

BUILDING INFORMATION

Category:	Residential
Status:	In planning
Building type:	New construction
Year of construction:	2016
Units:	1
Number of occupants:	4 (Design)



Boundary conditions

Climate:	PHILADELPHIA INTERNATIONAL AP PA
Internal heat gains:	0.8 Btu/hr ft ²
Interior temperature:	68 °F
Overheat temperature:	77 °F

Building geometry

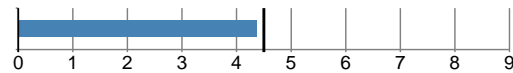
Enclosed volume:	38935.2 ft ³
Total area envelope:	7699.7 ft ²
AV ratio:	0.2 1/ft
Floor area:	2293 ft ²

PASSIVEHOUSE REQUIREMENTS

Certificate criteria: PHIUS+ 2015 Standard

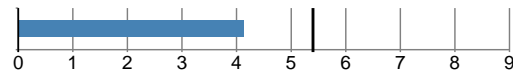
Heating demand

specific:	4.37 kBtu/ft ² yr
target:	4.5 kBtu/ft ² yr
total:	10024.91 kBtu/yr



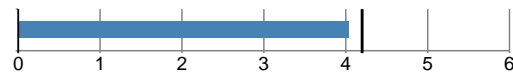
Cooling demand

specific:	4.13 kBtu/ft ² yr
target:	5.4 kBtu/ft ² yr
total:	9477.48 kBtu/yr
latent:	2.45 kBtu/ft ² yr



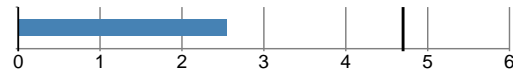
Heating load

specific:	4.04 Btu/hr ft ²
target:	4.2 Btu/hr ft ²
total:	9259.29 Btu/hr



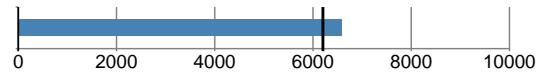
Cooling load

specific:	2.54 Btu/hr ft ²
target:	4.7 Btu/hr ft ²
total:	5833.06 Btu/hr



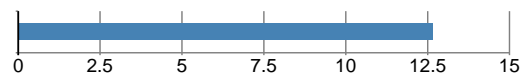
Primary energy

specific:	6593 kWh/Person yr
target:	6200 kWh/Person yr
total:	89976.51 kBtu/yr



Site energy

total:	12.64 kBtu/ft ² yr
building systems:	36.27 kBtu/yr
photovoltaic savings:	0 kBtu/ft ² yr



Air tightness

ACH50:	0.6 1/hr
target:	0.93 1/hr
CFM50 per envelope area:	0.03 cfm/ft ²
target:	0.05 cfm/ft ²

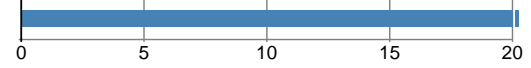


PASSIVEHOUSE RECOMMENDATIONS

HRV efficiency: **73.4 %**



Frequency of overheating: **29.5 %**
Cooling system is required

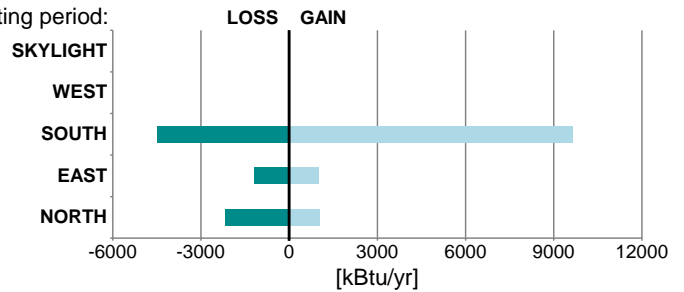


BUILDING ELEMENTS

Windows

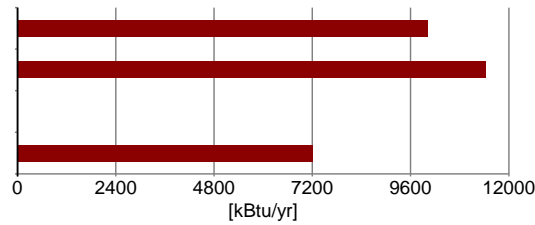
Average SHGC: **0.49**
Average solar reduction factor heating: **0.36**
Average solar reduction factor cooling: **0.21**
Average U-value: **0.146 Btu/hr ft² °F**
Total glazing area: **330.2 ft²**

Heat gain/loss heating period:



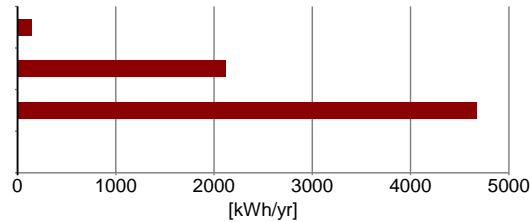
HVAC

Total heating demand: **10025 kBtu/yr**
Total DHW energy demand: **11451 kBtu/yr**
Solar DHW contribution: **0 kBtu/yr**
Auxiliary electricity: **7226 kBtu/yr**



Electricity

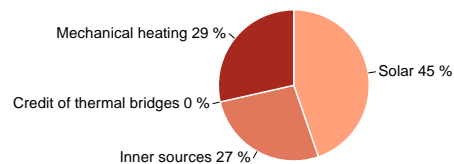
Direct heating / DHW: **147 kWh/yr**
HVAC auxiliary energy: **2118 kWh/yr**
Appliances: **4680 kWh/yr**
Output PV system: **0 kWh/yr**
Total electricity demand: **6944 kWh/yr**



