

BUILDING INFORMATION

Category:	Residential
Status:	In planning
Building type:	New construction
Year of construction:	2026
Units:	20
Number of occupants:	53 (Design)
Occupant density:	462.1 ft²/Person



Boundary conditions

Climate:	BOSTON LOGAN INT ARPT MA
Internal heat gains:	1.2 Btu/hr ft²
Interior temperature:	68 °F
Overheat temperature:	77 °F

Building geometry

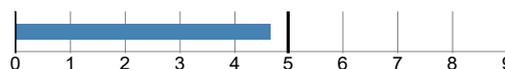
Enclosed volume:	274,194.3 ft³
Net-volume:	208,387.6 ft³
Total area envelope:	28,330 ft²
Area/Volume Ratio:	0.1 1/ft
Floor area:	24,489 ft²
Envelope area/iCFA:	1.157

PASSIVEHOUSE REQUIREMENTS

Certificate criteria: Phius CORE 2021

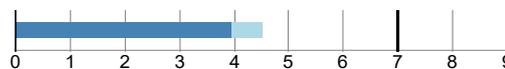
Heating demand

specific:	4.67 kBtu/ft²yr
target:	5 kBtu/ft²yr
total:	114,348.09 kBtu/yr



Cooling demand

sensible:	3.95 kBtu/ft²yr
latent:	0.58 kBtu/ft²yr
specific:	4.53 kBtu/ft²yr
target:	7 kBtu/ft²yr
total:	110,819.36 kBtu/yr



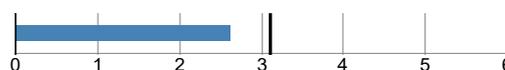
Heating load

specific:	3.73 Btu/hr ft²
target:	4.4 Btu/hr ft²
total:	91,416.03 Btu/hr



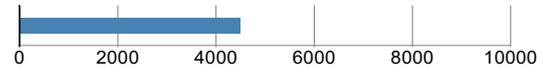
Cooling load

specific:	2.61 Btu/hr ft²
target:	3.1 Btu/hr ft²
total:	63,892.82 Btu/hr



Source energy

total: **238,302.04** kWh/yr
 specific: **4,496** kWh/Person yr
 target: **10,625** kWh/Person yr
 total: **813,040.04** kBtu/yr
 specific: **33.2** kBtu/ft²yr



Site energy

total: **406,520.02** kBtu/yr
 specific: **16.6** kBtu/ft²yr
 total: **119,151.02** kWh/yr
 specific: **4.87** kWh/ft²



Air tightness

ACH50: **0.41** 1/hr
 CFM50 per envelope area: **0.05** cfm/ft²
 target: **0.49** 1/hr
 target CFM50: **0.06** cfm/ft²

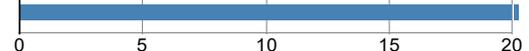


PASSIVEHOUSE RECOMMENDATIONS

Sensible recovery efficiency: **70.5** %



Frequency of overheating: **43.4** %
 Cooling system is required

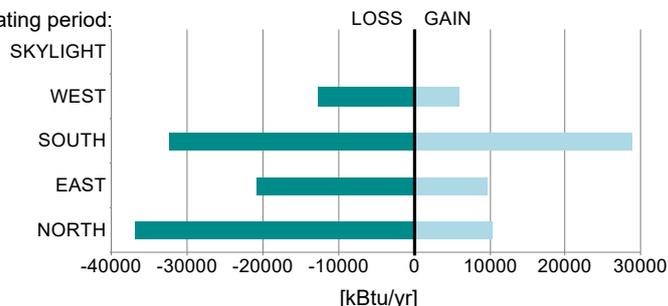


Frequency of overheating only applies if there is not a [properly sized] cooling system installed.

