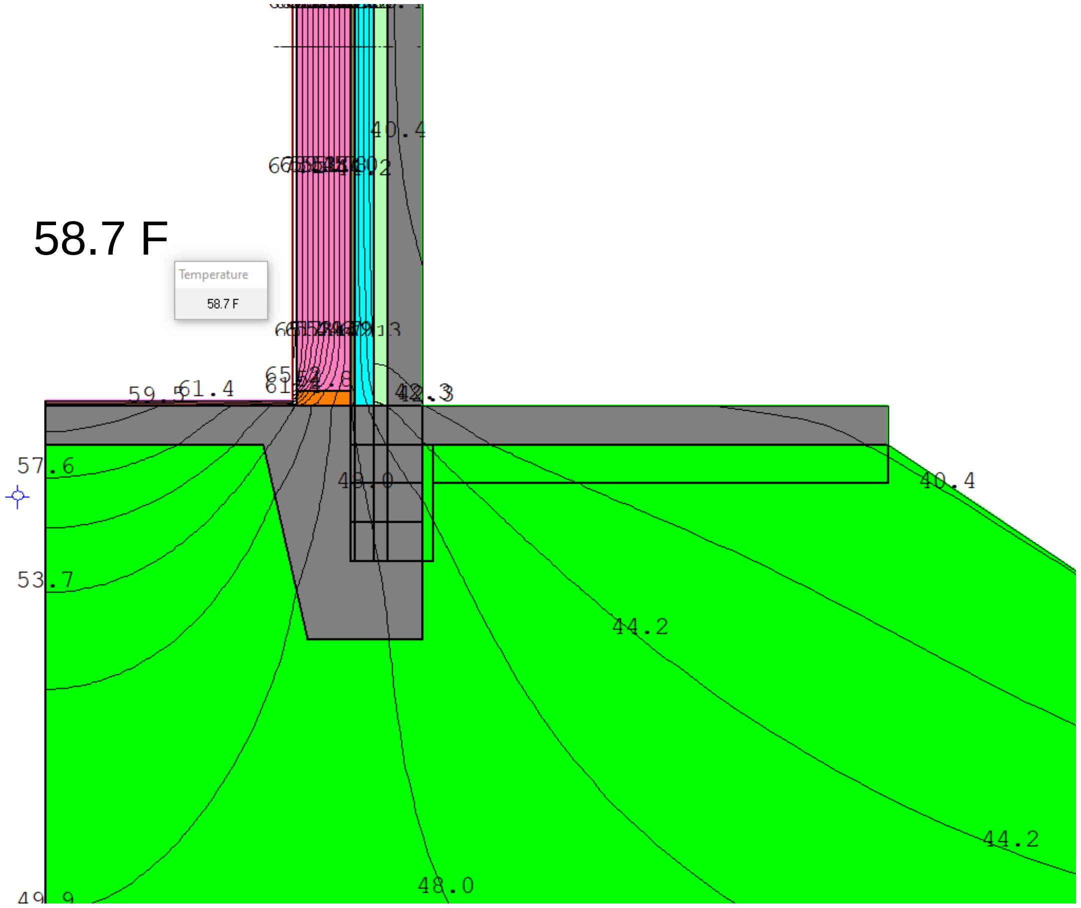
Component		U (btu/hr.sf.F)	dT (F)	L (in)	ULdT (btu/hr.ft)	error (%)
Component A	Exterior	0.0282	54	52.00	6.60	0.00%
Wall	Interior	0.028	54.00	52.00	6.60	0.00%
Component B	Exterior	0.5823	27	39	51.10	1.36%
Slab	Interior	0.5823	27.00	39.00	51.10	1.36%

Psi	PsidT (btu/hr.ft)	dT (F)	Psi (btu/hr.ft.F)	Psi for WUFI (btu/hr.ft.F)
Exterior	-25.88	54.00	-0.479	-0.480
Interior	-25.93	54.00	-0.480	

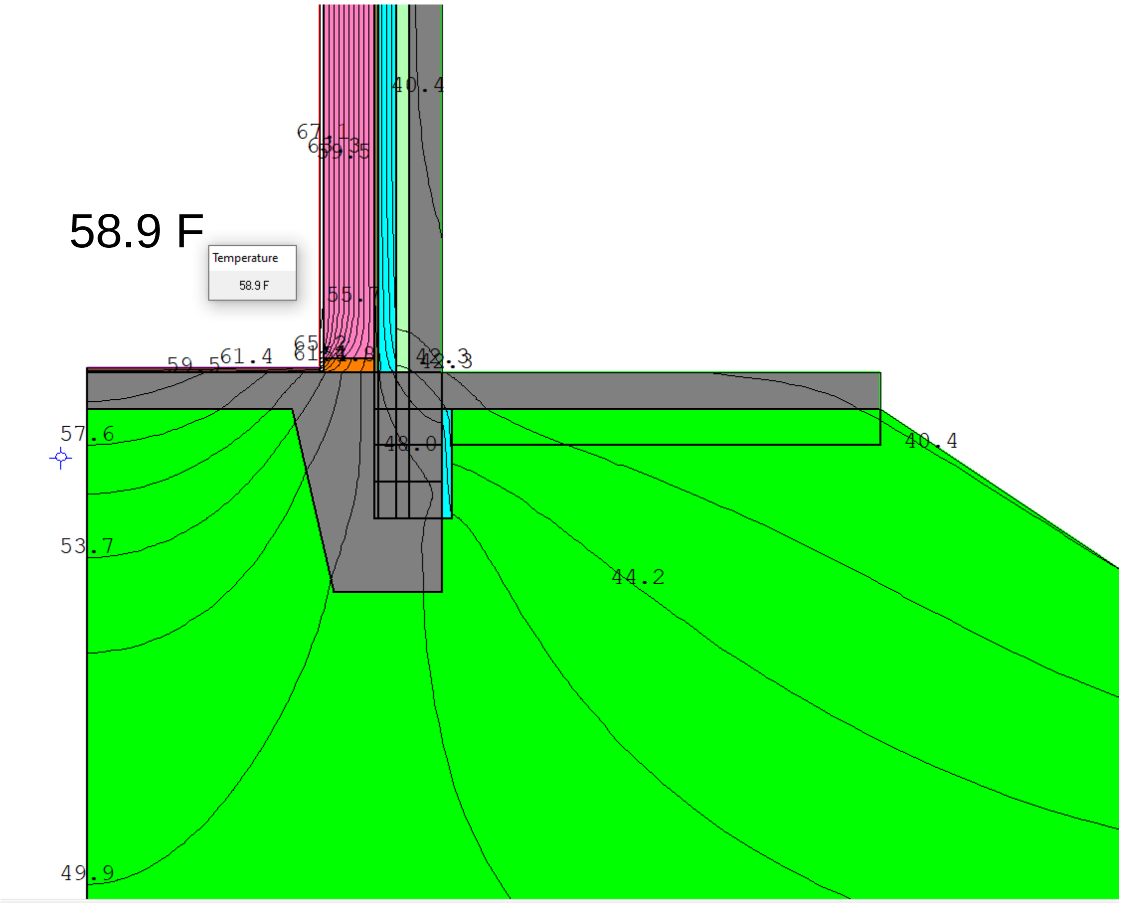
PHIUS recommends against taking negative thermal bridges in the design phase. See Thermal Bridges section in Certification Guidebook.