HEAT FLOW

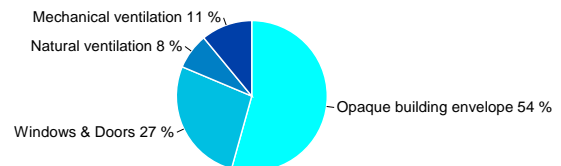
Heat gains

Solar: **14102 kBtu/yr**
Inner sources: **8435 kBtu/yr**
Credit of thermal bridges: **0 kBtu/yr**
Mechanical heating: **10025 kBtu/yr**



Heat losses

Opaque building envelope: **17698 kBtu/yr**
Windows & Doors: **8789 kBtu/yr**
Natural ventilation: **2502 kBtu/yr**
Mechanical ventilation: **3573 kBtu/yr**

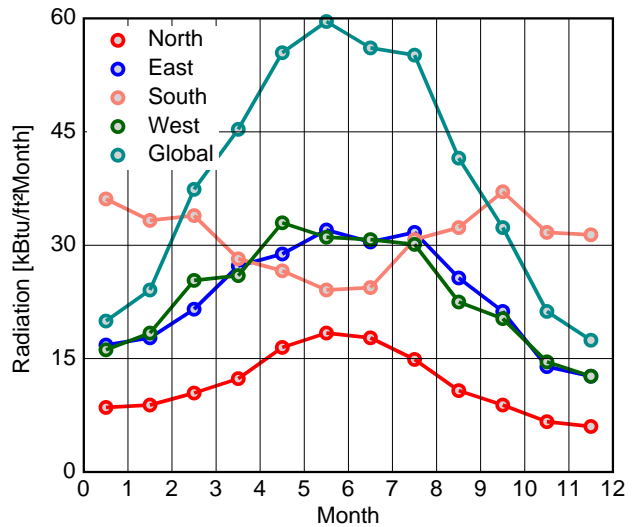
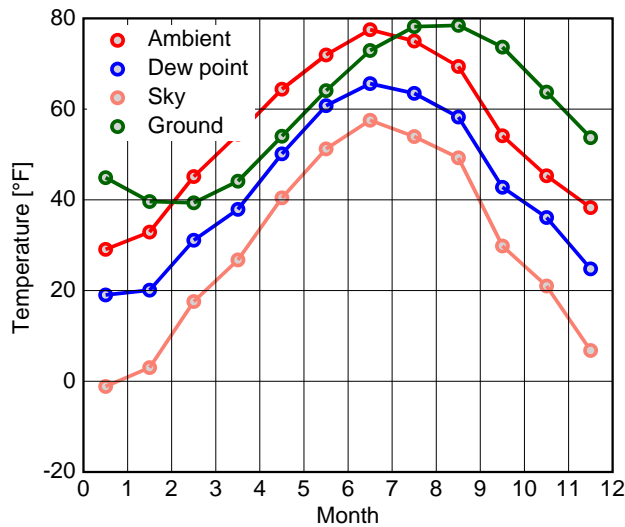


CLIMATE

Latitude: **39.9 °**
 Longitude: **-75.2 °**
 Elevation of weather station: **6.6 ft**
 Elevation of building site: **35 ft**
 Heat capacity air: **0.018 Btu/ft³F**
 Daily temperature swing summer: **18.4 °F**
 Average wind speed: **13.1 ft/s**

Ground

Average ground surface temperature: **56.5 °F**
 Amplitude ground surface temperature: **56.2 °F**
 Ground thermal conductivity: **1.2 Btu/hr ft °F**
 Ground heat capacity: **29.8 Btu/ft³F**
 Depth below grade of groundwater: **9.8 ft**
 Flow rate groundwater: **0.2 ft/d**



Calculation parameters

Length of heating period: **212 days/yr**
 Heating degree hours: **120.8 kFh/a**
 Phase shift months: **1.4 mths**

Climate for	Heating load 1	Heating load 2	Cooling
Temperature [°F]	20.3	26.2	81.9
Solar radiation North [Btu/hr ft²]	12.4	9.5	26.6
Solar radiation East [Btu/hr ft²]	27.9	9.8	49.8
Solar radiation South [Btu/hr ft²]	59	13.6	39.3
Solar radiation West [Btu/hr ft²]	23.5	10.8	50.7
Solar radiation Global [Btu/hr ft²]	30.4	16.2	97