BUILDING ELEMENTS

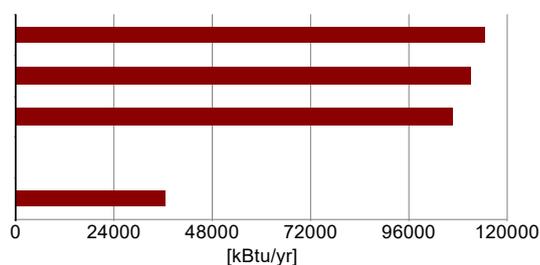
Windows

	Heat gain/loss heating period:
Average SHGC:	0.36
Average solar reduction factor heating:	0.37
Average solar reduction factor cooling:	0.33
Average U-value:	0.207 Btu/hr ft² °F
Total glazing area:	2,309 ft²
Total window area:	3,524.2 ft²



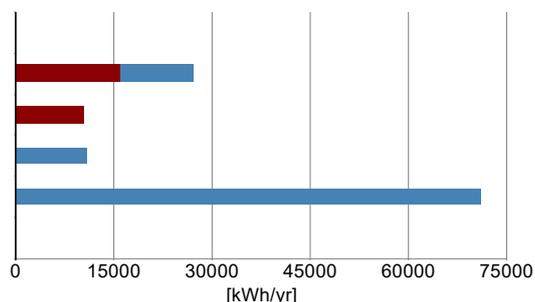
HVAC

Total heating demand:	114,348 kBtu/yr
Total cooling demand:	110,819 kBtu/yr
Total DHW energy demand:	106,641 kBtu/yr
Solar DHW contribution:	0 kBtu/yr
Auxiliary electricity:	36,620 kBtu/yr



Electricity

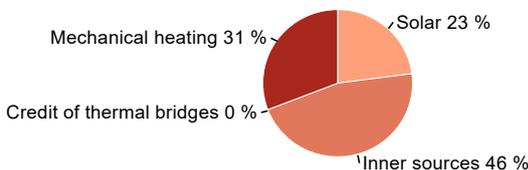
Direct heating / DHW:	0 kWh/yr
Heatpump heating:	26,973 kWh/yr
Cooling:	10,381 kWh/yr
HVAC auxiliary energy:	10,733 kWh/yr
Appliances:	71,064 kWh/yr
Renewable generation, coincident production and use:	0 kWh/yr
Total electricity demand:	119,151 kWh/yr



HEAT FLOW - HEATING PERIOD

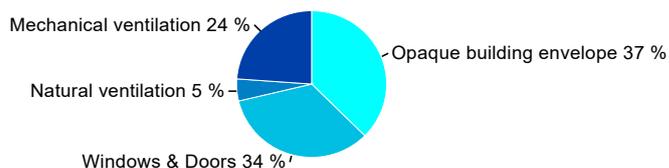
Heat gains

Solar:	74,790 kBtu/yr
Inner sources:	150,635 kBtu/yr
Credit of thermal bridges:	0 kBtu/yr
Mechanical heating:	114,348 kBtu/yr



Heat losses

Opaque building envelope:	127,266 kBtu/yr
Windows & Doors:	114,912 kBtu/yr
Natural ventilation:	16,500 kBtu/yr
Mechanical ventilation:	81,096 kBtu/yr

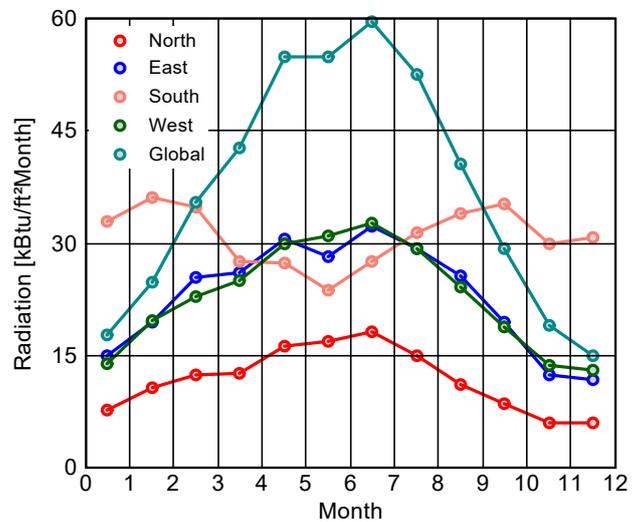
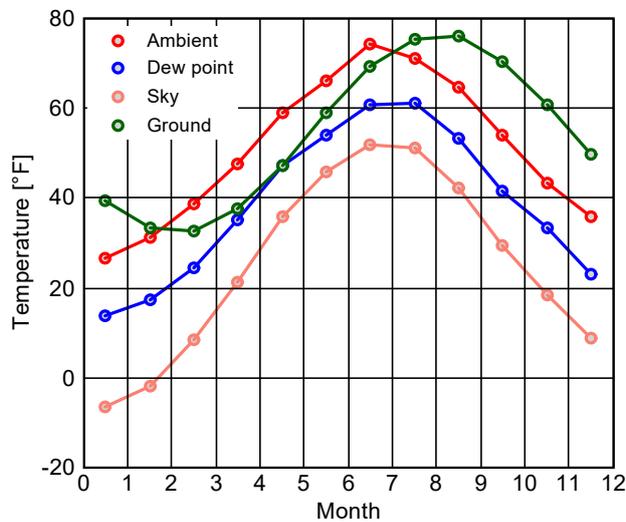