Glavel Slab Edge Insulation

Slab Insulation: Perimeter

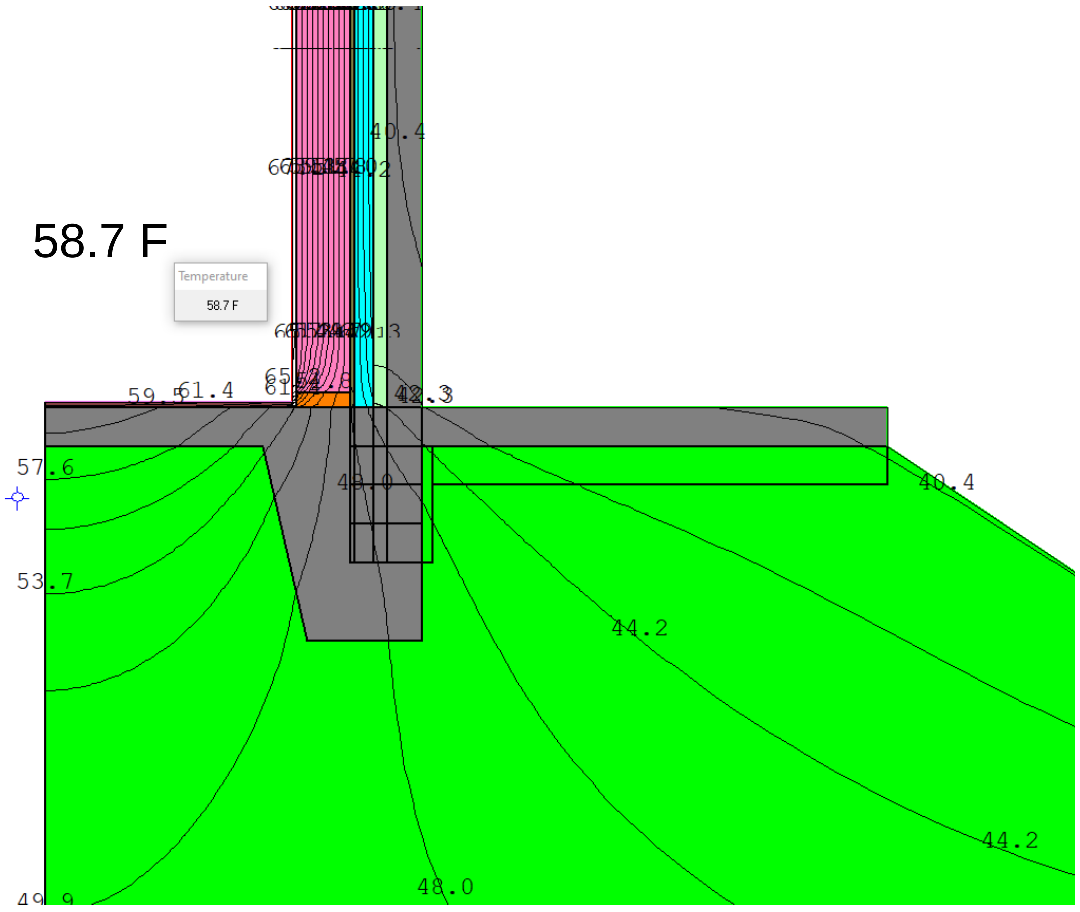


No Slab Edge Insulation

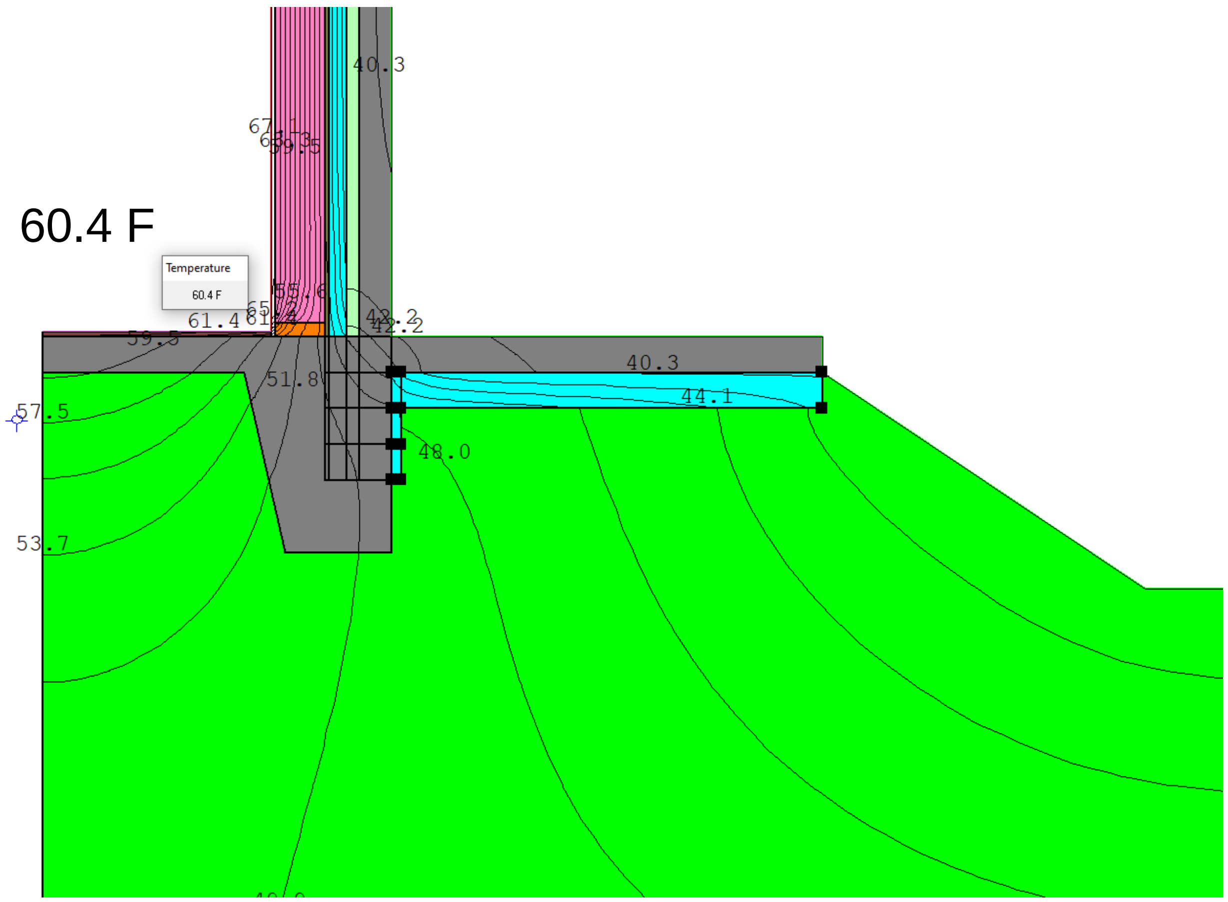


1” Slab Edge Insulation

Slab Insulation: Perimeter



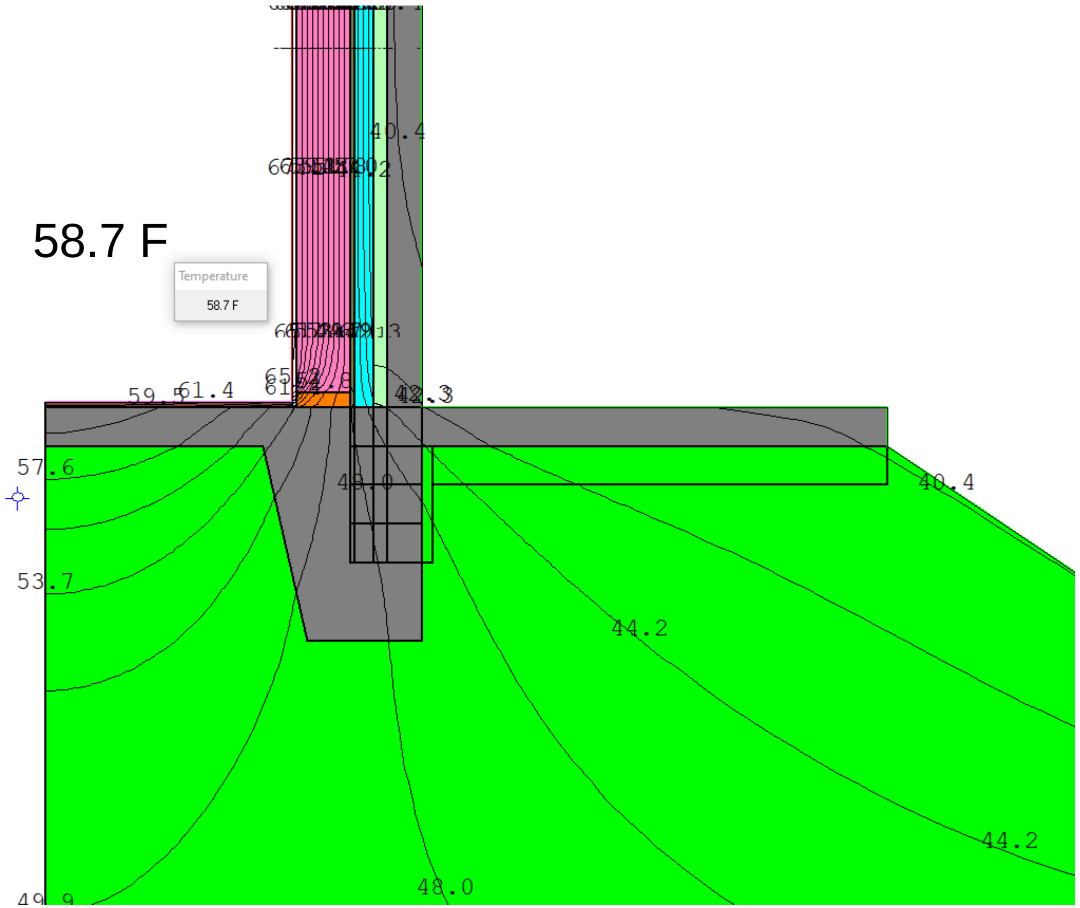
No Slab Edge Insulation



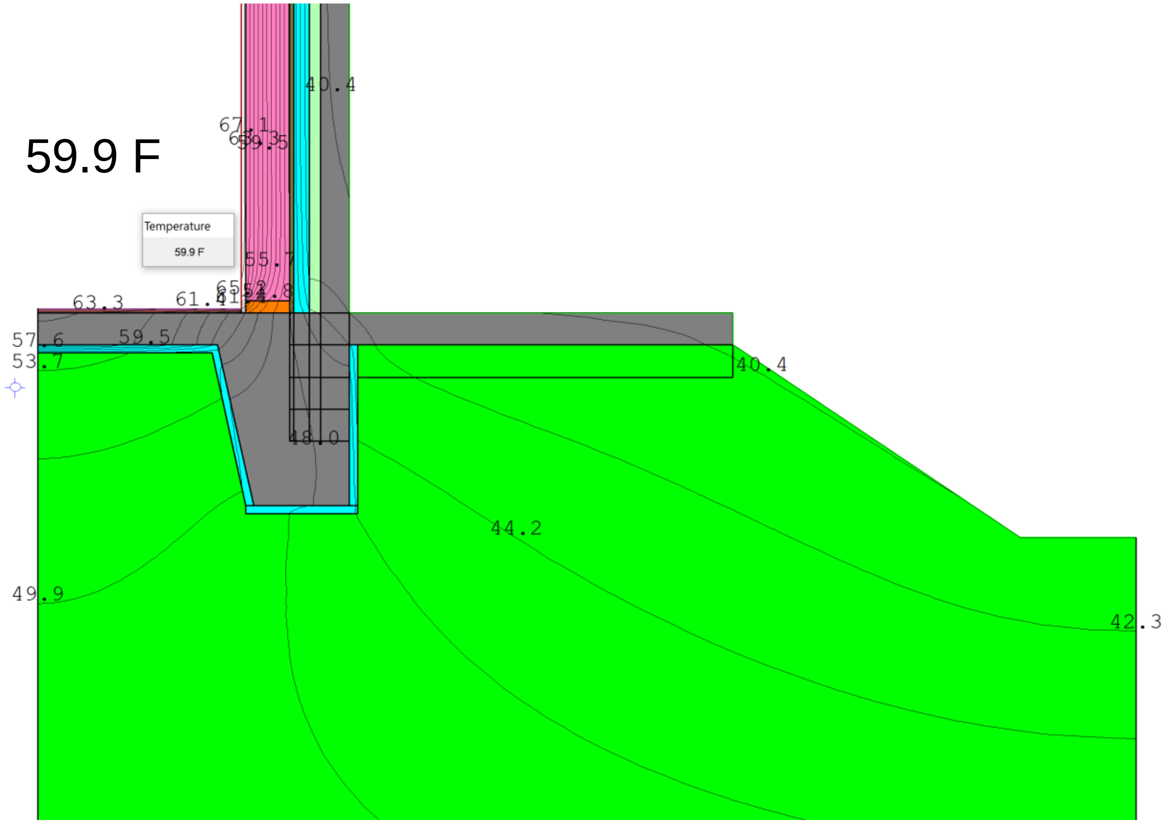
4” of R4 EPS Adjacent to Slab Edge
(1” Vertical R4 EPS)