Relevant boundary conditions for heating load calculation: Heating load 2

ANNUAL HEAT DEMAND

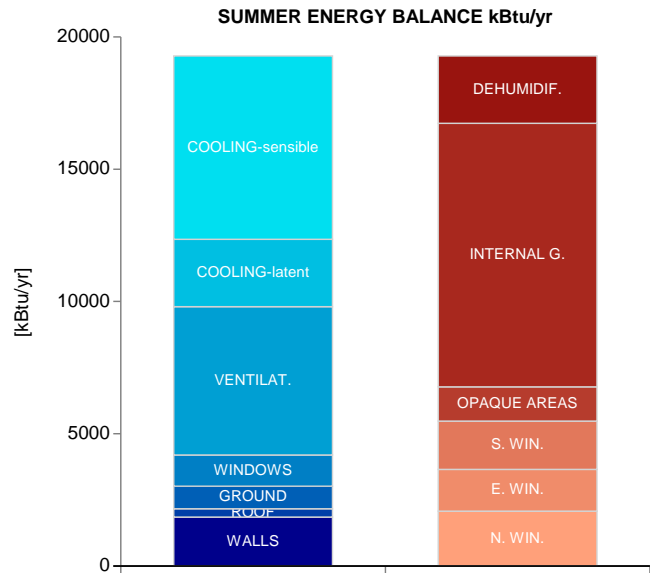
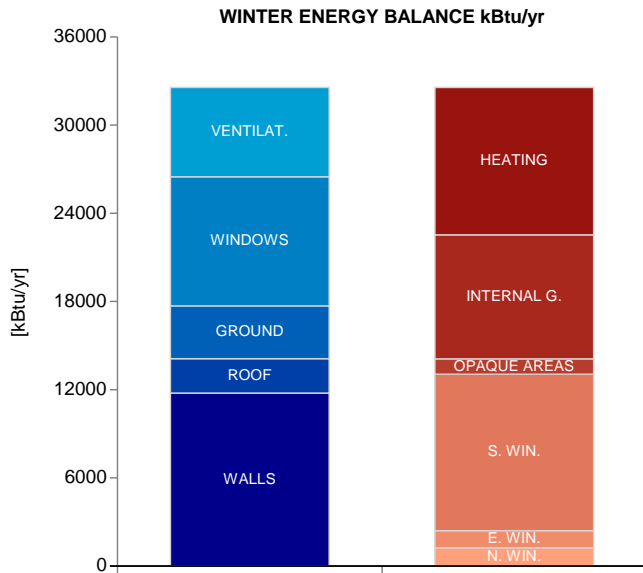
Transmission losses :	26487 kBtu/yr
Ventilation losses:	6075 kBtu/yr
Total heat losses:	32562 kBtu/yr
Solar heat gains:	15723 kBtu/yr
Internal heat gains:	9405 kBtu/yr
Total heat gains:	25129 kBtu/yr
Utilization factor:	89.7 %
Useful heat gains:	22537 kBtu/yr

Annual heat demand:	10025 kBtu/yr
Specific annual heat demand:	4372.4 Btu/ft ² yr

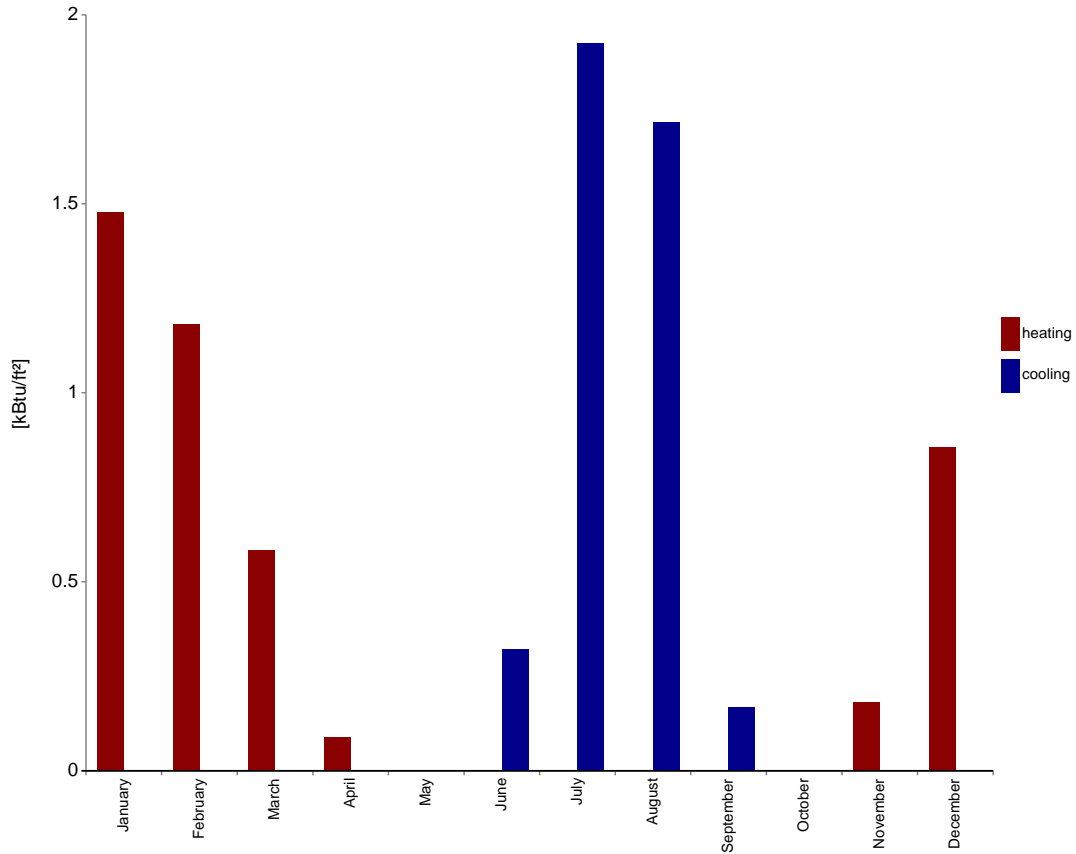
ANNUAL COOLING DEMAND

Solar heat gains:	6776 kBtu/yr
Internal heat gains:	9959 kBtu/yr
Total heat gains:	16736 kBtu/yr
Transmission losses :	5715 kBtu/yr
Ventilation losses:	7629 kBtu/yr
Total heat losses:	13344 kBtu/yr
Utilization factor:	73.5 %
Useful heat losses:	9805 kBtu/yr

Cooling demand - sensible:	6931 kBtu/yr
Cooling demand - latent:	2546 kBtu/yr
Annual cooling demand:	9477 kBtu/yr
Specific annual cooling demand:	4.1 kBtu/ft ² yr



SPECIFIC HEAT/COOLING DEMAND MONTHLY



Month	Heating [kBTu/ft²]	Cooling [kBTu/ft²]
January	1.5	0
February	1.2	0
March	0.6	0
April	0.1	0
May	0	0
June	0	0.3
July	0	1.9
August	0	1.7
September	0	0.2
October	0	0
November	0.2	0
December	0.9	0