CLIMATE

Latitude: **42.4 °**
 Longitude: **-71 °**
 Elevation of weather station: **19.7 ft**
 Elevation of building site: **10 ft**
 Heat capacity air: **0.018 Btu/ft³F**
 Daily temperature swing summer: **14.8 °F**
 Average wind speed: **13.1 ft/s**

Ground

Average ground surface temperature: **52.8 °F**
 Amplitude ground surface temperature: **55.8 °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: **243 days/yr**
 Heating degree hours: **140.9 kFh/a**
 Phase shift months: **1.3 mths**
 Time constant heating demand: **120.2 hr**
 Time constant cooling demand: **0 hr**
 Time constant cooling demand with night ventilation: **0 hr**

Climate for	Heating load 1	Heating load 2	Cooling
Temperature [°F]	16.9	31.6	83.5
Solar radiation North [Btu/hr ft²]	12	7.9	27.6
Solar radiation East [Btu/hr ft²]	22.8	13.3	61.5
Solar radiation South [Btu/hr ft²]	49.5	27.3	41.8
Solar radiation West [Btu/hr ft²]	22.2	11.4	53.3
Solar radiation Global [Btu/hr ft²]	26.9	16.5	101.4

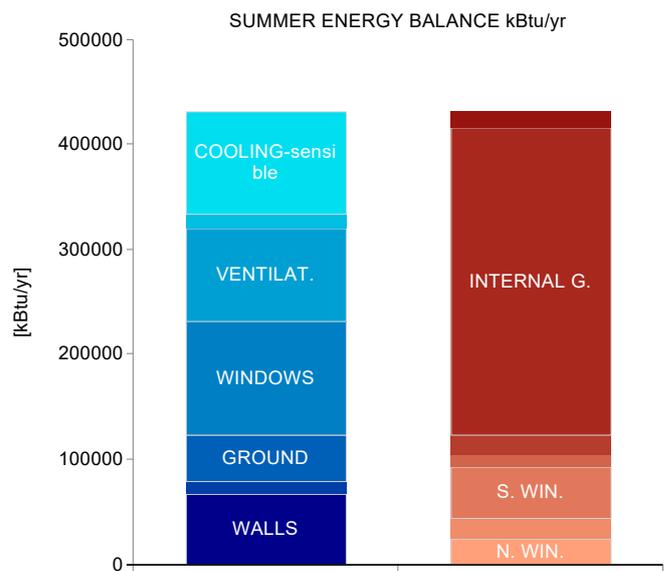
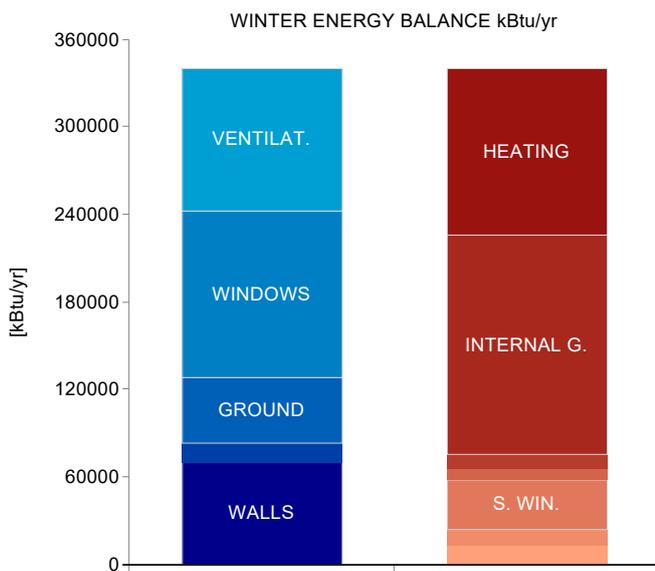
Relevant boundary conditions for heating load calculation: Heating load 1