Slab Insulation: Perimeter

1” of R4 Slab Insulation



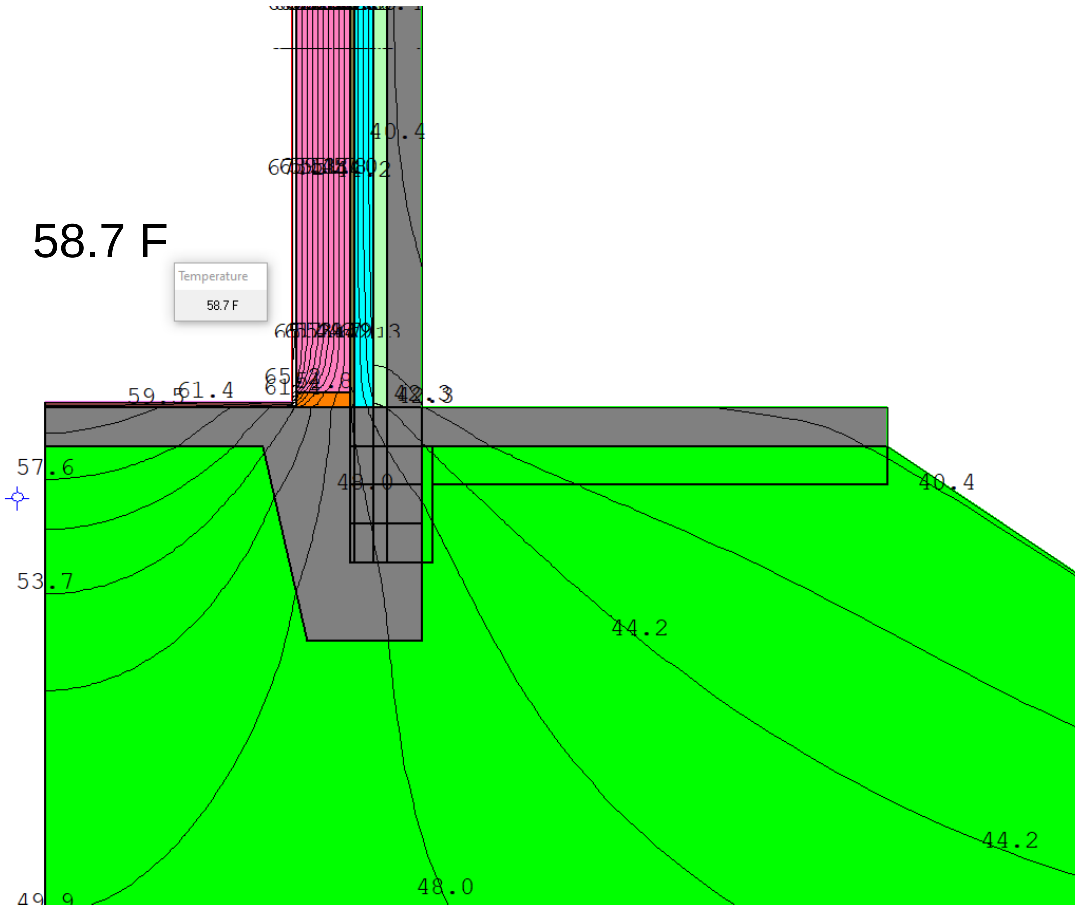
No Slab Edge Insulation



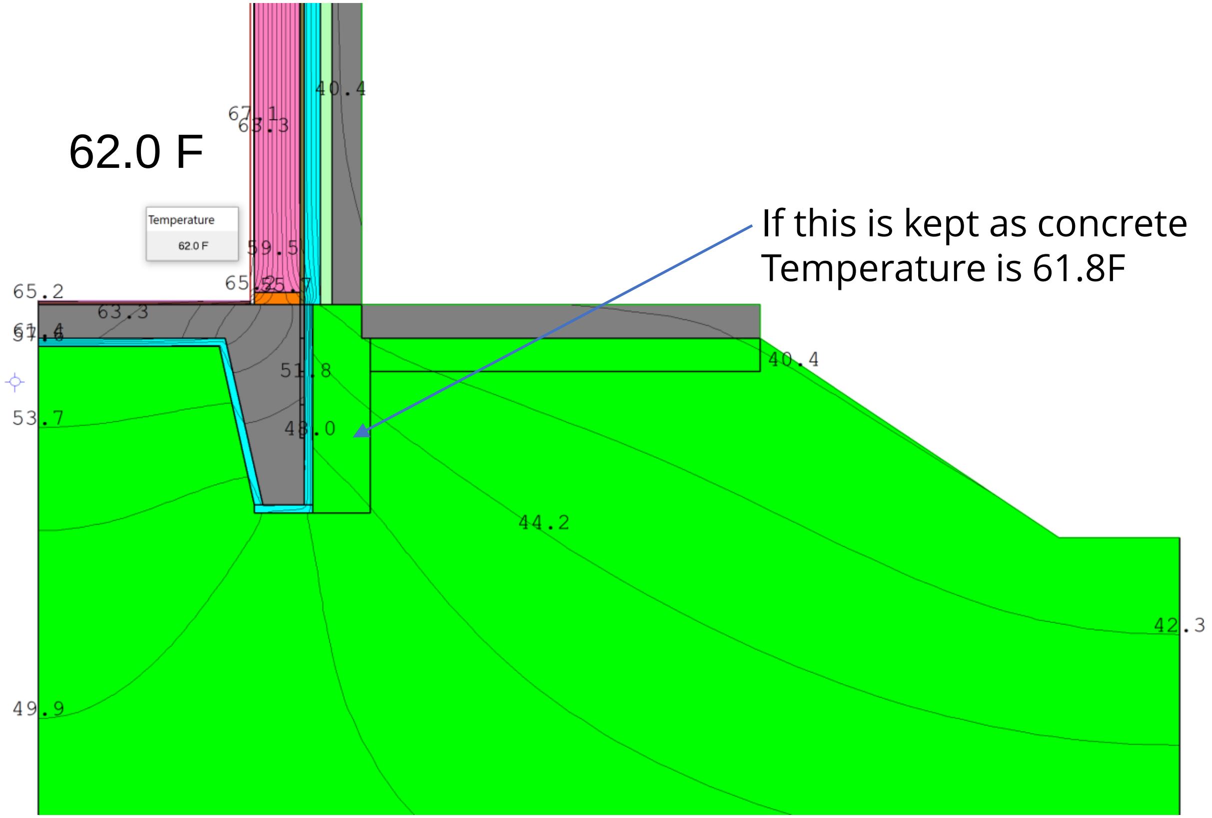
1” of R4 EPS – Almost Continuous

Slab Insulation: Perimeter

1” of R4 Slab Insulation



No Slab Edge Insulation



If this is kept as concrete Temperature is 61.8F

1” of R4 EPS – Continuous

Slab Insulation: Perimeter

Analyzing the climate with the Phius created ISO13788 Interior Surface fRsi Calculator v1.1

This calculator shows the temperatures are warm enough that the surface condensation risk potential should not be concern

Issues seen at slab edges in TX are (likely) related to air movement!

Cold exterior air meeting warm/humid air can cause moisture risk and damage.

Critical Month	**#DIV/0!**											
Exterior temp for moisture design												
Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Walls (F)	56.1	57.0	58.1	65.3	71.4	77.0	79.5	78.6	73.6	68.2	57.9	52.7
Ground (F)	61.3	63.0	63.5	64.0	67.6	70.7	73.4	74.7	74.3	71.7	69.0	63.9
Roof, simplified (F)	56.1	57.0	58.1	65.3	71.4	77.0	79.5	78.6	73.6	68.2	57.9	52.7

Exterior Wall Approaches

- Target R-Values lead to "No Exotic Materials or Techniques Required"
- "4 City" range for the Prescriptive Path is: R23 – R26
- Framing conservatively (accurately) modeled with a double top plate @ 16" o.c.

Positive Impact Homes : R30.475

Inhomogenous layers

Thermal resistance: 30.475 / 33.121 hr ft² °F/Btu (EN ISO 6946 / homogenous layers

Heat transfer coefficient (U-value): 0.032 Btu/hr ft² °F

Thickness: 8.625 in

Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	Polyisocyanurate Board	2.03	0.35	0.0139	2	
2	OSB 3 (oriented strand board)	37.14	0.33	0.0606	0.625	
3	FiberGlass 3.6 - Fibre Glass	1.87	0.2	0.0231	5.5	
4	Gypsum Board (USA)	53.06	0.21	0.0942	0.5	

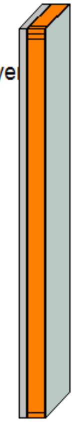
Palm Street: R 29.684

Inhomogenous layers

Thermal resistance: 29.864 / 32.935 hr ft² °F/Btu (EN ISO 6946 / homogenous laye

Heat transfer coefficient (U-value): 0.032 Btu/hr ft² °F

Thickness: 9.125 in



Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	ROXUL FacadeRock	8.43	0.25	0.022	2.5	
2	Plywood (USA)	29.34	0.45	0.0485	0.5	
3	Roxul ComfortBatt	2.25	0.2	0.0208	5.5	
4	Gypsum Board (USA)	53.06	0.21	0.0942	0.625	

Exterior Wall Approaches

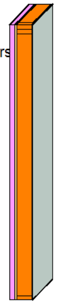
Positive Impact Homes: R30.475

Inhomogenous layers

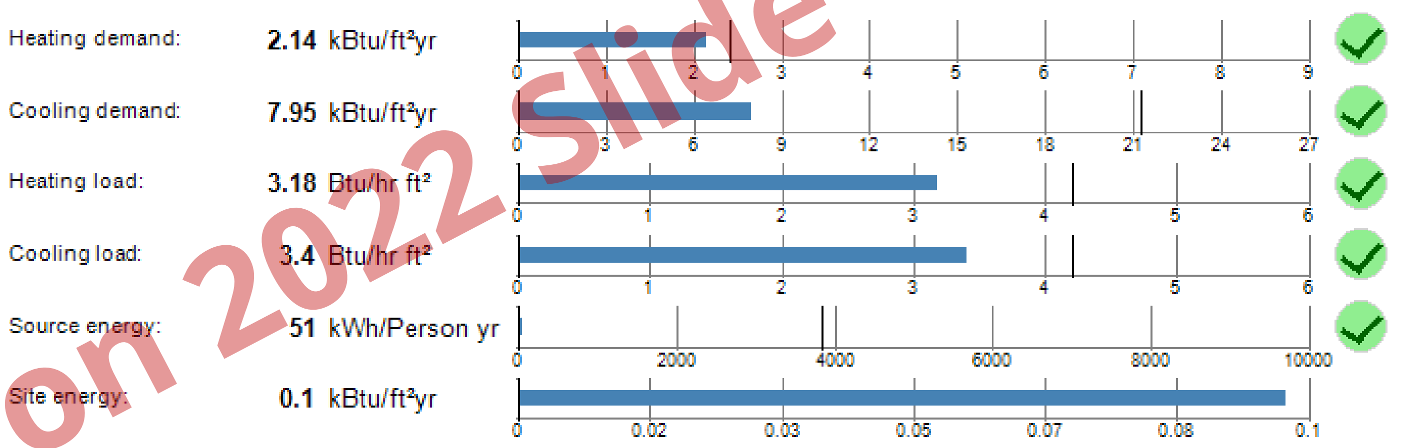
Thermal resistance: 30.475 / 33.121 hr ft² °F/Btu (EN ISO 6946 / homogenous layers)

Heat transfer coefficient (U-value): 0.032 Btu/hr ft² °F

Thickness: 8.625 in



Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	Polyisocyanurate Board	2.03	0.35	0.0139	2	
2	OSB 3 (oriented strand board)	37.14	0.33	0.0606	0.625	
3	FiberGlass 3.6 - Fibre Glass	1.87	0.2	0.0231	5.5	
4	Gypsum Board (USA)	53.06	0.21	0.0942	0.5	



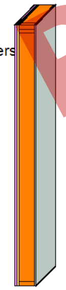
Positive Impact Homes: R 24.358

Inhomogenous layers

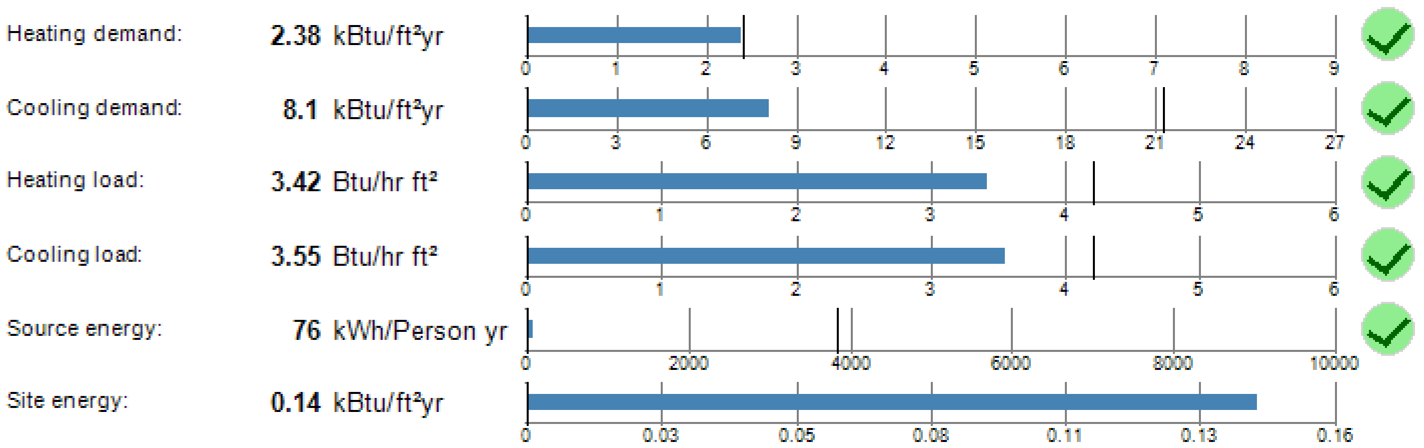
Thermal resistance: 24.358 / 27.111 hr ft² °F/Btu (EN ISO 6946 / homogenous layers)

Heat transfer coefficient (U-value): 0.039 Btu/hr ft² °F

Thickness: 7.625 in



Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	Polyisocyanurate Board	2.03	0.35	0.0139	1	
2	OSB 3 (oriented strand board)	37.14	0.33	0.0606	0.625	
3	FiberGlass 3.6 - Fibre Glass	1.87	0.2	0.0231	5.5	
4	Gypsum Board (USA)	53.06	0.21	0.0942	0.5	