HEATING LOAD

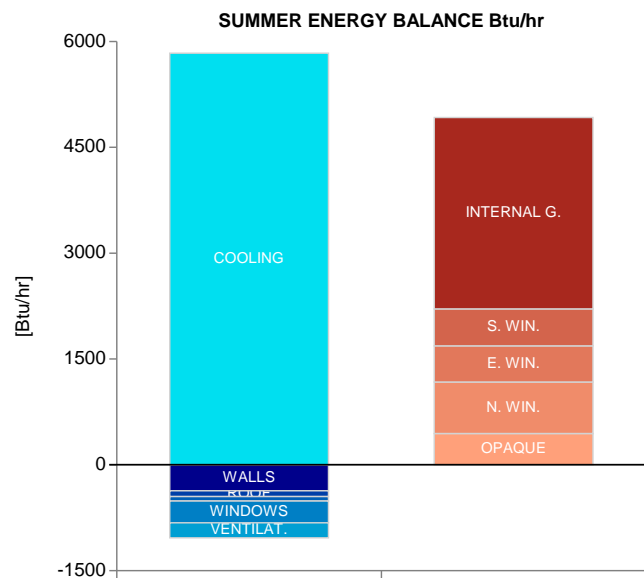
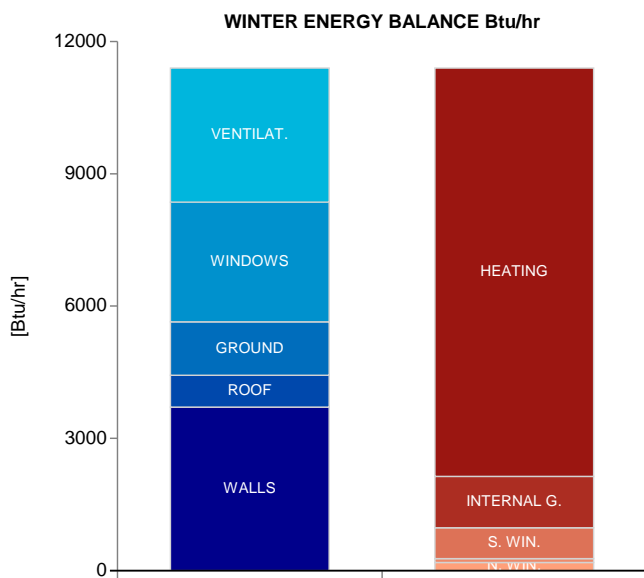
	First climate	Second climate
Transmission heat losses:	9247.2 Btu/hr	8357.2 Btu/hr
Ventilation heat losses:	3469.5 Btu/hr	3038.3 Btu/hr
Total heat loss:	12716.7 Btu/hr	11395.5 Btu/hr
Solar heat gain:	3563.3 Btu/hr	973.2 Btu/hr
Internal heat gain:	1163 Btu/hr	1163 Btu/hr
Total heat gains heating:	4726.3 Btu/hr	2136.2 Btu/hr
Heating load:	7990.4 Btu/hr	9259.3 Btu/hr

Relevant heating load: **9259.3** Btu/hr
 Specific heating load: **4** Btu/hr ft²

COOLING LOAD

Solar heat gain:	2209.3 Btu/hr
Internal heat gain:	2712.5 Btu/hr
Total heat gains cooling:	4921.8 Btu/hr
Transmission heat losses:	-697.4 Btu/hr
Ventilation heat losses:	-213.9 Btu/hr
Total heat loss:	-911.3 Btu/hr
Cooling load - sensible:	5833.1 Btu/hr
Cooling load - latent:	0 Btu/hr

Relevant cooling load: **5833.1** Btu/hr
 Specific maximum cooling load: **2.5** Btu/hr ft²