ANNUAL HEAT DEMAND

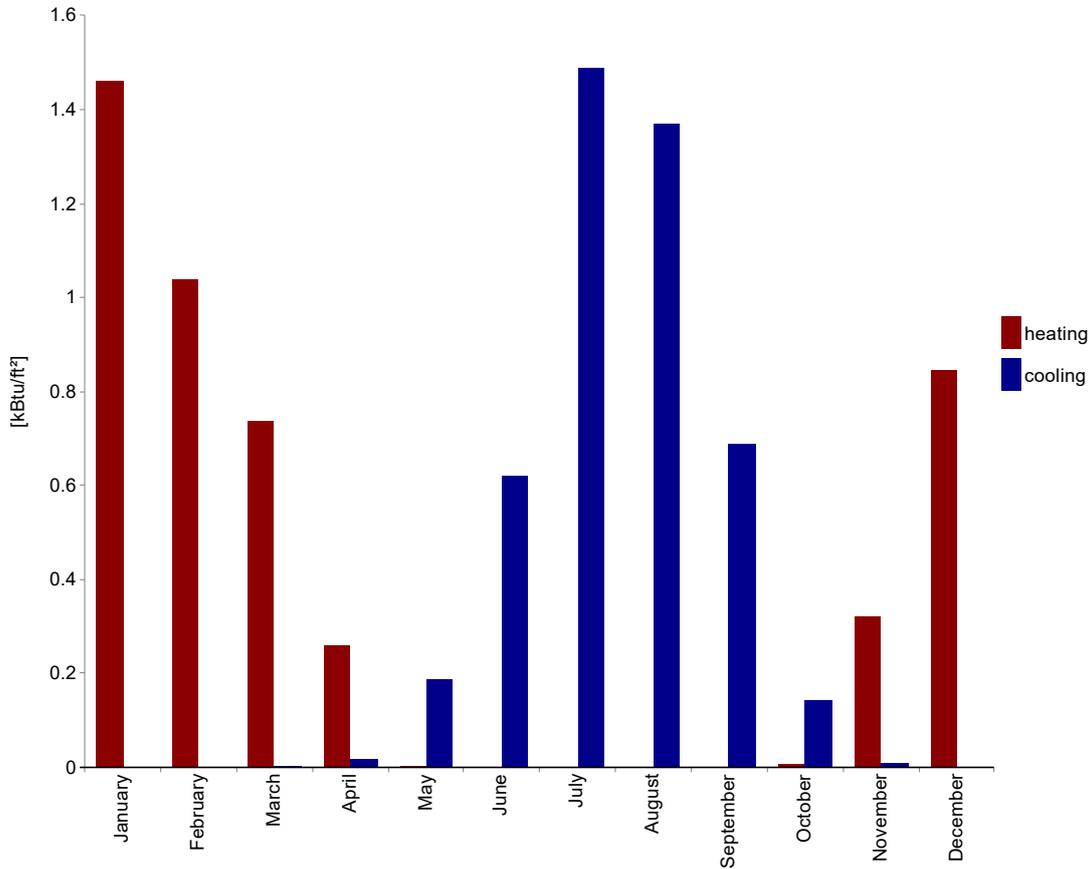
Transmission losses :	242,178 kBtu/yr
Ventilation losses:	97,596 kBtu/yr
Total heat losses:	339,773 kBtu/yr
Solar heat gains:	85,018 kBtu/yr
Internal heat gains:	171,234 kBtu/yr
Total heat gains:	256,252 kBtu/yr
Utilization factor:	88 %
Useful heat gains:	225,425 kBtu/yr
Annual heat demand:	114,348 kBtu/yr
Specific annual heat demand:	4,669.8 Btu/ft ² yr