Exterior Wall Approach: Austin

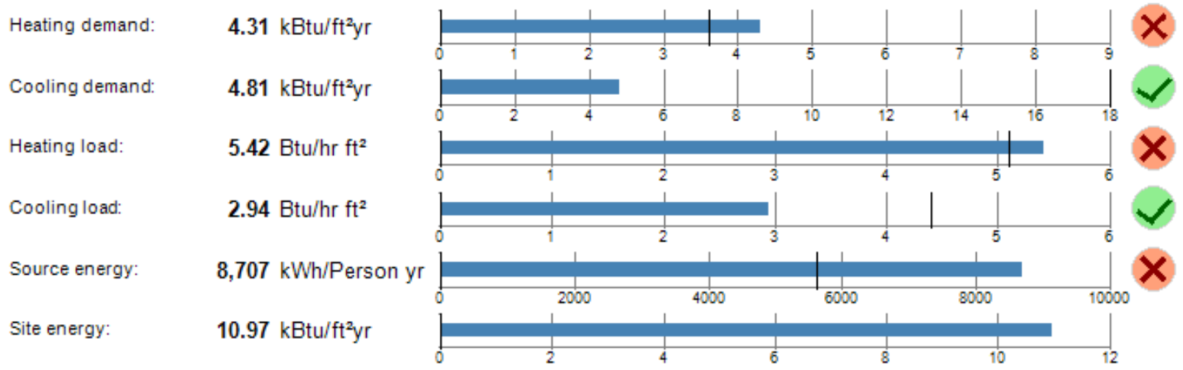
IECC 2021

CLIMATE ZONE	FENESTRATION U-FACTOR[b, i]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE[g]	MASS WALL R-VALUE[h]	FLOOR R-VALUE	BASEMENT[c,g] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c,g] WALL R-VALUE
2	0.40	0.65	0.25	49	13 or 0& 10ci	4/6	13	0	0	0

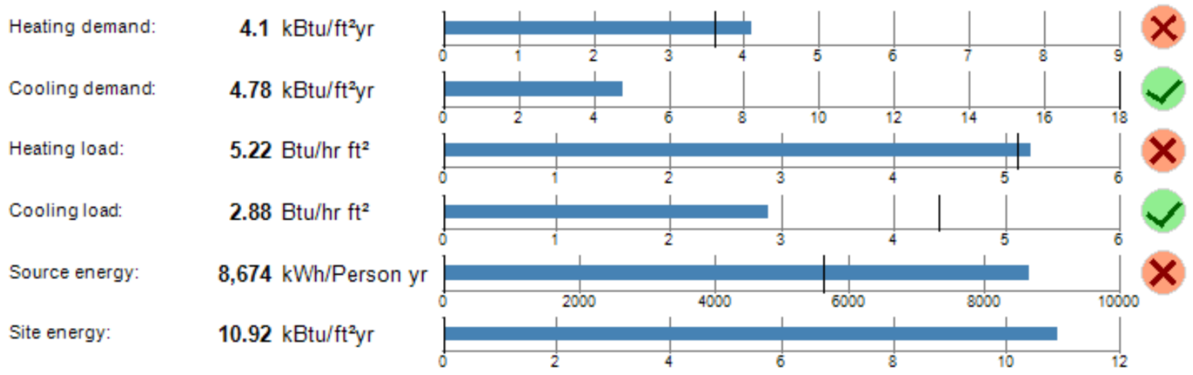
Baseline:
Slab R = .42
Wall R = 18.1
Roof R = 38
Slab Per. = R5, 2'

Window U = 0.25
Window SHGC= 0.25
Airtightness = 0.06 cfm_{50}/ft^2

Wall R-Value: 18.1



Wall R-Value: 21.2



Energy savings due to increased R-value: 109.8 kwh/year of site energy

Results in a 0.38% energy savings for the building and a cost savings of $16.47/year or $1.3725/month @ $0.15/kwh

Exterior Wall Approaches

Cost:

- 2x6 Framing is standard practice.
- Sheathing is standard as well
- Thin layers of CI are not standard, but fairly easy to accomplish
- 2” of foam can work well with almost all cladding materials
- Difference in cost between 2” and 1” is reasonable and can give advantages to meeting Phius Criteria (See previous slides)

Foam/No Foam

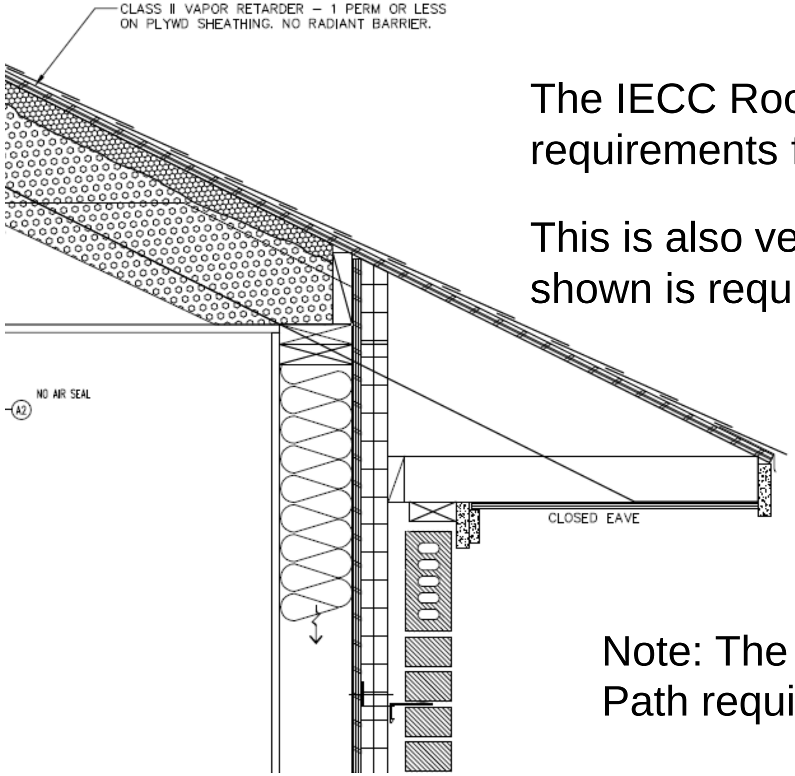
- Embodied Energy and Carbon come into play.
- Palm Street is based on a foam free assembly using rockwool
- Positive Impact Homes uses Polyisocyanurate foam
- Note: polyisocyanurate works very well in warmer climates
- Rockwool requires a thicker layer to get to equivalent R-values than some foam products.

All in one panel solutions:

- ZIP R Sheathing can be an excellent solution, the R9 panel would generally meet the requirements for Phius Certification (with 2x6 insulated framing)
- EPS “nailbase” panels are also an option and have roof applications (more on this soon)

Roof Approaches

Positive Impact Homes:
Insulation under the roof deck
Spray polyurethane foam, AeroBarrier
R40 Estimated

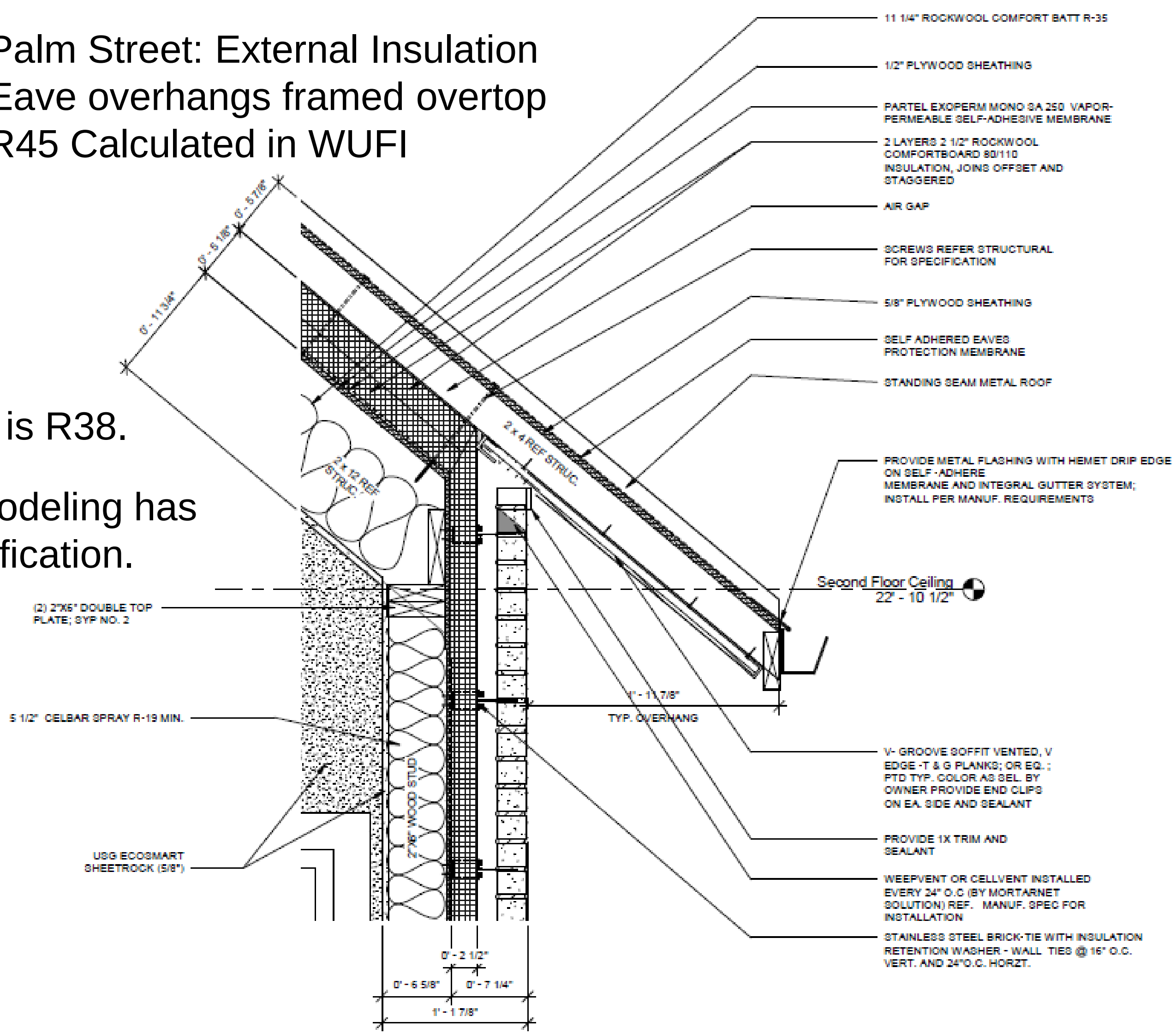


The IECC Roof Insulation requirements for Climate Zone 2 is R38.

This is also very close to what modeling has shown is required for Phius Certification.