AREAS

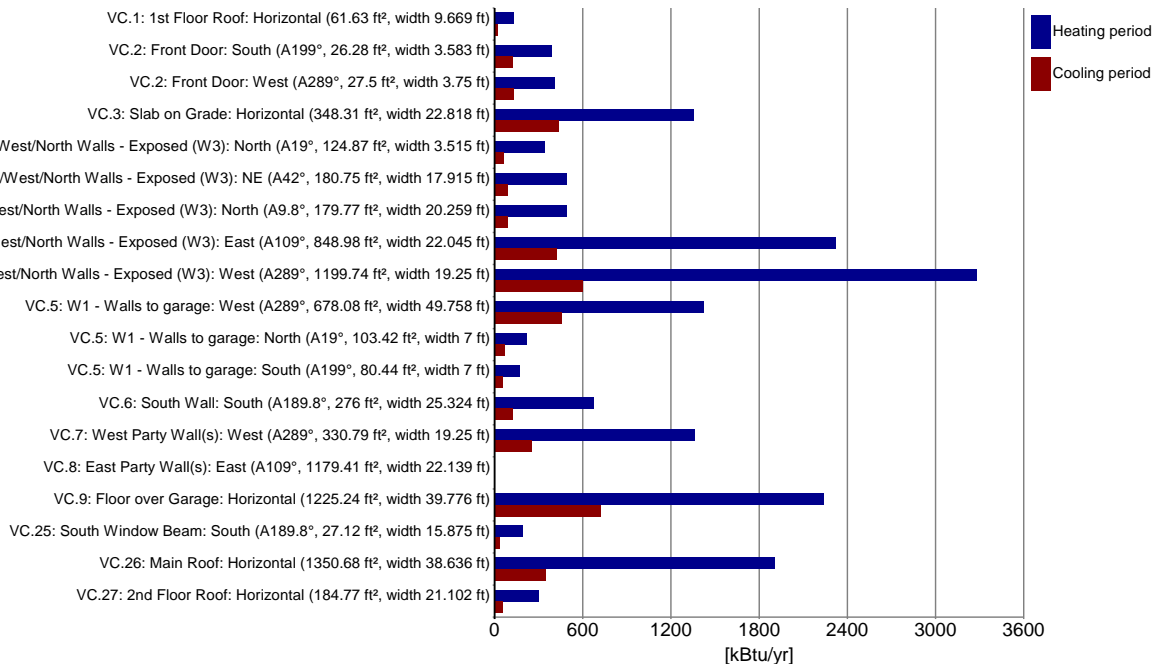
Transmission heat losses - areas

Name	Area [ft²]	Average U-value [Btu/hr ft² °F]	Absorption coefficient	Emission coefficient	Reduction factor shading [%]	Transmission losses heating [kBtu/yr]	Transmission losses cooling [kBtu/yr]
VC.1: 1st Floor Roof: Horizontal (61.63 ft², width 9.669 ft)	61.6	0.015	0.4	0.9	100	129	23.7
VC.2: Front Door: South (A199°, 26.28 ft², width 3.583 ft)	26.3	0.174	0	0	0	389.8	125.4
VC.2: Front Door: West (A289°, 27.5 ft², width 3.75 ft)	27.5	0.174	0	0	0	407.9	131.3
VC.3: Slab on Grade: Horizontal (348.31 ft², width 22.818 ft)	348.3	0.046	0	0	0	1354.1	435.7
VC.4: East/West/North Walls - Exposed (W3): North (A19°, 124.87 ft², width 3.515 ft)	124.9	0.02	0.4	0.9	100	341.5	62.6
VC.4: East/West/North Walls - Exposed (W3): NE (A42°, 180.75 ft², width 17.915 ft)	180.7	0.02	0.4	0.9	100	494.3	90.6
VC.4: East/West/North Walls - Exposed (W3): North (A9.8°, 179.77 ft², width 20.259 ft)	179.8	0.02	0.4	0.9	100	491.6	90.2
VC.4: East/West/North Walls - Exposed (W3): East (A109°, 848.98 ft², width 22.045 ft)	849	0.02	0.4	0.9	100	2321.8	425.8
VC.4: East/West/North Walls - Exposed (W3): West (A289°, 1199.74 ft², width 19.25 ft)	1199.7	0.02	0.4	0.9	100	3281.1	601.7
VC.5: W1 - Walls to garage: West (A289°, 678.08 ft², width 49.758 ft)	678.1	0.025	0	0	0	1422.4	457.7
VC.5: W1 - Walls to garage: North (A19°, 103.42 ft², width 7 ft)	103.4	0.025	0	0	0	217	69.8
VC.5: W1 - Walls to garage: South (A199°, 80.44 ft², width 7 ft)	80.4	0.025	0	0	0	168.7	54.3
VC.6: South Wall: South (A189.8°, 276 ft², width 25.324 ft)	276	0.018	0.4	0.9	100	675.4	123.9
VC.7: West Party Wall(s): West (A289°, 330.79 ft², width 19.25 ft)	330.8	0.03	0	0	0	1363.1	250
VC.8: East Party Wall(s): East (A109°, 1179.41 ft², width 22.139 ft)	1179.4	0.072	0	0	0	0	0
VC.9: Floor over Garage: Horizontal (1225.24 ft², width 39.776 ft)	1225.2	0.021	0	0	0	2240.4	720.9
VC.25: South Window Beam: South (A189.8°, 27.12 ft², width 15.875 ft)	27.1	0.053	0.4	0.9	100	193.8	35.5
VC.26: Main Roof: Horizontal (1350.68 ft², width 38.636 ft)	1350.7	0.01	0.4	0.9	70	1908.1	349.9
VC.27: 2nd Floor Roof: Horizontal (184.77 ft², width 21.102 ft)	184.8	0.012	0.4	0.9	100	297.9	54.6

Degree hours [kFh/a]