ANNUAL COOLING DEMAND

Solar heat gains:	123,114 kBtu/yr
Internal heat gains:	293,014 kBtu/yr
Total heat gains:	416,128 kBtu/yr
Transmission losses :	371,840 kBtu/yr
Ventilation losses:	141,109 kBtu/yr
Total heat losses:	512,949 kBtu/yr
Utilization factor:	62.3 %
Useful heat losses:	319,397 kBtu/yr
Cooling demand - sensible:	96,731 kBtu/yr
Cooling demand - latent:	14,089 kBtu/yr
Annual cooling demand:	110,819 kBtu/yr
Specific annual cooling demand:	4.5 kBtu/ft ² yr



SPECIFIC HEAT/COOLING DEMAND MONTHLY



Month	Heating [kBtu/ft²]	Cooling [kBtu/ft²]
January	1.5	0
February	1	0
March	0.7	0
April	0.3	0
May	0	0.2
June	0	0.6
July	0	1.5
August	0	1.4
September	0	0.7
October	0	0.1
November	0.3	0
December	0.8	0

HEATING LOAD

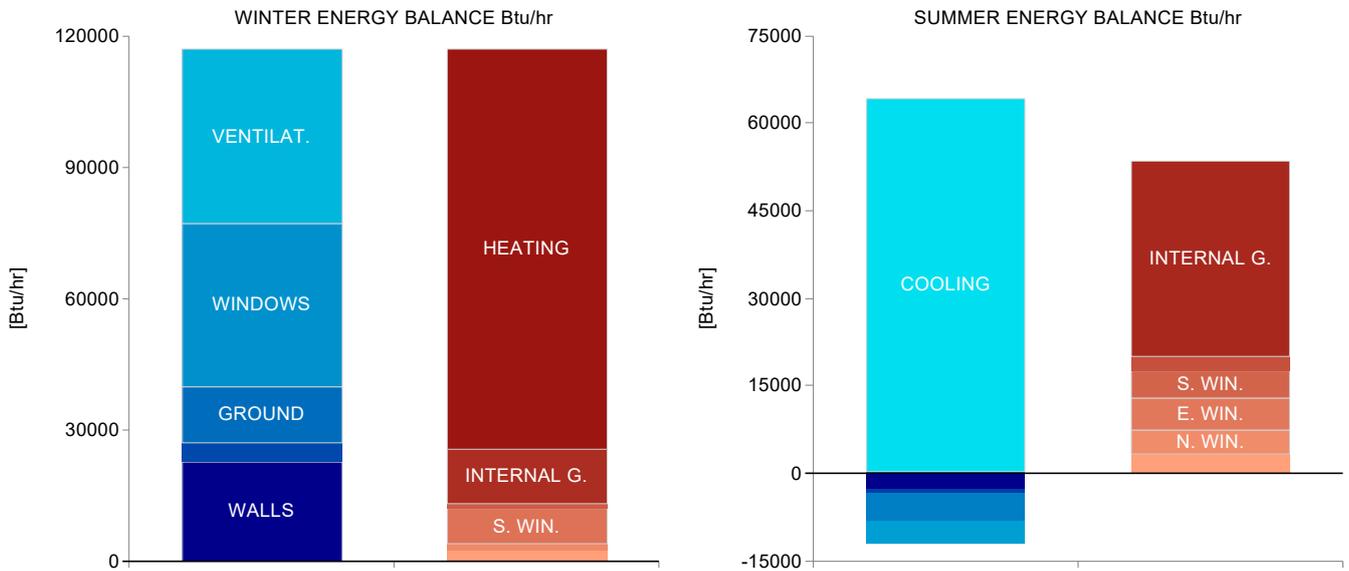
	First climate	Second climate
Transmission heat losses:	76,989.2 Btu/hr	58,457.6 Btu/hr
Ventilation heat losses:	39,893.3 Btu/hr	28,367.7 Btu/hr
Total heat loss:	116,882.5 Btu/hr	86,825.2 Btu/hr
Solar heat gain:	13,045.7 Btu/hr	7,443.8 Btu/hr
Internal heat gain:	12,420.7 Btu/hr	12,420.7 Btu/hr
Total heat gains heating:	25,466.5 Btu/hr	19,864.5 Btu/hr
Heating load:	91,416 Btu/hr	66,960.7 Btu/hr