Note: The Phius Prescriptive Path requires approx. R55

Palm Street: External Insulation
Eave overhangs framed overtop
R45 Calculated in WUFI



Exterior Roof Approach: Austin

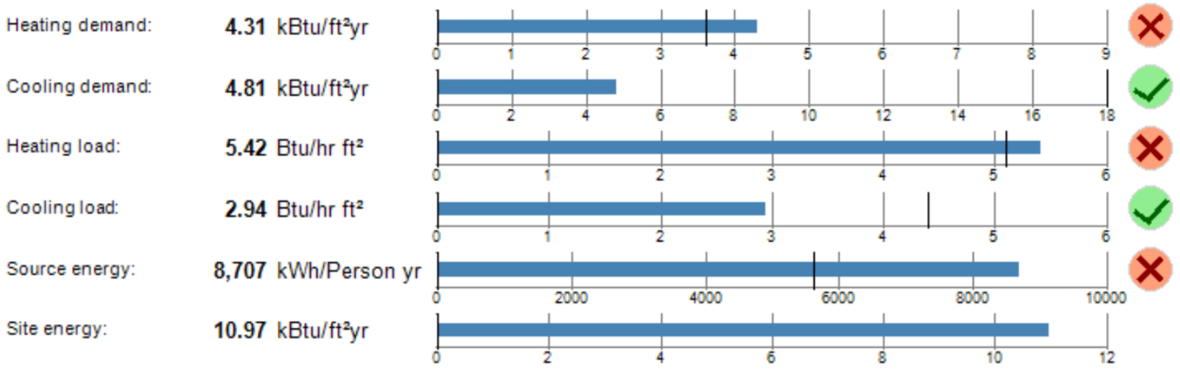
IECC 2021

CLIMATE ZONE	FENESTRATION *U*-FACTOR[b, i]	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE[g]	MASS WALL *R*-VALUE[h]	FLOOR *R*-VALUE	BASEMENT[c,g] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c,g] WALL *R*-VALUE
2	0.40	0.65	0.25	49	13 or 0& 10ci	4/6	13	0	0	0

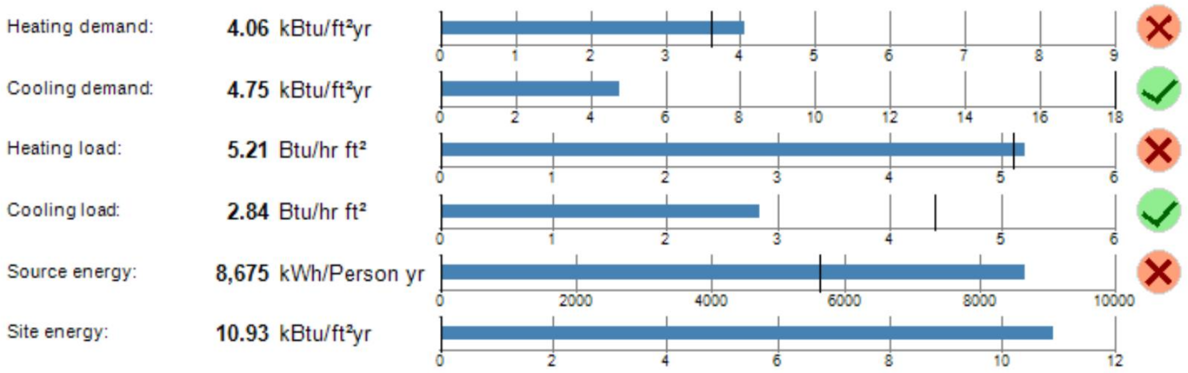
Baseline:
Slab R = .42
Wall R = 18.1
Roof R = 38
Slab Per. = R5, 2'

Window U = 0.25
Window SHGC= 0.25
Airtightness = 0.06 cfm_{50}/ft^2

Roof R-Value: 38



Roof R-Value: 49



Energy savings due to increased R-value: 106.3 kwh/year of site energy

Results in a 0.37% energy savings for the building and a cost savings of $15.95/year or $1.33/month @ $0.15/kwh

Project Teams

Where are all the Rater/Verifiers?

Grand total of:

3 Phius Raters in Texas

1 each in Houston (not active), Austin, Dallas

0 Phius Verifiers in Texas

Builders?

If we remove the listings with 3+ States served, there are:

11 Phius Certified Builders in Texas

Questions?

Thank You!

We have additional data on windows, ventilation systems, hot water, PV integration, etc.!
Let's meet to discuss!

Ryan Abendroth, M.Arch, CPHC
Co-Founder and Consultant

Stefan Goebel, M.Eng., CPHC
Co-Founder and Consultant

Build Zero Consulting

Back Up

Phius CORE Prescriptive 2021 Snapshot

		Input or select data in teal cells	*Input or select data in teal cells*
State		NEW YORK	TEXAS
City		NEW YORK LAGUARDIA ARPT	HOUSTON WILLIAM P HOBBY
ASHRAE (169-2021) Climate Zone		4A	2A
iCFA* (ft^2)		2500	2500
Number of Bedrooms*		4	4
Number of Stories		2	2
		*per dwelling unit	*per dwelling unit

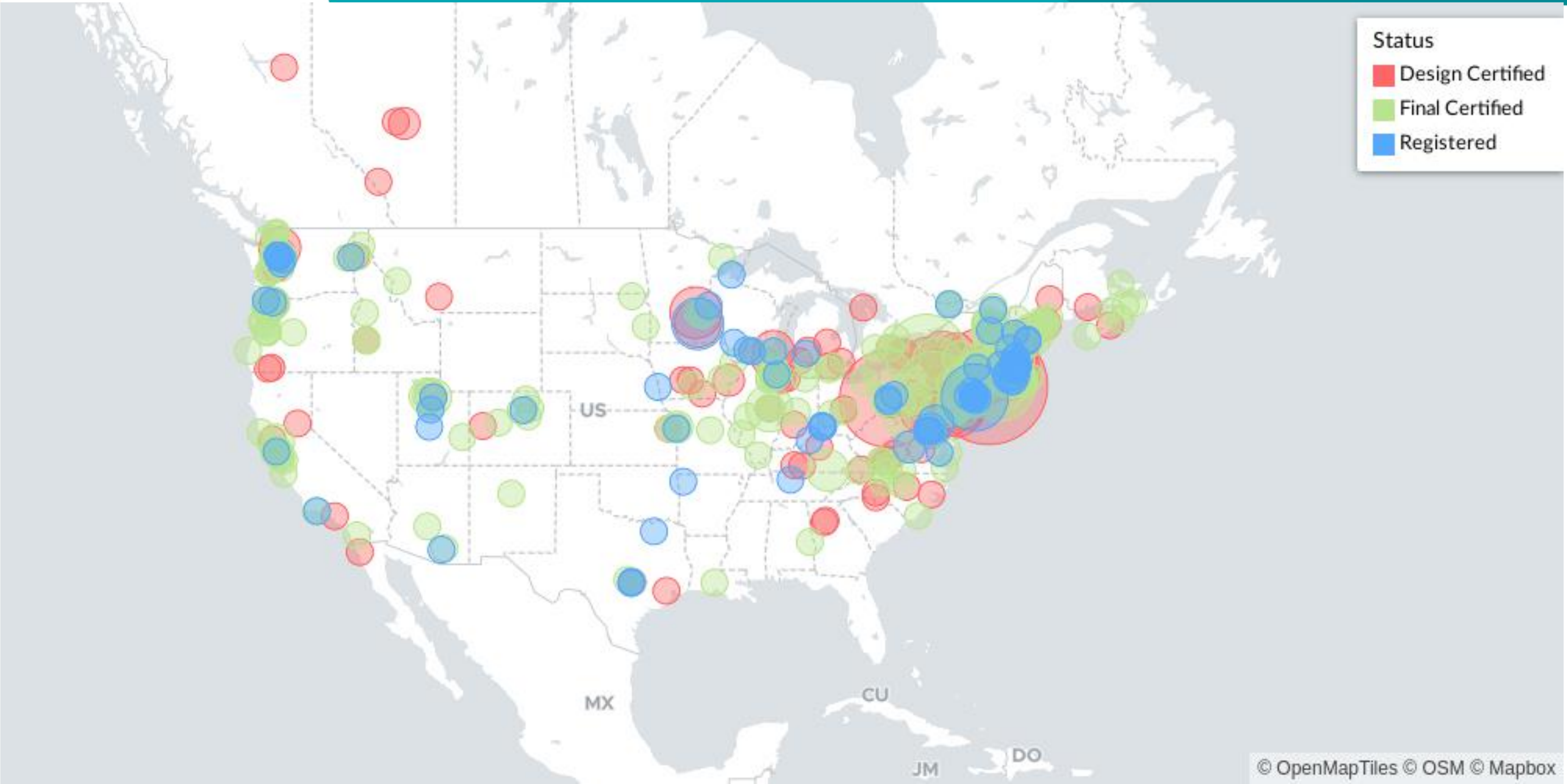
			New York		Texas	
1	**General**					
1.1.2	iCFA divided by Number of Bedrooms	Maximum Limit	900	ft^2	900	ft^2
	(Calculated Value based on Inputs)	*OK, Meets Limit*	625	ft^2	625	ft^2
3	**Compactness**					
3.1.1	Envelope Area	Maximum	6946	ft^2	6946	ft^2
	(Maximum Envelope to Floor Area Ratio)		2.78		2.78	
4	**Solar Protection**					
4.1.1	Whole Window SHGC	Maximum	0.40		0.25	
4.4.1	Projection Factor for Fixed Overhangs	Minimum	NR		0.57	
5	**Thermal Enclosure**					
5.1.1a	Fenestration / Openings	Maximum Whole U-Value	0.20	(BTU/h.ft².°F)	0.31	(BTU/h.ft².°F)
5.1.1b	Walls & Overhang Floors - Effective R-value	Minimum Effective R-Value	36	(ft².°F.h/BTU)	23	(ft².°F.h/BTU)
5.1.1c	Roofs / Ceilings	Minimum Effective R-Value	67	(ft².°F.h/BTU)	53	(ft².°F.h/BTU)
5.1.1d	Whole Slab Foundations, Below-Grade Walls, Floors of Conditioned Basements & Crawl Spaces	Minimum Effective R-Value	17	(ft².°F.h/BTU)	8	(ft².°F.h/BTU)
5.1.1e	Ceilings of Unconditioned Basements or Crawl Spaces & Pier and Beam Floors	Minimum Effective R-Value	22	(ft².°F.h/BTU)	13	(ft².°F.h/BTU)
6	**Moisture Risk Limitation**					
6.2.1	Fenestration Condensation Resistance	Minimum	60%		65%	
7	**Mechanical Ventilation**					
7.2.1	Sensible Recovery Efficiency, Heating Mode	Minimum	76%		NR	
7.2.2	Total Recovery Efficiency, Cooling Mode	Minimum	50%		60%	
7.2.5	Total Length of Fresh Air Ducts to Outside	Maximum	28	ft	28	ft
8	**Mechanical Systems**					
	Select System Type					
8.2.1	Air Source Heat Pump	Minimum COP @ 5F	1.8		9.6	
		Minimum SEER	15.0		18.0	

Phius CORE Prescriptive **Snapshot**

(www.phius.org)