	Heating	Cooling
Ambient heating	75.2	13.8
Ground heating	47.3	15.2

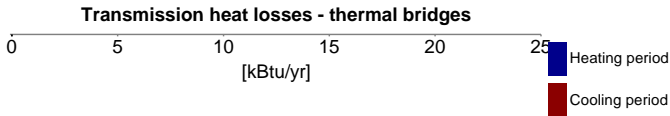
Transmission heat losses - areas



THERMAL BRIDGES

Transmission heat losses - thermal bridges

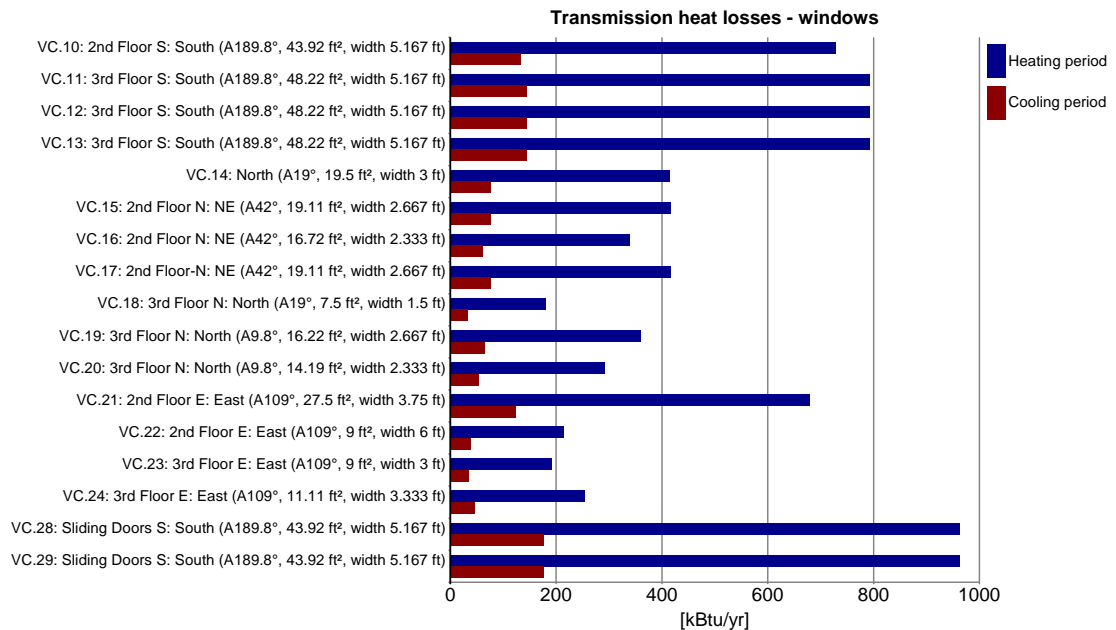
Name	Length [ft]	Psi-value [Btu/hr ft °F]	Transmission losses [kBtu/yr]	Transmission losses cooling [kBtu/yr]
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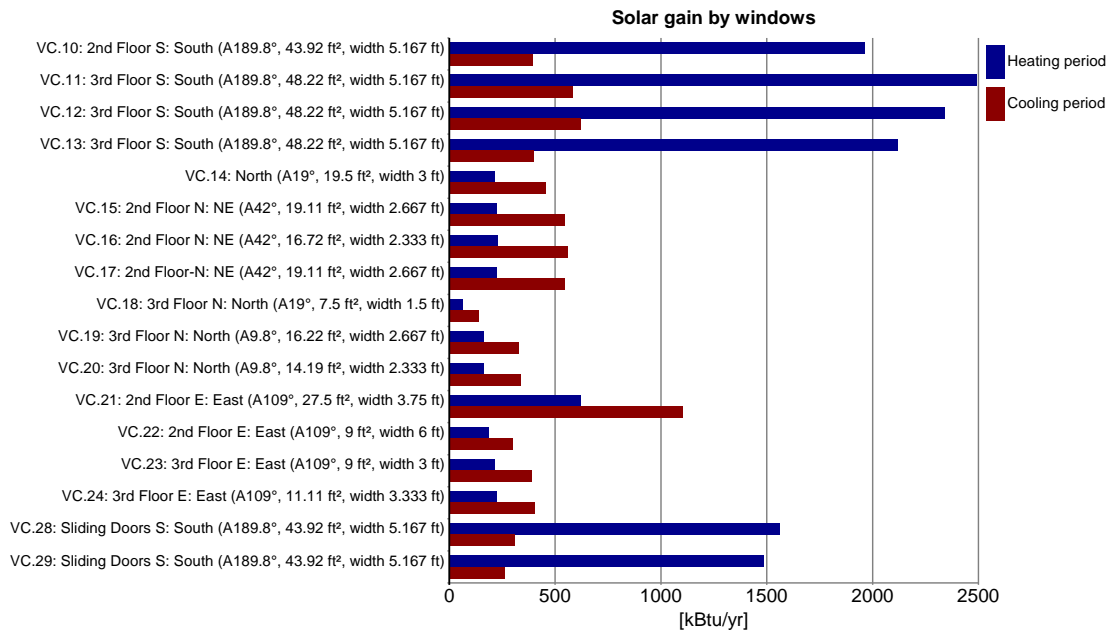


WINDOWS

Transmission heat losses - windows

Name	Quantity	Inclination [°]	U-value total [Btu/hr ft² °F]	SHGC (perpendicular)	Reduction factor shading [%]	Reduction factor shading summer [%]	Solar gain heating [kBtu/yr]	Solar gain cooling [kBtu/yr]	Transmission losses heating [kBtu/yr]	Transmission losses cooling [kBtu/yr]
VC.10: 2nd Floor S: South (A189.8°, 43.92 ft², width 5.167 ft)	1	90	0.122	0.5	56.5	12.7	1961.9	393.7	727.9	133.5
VC.11: 3rd Floor S: South (A189.8°, 48.22 ft², width 5.167 ft)	1	90	0.121	0.5	65	17.1	2493.2	582.6	792.3	145.3
VC.12: 3rd Floor S: South (A189.8°, 48.22 ft², width 5.167 ft)	1	90	0.121	0.5	61.1	18.2	2343	622.6	792.3	145.3
VC.13: 3rd Floor S: South (A189.8°, 48.22 ft², width 5.167 ft)	1	90	0.121	0.5	55.2	11.7	2117.7	399.3	792.3	145.3
VC.14: North (A19°, 19.5 ft², width 3 ft)	1	90	0.157	0.5	70.6	75.1	214.5	455.1	414.5	76
VC.15: 2nd Floor N: NE (A42°, 19.11 ft², width 2.667 ft)	1	90	0.161	0.5	68.1	76.8	227	548.4	417	76.5
VC.16: 2nd Floor N: NE (A42°, 16.72 ft², width 2.333 ft)	1	90	0.15	0.5	66	75.2	229.1	559.7	338.5	62.1
VC.17: 2nd Floor-N: NE (A42°, 19.11 ft², width 2.667 ft)	1	90	0.161	0.5	68.1	76.8	227	548.4	417	76.5
VC.18: 3rd Floor N: North (A19°, 7.5 ft², width 1.5 ft)	1	90	0.179	0.5	58	63.5	64.5	141	181.5	33.3
VC.19: 3rd Floor N: North (A9.8°, 16.22 ft², width 2.667 ft)	1	90	0.164	0.5	69.2	73	161.4	329	359.4	65.9
VC.20: 3rd Floor N: North (A9.8°, 14.19 ft², width 2.333 ft)	1	90	0.152	0.5	67.4	71.1	165.1	337	291.4	53.4
VC.21: 2nd Floor E: East (A109°, 27.5 ft², width 3.75 ft)	1	90	0.182	0.5	61.5	74	619.4	1102.5	678.8	124.5
VC.22: 2nd Floor E: East (A109°, 9 ft², width 6 ft)	1	90	0.176	0.5	54.5	58.9	186.8	298.6	215.1	39.4
VC.23: 3rd Floor E: East (A109°, 9 ft², width 3 ft)	1	90	0.157	0.5	55.7	68.1	215.6	390.1	191.5	35.1
VC.24: 3rd Floor E: East (A109°, 11.11 ft², width 3.333 ft)	1	90	0.169	0.5	57.5	69.8	225.6	404.4	253.9	46.6
VC.28: Sliding Doors S: South (A189.8°, 43.92 ft², width 5.167 ft)	1	90	0.162	0.5	56	12.4	1561.8	308.6	962.6	176.5
VC.29: Sliding Doors S: South (A189.8°, 43.92 ft², width 5.167 ft)	1	90	0.162	0.5	53.3	10.5	1487.4	261	962.6	176.5