Relevant heating load: **91,416** Btu/hr
 Specific heating load: **3.7** Btu/hr ft²

COOLING LOAD

Solar heat gain:	19,992.1 Btu/hr
Internal heat gain:	33,452.4 Btu/hr
Total heat gains cooling:	53,444.5 Btu/hr
Transmission heat losses:	-6,392 Btu/hr
Ventilation heat losses:	-4,056.3 Btu/hr
Total heat loss:	-10,448.3 Btu/hr
Cooling load - sensible:	63,892.8 Btu/hr
Cooling load - latent:	0 Btu/hr

Relevant cooling load: **63,892.8** Btu/hr
 Specific maximum cooling load: **2.6** Btu/hr ft²



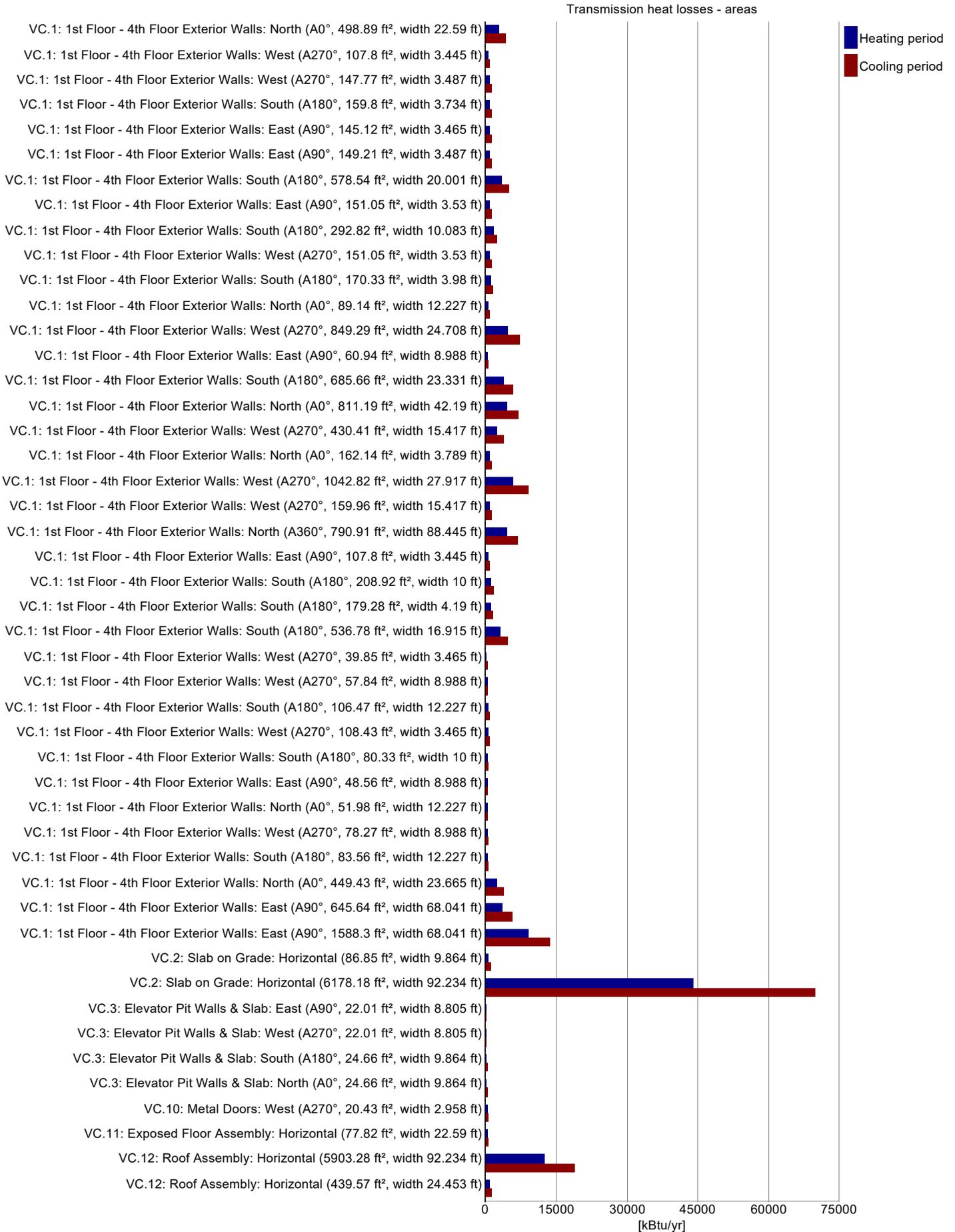
AREAS

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 - 4th Floor Exterior Walls: North (A0°, 498.89 ft², width 22.59 ft)	498.9	0.036	0.4	0.9	100	2827.5	4309.5
VC.1: 1st Floor - 4th Floor Exterior Walls: West (A270°, 107.8 ft², width 3.445 ft)	107.8	0.036	0.4	0.9	100	610.9	931.2
VC.1: 1st Floor - 4th Floor Exterior Walls: West (A270°, 147.77 ft², width 3.487 ft)	147.8	0.036	0.4	0.9	100	837.5	1276.5
VC.1: 1st Floor - 4th Floor Exterior Walls: South (A180°, 159.8 ft², width 3.734 ft)	159.8	0.036	0.4	0.9	100	905.7	1380.4
VC.1: 1st Floor - 4th Floor Exterior Walls: East (A90°, 145.12 ft², width 3.465 ft)	145.1	0.036	0.4	0.9	100	822.4	1253.5
VC.1: 1st Floor - 4th Floor Exterior Walls: East (A90°, 149.21 ft², width 3.487 ft)	149.2	0.036	0.4	0.9	100	845.7	1288.9