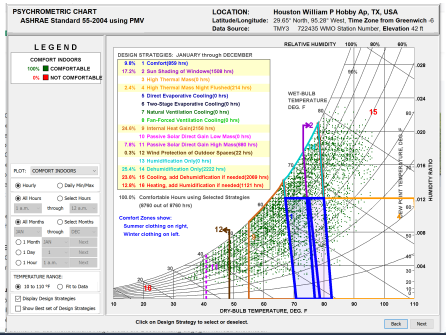
phius

Certification Growth



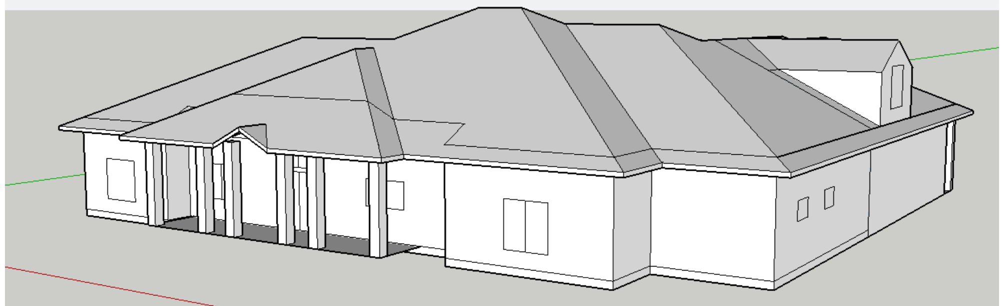
Hot and Humid Texas

20	Provide double pane high performance glazing (Low-E) on west, north, and east, but clear on south for maximum passive solar gain
59	In this climate air conditioning will always be needed, but can be greatly reduced if building design minimizes overheating
19	For passive solar heating face most of the glass area south to maximize winter sun exposure, but design overhangs to fully shade in summer
65	Traditional passive homes in warm humid climates used high ceilings and tall operable (French) windows protected by deep overhangs and verandahs
18	Keep the building small (right-sized) because excessive floor area wastes heating and cooling energy
37	Window overhangs (designed for this latitude) or operable sunshades (awnings that extend in summer) can reduce or eliminate air conditioning
68	Traditional passive homes in hot humid climates used light weight construction with openable walls and shaded outdoor porches, raised above ground
17	Use plant materials (bushes, trees, ivy-covered walls) especially on the west to minimize heat gain (if summer rains support native plant growth)
38	Raise the indoor comfort thermostat setpoint to reduce air conditioning energy consumption (especially if occupants wear seasonally appropriate clothi...
3	Lower the indoor comfort temperature at night to reduce heating energy consumption (lower thermostat heating setback) (see comfort low criteria)
4	Extra insulation (super insulation) might prove cost effective, and will increase occupant comfort by keeping indoor temperatures more uniform
56	Screened porches and patios can provide passive comfort cooling by ventilation in warm weather and can prevent insect problems
33	Long narrow building floorplan can help maximize cross ventilation in temperate and hot humid climates
35	Good natural ventilation can reduce or eliminate air conditioning in warm weather, if windows are well shaded and oriented to prevailing breezes
46	High Efficiency air conditioner or heat pump (at least Energy Star) should prove cost effective in this climate
16	Trees (neither conifer or deciduous) should not be planted in front of passive solar windows, but are OK beyond 45 degrees from each corner
25	In wet climates well ventilated attics with pitched roofs work well to shed rain and can be extended to protect entries, porches, verandas, outdoor work ...
43	Use light colored building materials and cool roofs (with high emissivity) to minimize conducted heat gain
5	Carefully seal building to minimize infiltration and eliminate drafts, especially in windy sites (house wrap, weather stripping, tight windows)
15	High Efficiency furnace (at least Energy Star) should prove cost effective

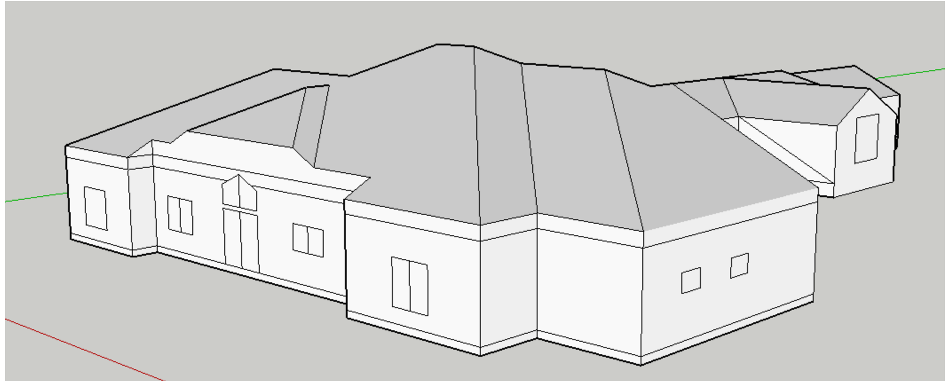


Positive Impact Homes

The thermal envelope area is not overly large in plan, but there is a conditioned space over the attic that greatly adds to the overall envelope to iCFA ratio.



Thermal Envelope with Shading



Thermal Envelope

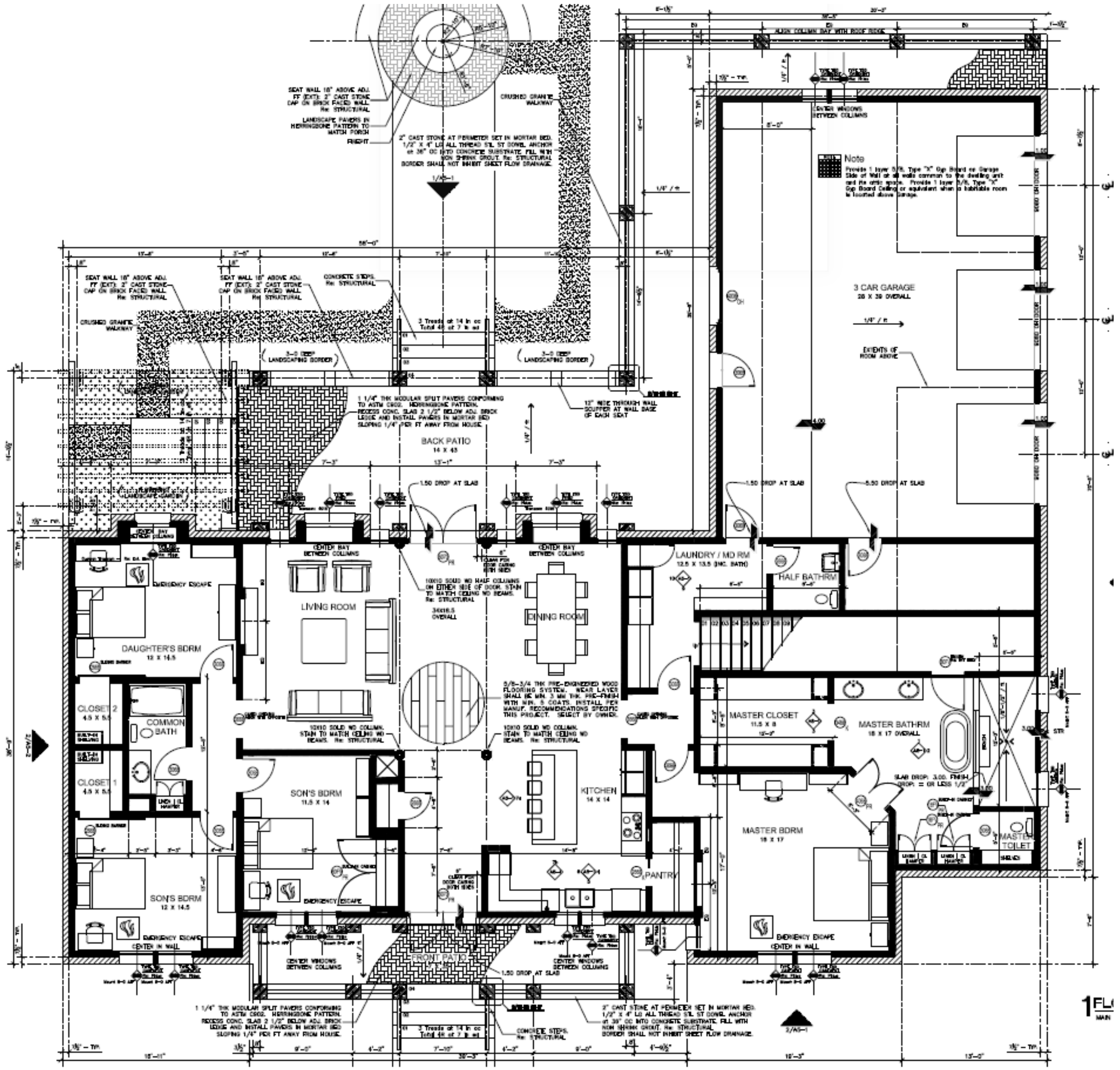


Image by Stella Maris Architecture

Positive Impact Homes: Criteria

Phius 2021
Performance Criteria Calculator v3.2

UNITS:	IMPERIAL (IP)
BUILDING FUNCTION:	RESIDENTIAL
PROJECT TYPE:	NEW CONSTRUCTION
STATE/ PROVINCE	TEXAS
CITY	HOUSTON WILLIAM P HC
Envelope Area (ft²)	12,905.6
iCFA (ft²)	3,200.0
Dwelling Units (Count)	1
Total Bedrooms (Count)	4

Space Conditioning Criteria

Annual Heating Demand	2.8	kBtu/ft²yr
Annual Cooling Demand	19.3	kBtu/ft²yr
Peak Heating Load	3.2	Btu/ft²hr
Peak Cooling Load	4.2	Btu/ft²hr

Source Energy Criteria

Phius CORE	5000	kWh/person.yr
Phius ZERO	0	kWh/person.yr

PHIUS+ 2018
Space Conditioning Criteria Calculator v2

METHOD:	CALCULATOR
UNITS:	IMPERIAL (IP)
STATE / PROVINCE	TEXAS
CITY	HOUSTON WILLIAM P HOBBY

Envelope Area (ft²) / iCFA (ft²) 4.03 or enter here: 4.03

iCFA (ft²) / person 640 or enter here: 640

**Calculator method is used for official certification targets.*

Space Conditioning Criteria

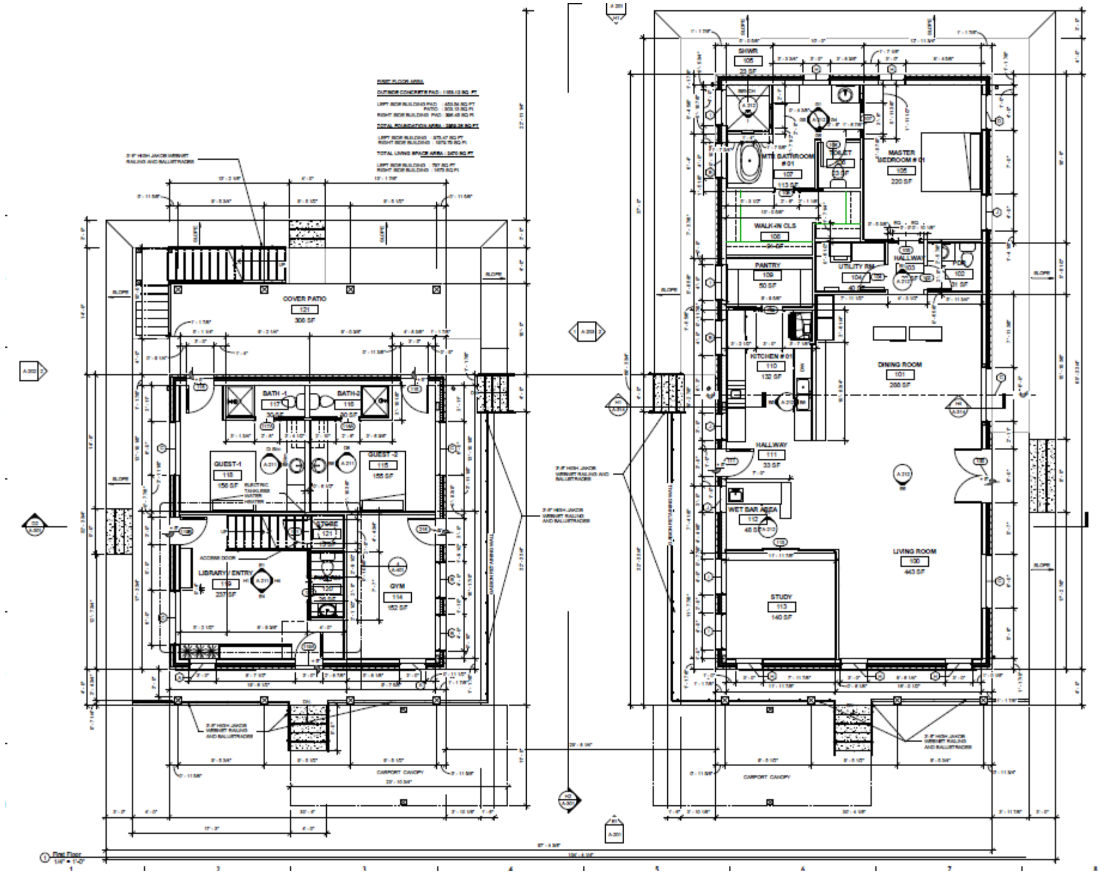
Annual Heating Demand	3.4	kBTU/ft²yr
Annual Cooling Demand	24.3	kBTU/ft²yr
Peak Heating Load	3.1	BTU/ft²hr
Peak Cooling Load	5.7	BTU/ft²hr

Typed entry will override sliding scale.
The results of the CALCULATOR method take precedence over the ESTIMATOR method.