Summary building envelope

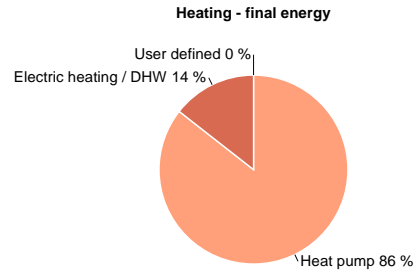
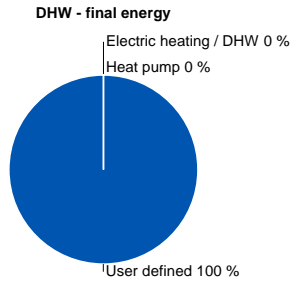
	Total area / length	Average U-value / Psi value	Transmission losses
Exterior wall ambient:	3168 ft²	0.02 Btu/hr ft² °F	9162.7 kBtu/yr
Exterior wall ground:	915.7 ft²	0.03 Btu/hr ft² °F	2605.8 kBtu/yr
Basement:	1573.5 ft²	0.03 Btu/hr ft² °F	3594.5 kBtu/yr
Roof:	1597.1 ft²	0.01 Btu/hr ft² °F	2335 kBtu/yr
Windows:	445.4 ft²	0.15 Btu/hr ft² °F	8788.7 kBtu/yr
Doors:	0 ft²	0 Btu/hr ft² °F	0 kBtu/yr
Thermal bridge ambient:	0 ft	0 Btu/hr ft °F	0 kBtu/yr
Thermal bridge perimeter:	0 ft	0 Btu/hr ft °F	0 kBtu/yr
Thermal bridge floor slab:	0 ft	0 Btu/hr ft °F	0 kBtu/yr

Shading

	Heating	Cooling
Reduction factor North:	67.6 %	74.4 %
Reduction factor East:	58.6 %	69.7 %
Reduction factor South:	58.2 %	14 %
Reduction factor West:	100 %	100 %
Reduction factor Horizontal:	100 %	100 %

HVAC SYSTEMS

System	DHW			Heating			Total		
	Covered DHW demand [%]	Estimated solar fraction [%]	Final energy demand [kBtu/yr]	Covered heating demand [%]	Estimated solar fraction [%]	Final energy demand [kBtu/yr]	Performance ratio	CO2 equivalent emissions [lb/yr]	Primary energy demand [kBtu/yr]
Heat pump	0	0	0	95	0	2971.4	0	1305.6	9389.6
Electric heating / DHW	0	0	0	5	0	501.2	0	220.2	1583.9
User defined	100	0	4780.8	0	0	0	0.5	1372	15107.2
Σ	100	0	4780.8	100	0	3472.6		2897.9	26080.7



COOLING UNITS

	sensible	latent
Air cooling:	0 kBtu/ft²yr	0 kBtu/ft²yr
Recirculation cooling:	3 kBtu/ft²yr	2.5 kBtu/ft²yr
Additional dehumidification:		0 kBtu/ft²yr
Panel cooling:	0 kBtu/ft²yr	
Sum:	3 kBtu/ft²yr	2.5 kBtu/ft²yr

VENTILATION

Infiltration pressure test ACH50: **0.6** 1/hr
 Room ventilation volume: **24841** ft³
 Total extract air demand: **120** cfm
 Supply air per person: **18** cfm
 Occupancy: **4**

Average air flow rate: **93.5** cfm
 Average air change rate: **0.23** 1/hr
 Effective ACH ambient: **0.1** 1/hr
 Effective ACH ground: **0** 1/hr
 Energetically effective air exchange: **0.1** 1/hr
 Infiltration air change rate: **0.04** 1/hr
 Infiltration air change rate (heating load): **0.11** 1/hr

Type of ventilation system: **Balanced PH ventilation**
 Wind screening coefficient (e): **0.07**
 Wind exposure factor: **15**
 Wind shield factor: **0.05**

Ventilation heat losses: **5420.74** kBtu/yr

Devices

Name	HRV / ERV efficiency [-]	Electric efficiency [Btu/ft ³]	Heat recovery efficiency SHX [-]	Effective recovery efficiency [-]
ComfoAir350, Cofod350, WHR930 - Zehnder	0.8	0	0	0.8
Altogether	0.7	0	0	0.7

Ducts

Name	Length (total) [ft]	Clear cross-section [ft ²]	U-value [Btu/hr ft ² °F]	Assigned ventilation units
Supply / outdoor air duct	8.2	0.1963	1.4	ComfoAir350, Cofod350, WHR930 - Zehnder
Extract / Exhaust air duct	8.2	0.1963	1.4	ComfoAir350, Cofod350, WHR930 - Zehnder
Σ	16.4			

*length * quantity

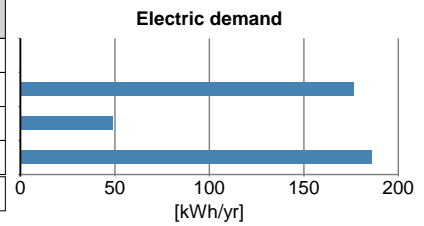
** thermal conductivity / thickness

SUMMER VENTILATION

ACH night ventilation: **0.3** 1/hr
 ACH natural summer: **0** 1/hr
 Mechanical ventilation summer: **0.2** 1/hr
 Mechanical ventilation summer with HR: **no**
 Preferred minimum indoor temperature for night ventilation: **68** °F
 Overheating temperature: **77** °F

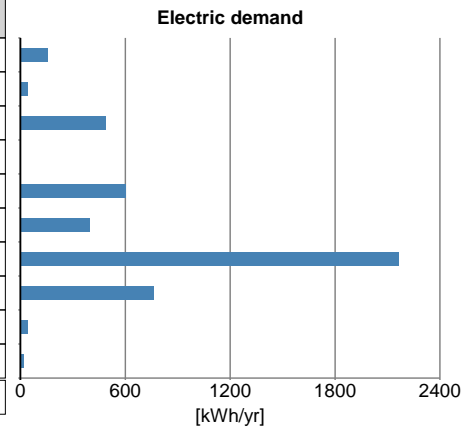
ELECTRICITY DEMAND - AUXILIARY ELECTRICITY

Type	Quantity	Indoor	Norm demand	Electric demand [kWh/yr]	Primary energy [kBtu/yr]
Other	1	yes	0 W	0	0
Ventilation winter	1	no	0.4 W/cfm	176.3	1900.9
Defroster HX	1	no	362.4 W	48.9	527.4
Ventilation summer	1	no	0.4 W/cfm	185.8	2003.4
Σ				411	4431.6



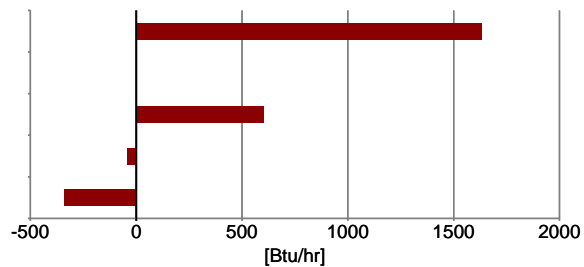
ELECTRICITY DEMAND RESIDENTIAL BUILDING

Type	Quantity	Indoor	Norm demand	Electric demand [kWh/yr]	Primary energy [kBtu/yr]
Kitchen dishwasher	1	yes	1.2 kWh/Use	159.9	1723.9
Laundry - washer	1	yes	0.3 kWh/Use	40.1	432.6
Laundry - dryer	1	yes	2.4 kWh/Use	486.8	5248.1
Energy consumed by evaporation	0	yes	3.1 kWh	0	0
Kitchen fridge/freeze combo	1	yes	1.7 kWh/d	602.3	6493
Kitchen cooktop	1	yes	0.2 kWh/Use	400	4312.5
PHIUS+ 2015 MELS	1	yes	2165.3 kWh/yr	2165.3	23344.8
PHIUS+ 2015 Interior lighting	1	yes	762.3 kWh/yr	762.3	8218.7
PHIUS+ 2015 Exterior lighting	1	no	42.9 kWh/yr	42.9	462.8
PHIUS+ 2015 Garage lighting	1	no	20 kWh/yr	20	215.6
Σ	9			4679.6	50452.2



INTERNAL HEAT GAINS

Electricity total:	1631.5 Btu/hr
Auxiliary electricity:	0 Btu/hr
Persons:	600.5 Btu/hr
Cold water:	-42.1 Btu/hr
Evaporation persons:	-341.2 Btu/hr
Σ:	1848.7 Btu/hr
Specific internal heat gains:	0.8 Btu/hr ft ²



DHW AND DISTRIBUTION

DHW consumption per person per day:	6.6 gal/Person/day
Average cold water temperature supply:	56.5 °F
Useful heat DHW:	7526.3 kBtu/yr
Specific useful heat DHW:	3282.6 Btu/ft²yr
Total heat losses of the DHW system:	3924.5 kBtu/yr
Specific losses of the DHW system:	1711.7 Btu/ft²yr
Performance ratio DHW distribution system and storage:	1.5
Utilization ratio DHW distribution system and storage:	0.7
Total heat demand of DHW system:	11450.7 kBtu/yr
Total specific heat demand of DHW system:	4994.3 Btu/ft²yr
Total heat losses of the hydronic heating distribution:	0 kBtu/yr
Specific losses of the hydronic heating distribution:	0 Btu/ft²yr
Performance ratio of heat distribution:	100 %

Region	Length [ft]	Annual heat loss [kBtu/yr]
Hydronic heating distribution pipes		
Σ	0	0
DHW circulation pipes		
Warm region	0	0
Σ	0	0
Individual pipes		
Warm region	280.8	3924.5
Σ	280.8	3924.5
Water storage		
Σ		0