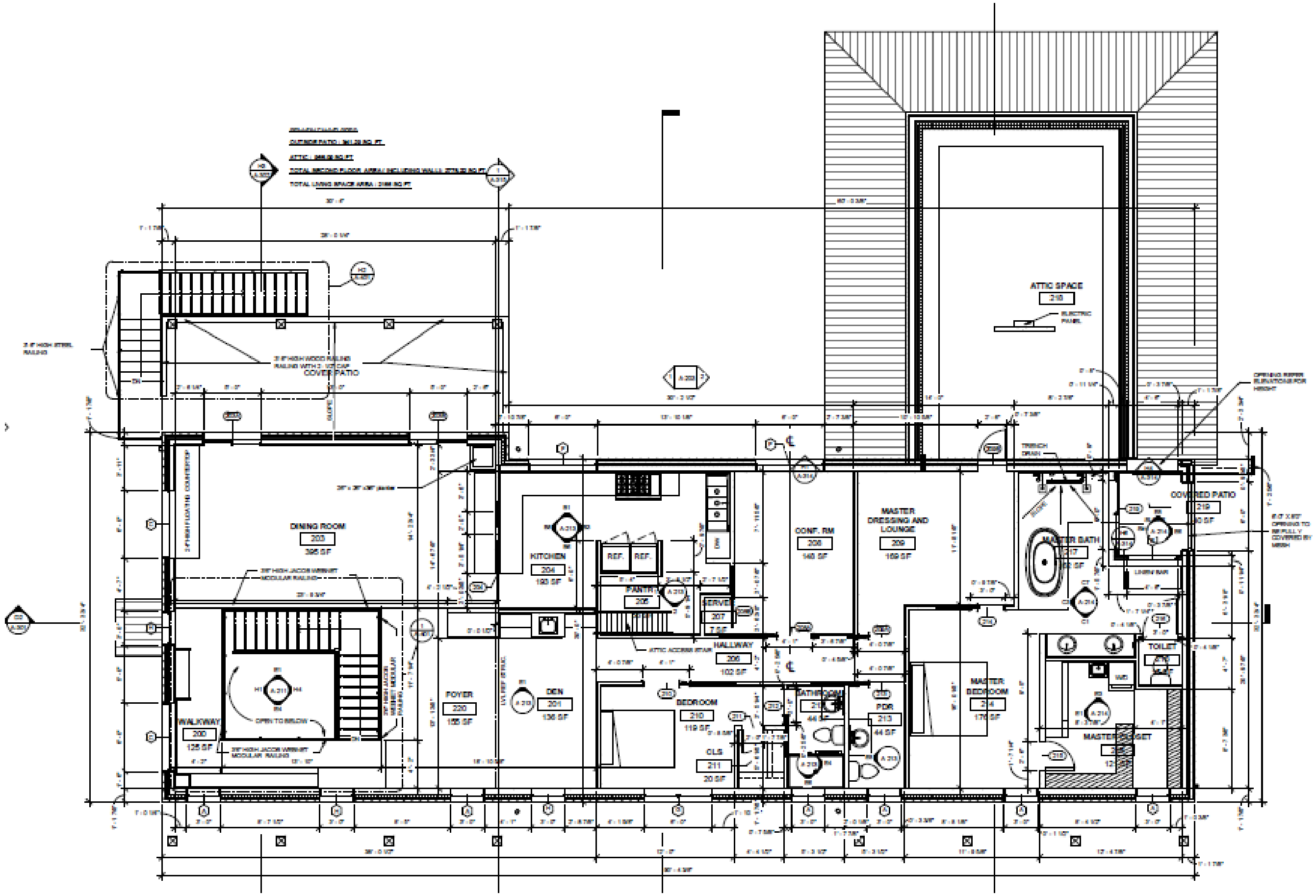
Update Reset

Palm Street Development

1st Floor



2nd Floor



Images courtesy of Mint Homes / Raj Development Corporation

Palm Street: Criteria

Phius 2021
Performance Criteria Calculator v3.2

UNITS:	IMPERIAL (IP)
BUILDING FUNCTION:	RESIDENTIAL
PROJECT TYPE:	NEW CONSTRUCTION
STATE/ PROVINCE	TEXAS
CITY	HOUSTON WILLIAM P HC
Envelope Area (ft²)	16,032.0
iCFA (ft²)	5,254.0
Dwelling Units (Count)	2
Total Bedrooms (Count)	5

Space Conditioning Criteria

Annual Heating Demand	2.7	kBtu/ft²yr
Annual Cooling Demand	19.1	kBtu/ft²yr
Peak Heating Load	3.1	Btu/ft²hr
Peak Cooling Load	4.1	Btu/ft²hr

Source Energy Criteria

Phius CORE	5600	kWh/person.yr
Phius ZERO	0	kWh/person.yr

phius 2021
Performance Criteria Calculator v2

UNITS:	IMPERIAL (IP)
BUILDING FUNCTION:	RESIDENTIAL
PROJECT TYPE:	NEW CONSTRUCTION
STATE/ PROVINCE	TEXAS
CITY	HOUSTON WILLIAM P HC
Envelope Area (ft²)	16,032
iCFA (ft²)	5,254
Dwelling Units (Count)	2
Total Bedrooms (Count)	5

Space Conditioning Criteria

Annual Heating Demand	2.6	kBtu/ft²yr
Annual Cooling Demand	17.3	kBtu/ft²yr
Peak Heating Load	3.1	Btu/ft²hr
Peak Cooling Load	4.0	Btu/ft²hr

Source Energy Criteria

phius CORE	5612	kWh/person.yr
phius ZERO	0	kWh/person.yr

PHIUS+ 2018
Space Conditioning Criteria Calculator v2

METHOD:	CALCULATOR
UNITS:	IMPERIAL (IP)
STATE / PROVINCE	TEXAS
CITY	HOUSTON WILLIAM P HOBBY

Envelope Area (ft²) / iCFA (ft²)	3.05	or enter here:	3.05
iCFA (ft²) / person	751	or enter here:	751

**Calculator method is used for official certification targets.*

Space Conditioning Criteria

Annual Heating Demand	3.3	kBTU/ft²yr
Annual Cooling Demand	23.8	kBTU/ft²yr
Peak Heating Load	3.0	BTU/ft²hr
Peak Cooling Load	5.6	BTU/ft²hr

Typed entry will override sliding scale.
The results of the CALCULATOR method take precedence over the ESTIMATOR method.

Update Reset

Phius 2018 (+V2) vs Phius 2021

Phius 2021
Performance Criteria Calculator v3.2

UNITS:	IMPERIAL (IP)
BUILDING FUNCTION:	RESIDENTIAL
PROJECT TYPE:	NEW CONSTRUCTION
STATE/ PROVINCE	TEXAS
CITY	HOUSTON WILLIAM P HC
Envelope Area (ft²)	16,032.0
iCFA (ft²)	5,254.0
Dwelling Units (Count)	2
Total Bedrooms (Count)	5

Space Conditioning Criteria

Annual Heating Demand	2.7	kBtu/ft²yr
Annual Cooling Demand	19.1	kBtu/ft²yr
Peak Heating Load	3.1	Btu/ft²hr
Peak Cooling Load	4.1	Btu/ft²hr

Source Energy Criteria

Phius CORE	5600	kWh/person.yr
Phius ZERO	0	kWh/person.yr

phius 2021
Performance Criteria Calculator v2

UNITS:	IMPERIAL (IP)
BUILDING FUNCTION:	RESIDENTIAL
PROJECT TYPE:	NEW CONSTRUCTION
STATE/ PROVINCE	TEXAS
CITY	HOUSTON WILLIAM P HC
Envelope Area (ft²)	16,032
iCFA (ft²)	5,254
Dwelling Units (Count)	2
Total Bedrooms (Count)	5

Space Conditioning Criteria

Annual Heating Demand	2.6	kBtu/ft²yr
Annual Cooling Demand	17.3	kBtu/ft²yr
Peak Heating Load	3.1	Btu/ft²hr
Peak Cooling Load	4.0	Btu/ft²hr

Source Energy Criteria

phius CORE	5612	kWh/person.yr
phius ZERO	0	kWh/person.yr

PHIUS+ 2018
Space Conditioning Criteria Calculator v2

METHOD:	CALCULATOR
UNITS:	IMPERIAL (IP)
STATE / PROVINCE	TEXAS
CITY	HOUSTON WILLIAM P HOBBY

Envelope Area (ft²) / iCFA (ft²) 3.05 or enter here: 3.05

iCFA (ft²) / person 751 or enter here: 751

*Calculator method is used for official certification targets.

Space Conditioning Criteria

Annual Heating Demand	3.3	kBTU/ft²yr
Annual Cooling Demand	23.8	kBTU/ft²yr
Peak Heating Load	3.0	BTU/ft²hr
Peak Cooling Load	5.6	BTU/ft²hr

Typed entry will override sliding scale.
The results of the CALCULATOR method take precedence over the ESTIMATOR method.

Update Reset

Cooling has tightened significantly while heating has tightened marginally. Source Energy is just different!

Windows

Performance criteria for windows in a predominately cooling climate are highly varied. Like in colder climates, the best thing to do is to have excellent shading control for passive solar gain in the winter and complete shading in the summer.

U-values in the Prescriptive Path vary from: U 0.24 (Dallas) to U 0.31 (Houston)
The WUFI model results shown to this point vary from U 0.2 to U 0.25

Glazing specifications is still a balance as it gets cold enough to warrant some passive solar gain, but for the majority of the year strategies to limit gain is best.

- Limit West Windows
- North Windows

SHGC vs U-value vs Shading

- The better shading you have, the higher SHGC would be possible.
- SHGC is VERY Important. In testing, a SHGC reduction from .3 to .25 allowed the window to go from U .2 to U .5 and achieve the same cooling demand.
- Heating Performance suffered in the above example.

Triple Pane windows for acoustics, better performance, etc.

- Watch code requirements for SHGC (NFRC vs Center of Glass)

Comfort in Cooling Climates

- With a high degree of certainty, I will state that Point Source Cooling is NOT EFFECTIVE
  (while point source heating often is – or can be)
- Distribution of cooling energy (and probably heating energy too) should be ducted to each room
  Central AHU not necessarily required.
  Ducted mini-splits with short runs located in conditioned attic may be sufficient pending overall design constraints.
  Dedicated Dehumidification should be provided.

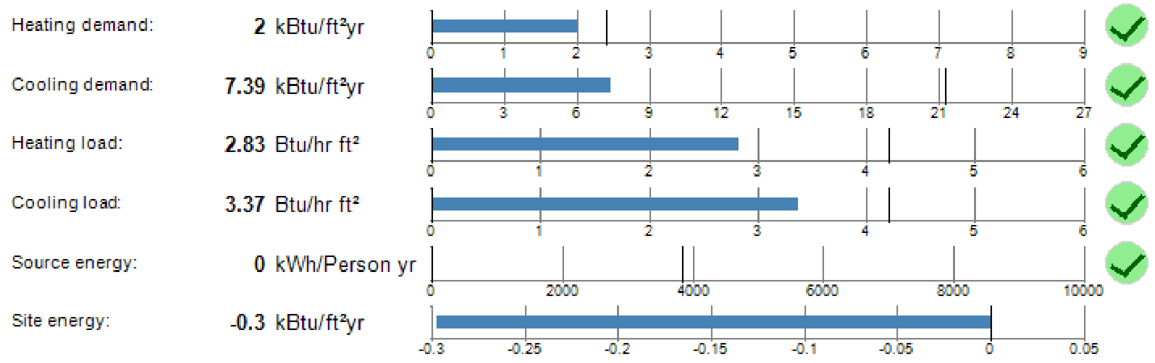
Questions - that need some more clarifying, discussion, or research:

- Impact of glass surface temperature for thermal comfort – "Mean Radiant Temperature"
- Effects of air leakage, stratification and air movement.
  Ceiling fans being planned for in both projects.

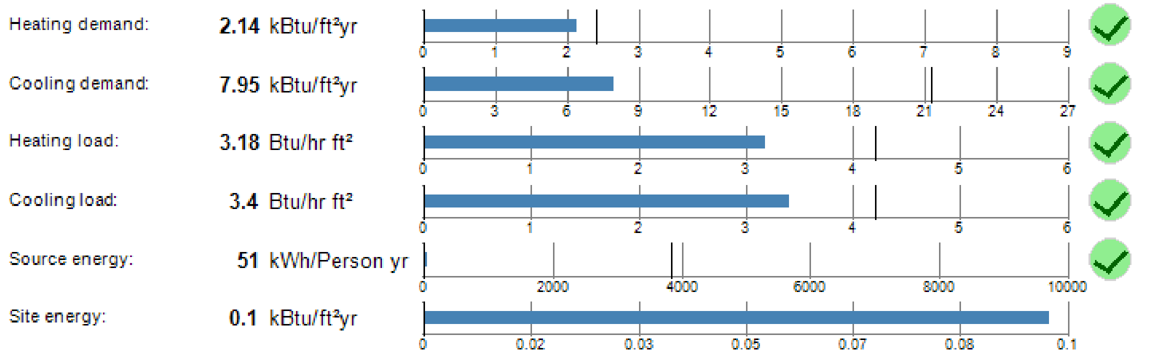
Airtightness

Baseline Target

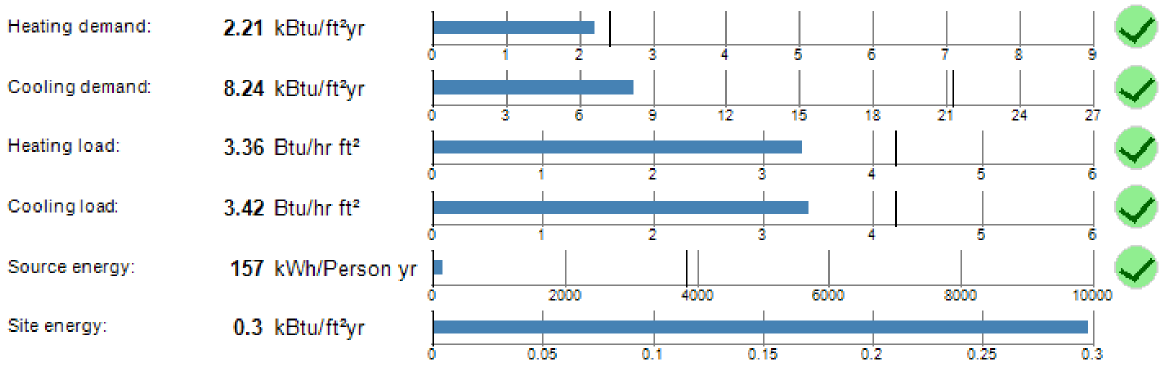
0.03 CFM50 / .48 ACH



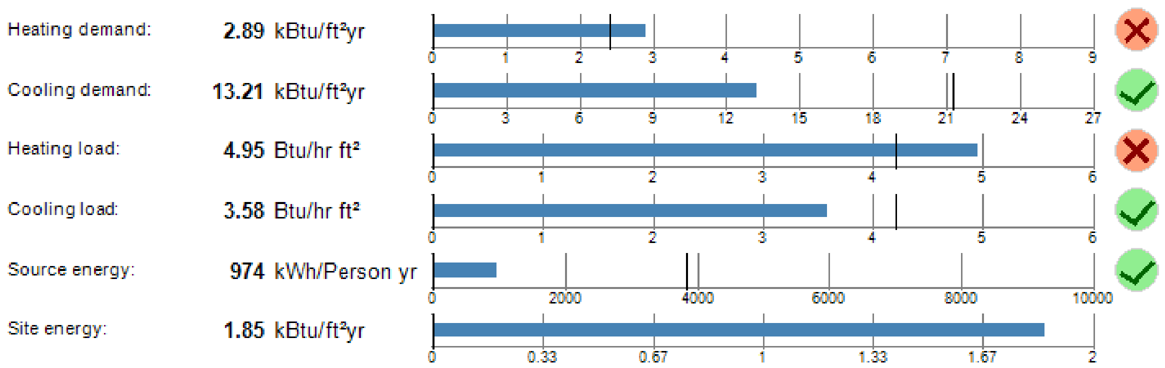
0.05 CFM50 / .81 ACH



0.06 CFM50 / .97 ACH



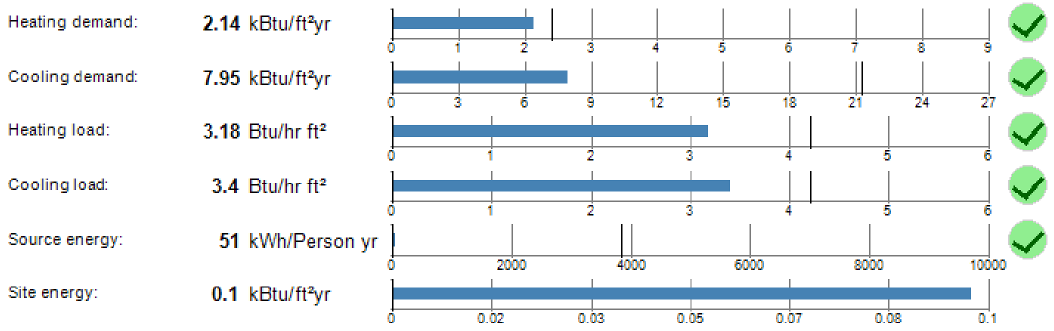
0.15 CFM50 / 2.42 ACH



Ventilation

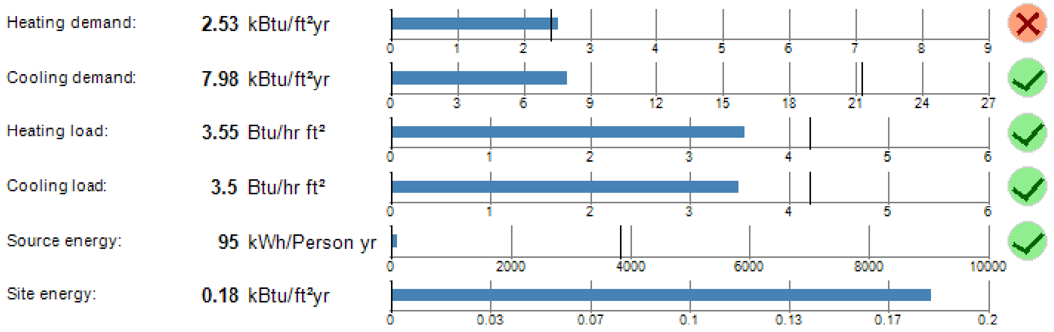
Baseline:

Sensible recovery efficiency [-]	.8
Humidity recovery efficiency [-]	.68
Electric efficiency [W/cfm]	.5



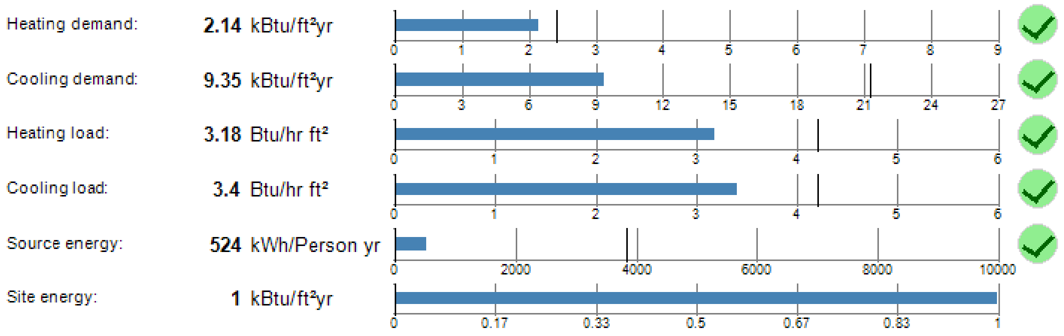
Lower Sensible Recovery:

Sensible recovery efficiency [-]	.6
Humidity recovery efficiency [-]	.68
Electric efficiency [W/cfm]	.5



Lower Humidity Recovery:

Sensible recovery efficiency [-]	.8
Humidity recovery efficiency [-]	.5
Electric efficiency [W/cfm]	.5



Zero Humidity Recovery = Cooling Demand @ 13.4 kBtu/ft^{2}yr!

DHW

Large buildings and slab on grade construction leads to longer DHW piping runs and wait times for hot water (ZERH requirement can be challenging).

Preference to:
On-demand recirculation systems
Instantaneous water heaters for specific locations

Hot water heaters sometimes located in attics to save space on main floor

Heat Pump Water Heater inside vs Split system:

Non-Split HPWH provide free cooling inside the project.
This is a big advantage compared to the split system.
The cost is substantially less as well and easier to replace.
Acoustics and cold air distribution / location of the HPWH are a concern.

System Considerations

System Requirements:

Heating, Cooling, Dehumidification

Both projects plan on using Mini-Split Heat Pump technologies as the primary heating and cooling system.

Dehumidification is being specified using a dedicated dehumidifier and duct system

Positive Impact Homes is specifying an additional air filtration system in addition to the filters on the rest of the mechanical equipment

Electrification

Both projects are pursuing full electrification, but there are some issues.

Backup Energy

A main drawback to full electrification is the requirement for backup and resiliency.
This is especially a concern regarding recent events with grid outages during frosts and hurricane season.
For this reason, Positive Impact Homes has been specifying Natural Gas supply or Propane Tank for a backup generator.

System Considerations

PV Potential:

Houston: 20deg Tilt

Houston Tx
» Change Location

English | Español | HELP | FEEDBACK

RESULTS

RESULTS

Print Results

14,113 kWh/Year*

n 13,653 to 14,493 kWh per year near this location.
Click HERE for more information.

Month	AC Energy (kWh)
January	901
February	956
March	1,196
April	1,303
May	1,346
June	1,337
July	1,343
August	1,311
September	1,271
October	1,239
November	992
December	917
Annual	14,112

Houston: 40deg Tilt

English | Español | HELP | FEEDBACK

RESULTS

13,990 kWh/Year*

13,534 to 14,366 kWh per year near this location.
Click HERE for more information.

	AC Energy (kWh)
	1,024
	1,041
	1,204
	1,224
	1,191
	1,146
	1,178
	1,211
	1,260
	1,324
	1,121
	1,063
	13,987

Chicago: 40deg Tilt

Chicago IL
» Change Location

English | Español | HELP | FEEDBACK

RESOURCE DATA | SYSTEM INFO | RESULTS

RESULTS

Print Results

13,291 kWh/Year*

System output may range from 12,724 to 13,848 kWh per year near this location.
Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	2.96	797
February	3.87	912
March	4.79	1,209
April	5.38	1,292
May	5.41	1,299
June	5.94	1,336
July	6.06	1,371
August	5.91	1,330
September	5.47	1,214
October	4.32	1,045
November	3.30	815
December	2.52	672
Annual	4.66	13,292