VC.1: 1st Floor - 4th Floor Exterior Walls: South (A180°, 578.54 ft², width 20.001 ft)	578.5	0.036	0.4	0.9	100	3278.9	4997.6
VC.1: 1st Floor - 4th Floor Exterior Walls: East (A90°, 151.05 ft², width 3.53 ft)	151	0.036	0.4	0.9	100	856.1	1304.8
VC.1: 1st Floor - 4th Floor Exterior Walls: South (A180°, 292.82 ft², width 10.083 ft)	292.8	0.036	0.4	0.9	100	1659.5	2529.4
VC.1: 1st Floor - 4th Floor Exterior Walls: West (A270°, 151.05 ft², width 3.53 ft)	151	0.036	0.4	0.9	100	856.1	1304.8
VC.1: 1st Floor - 4th Floor Exterior Walls: South (A180°, 170.33 ft², width 3.98 ft)	170.3	0.036	0.4	0.9	100	965.3	1471.3
VC.1: 1st Floor - 4th Floor Exterior Walls: North (A0°, 89.14 ft², width 12.227 ft)	89.1	0.036	0.4	0.9	100	505.2	770
VC.1: 1st Floor - 4th Floor Exterior Walls: West (A270°, 849.29 ft², width 24.708 ft)	849.3	0.036	0.4	0.9	100	4813.4	7336.3
VC.1: 1st Floor - 4th Floor Exterior Walls: East (A90°, 60.94 ft², width 8.988 ft)	60.9	0.036	0.4	0.9	100	345.4	526.4
VC.1: 1st Floor - 4th Floor Exterior Walls: South (A180°, 685.66 ft², width 23.331 ft)	685.7	0.036	0.4	0.9	100	3886	5922.9
VC.1: 1st Floor - 4th Floor Exterior Walls: North (A0°, 811.19 ft², width 42.19 ft)	811.2	0.036	0.4	0.9	100	4597.5	7007.3
VC.1: 1st Floor - 4th Floor Exterior Walls: West (A270°, 430.41 ft², width 15.417 ft)	430.4	0.036	0.4	0.9	100	2439.4	3718
VC.1: 1st Floor - 4th Floor Exterior Walls: North (A0°, 162.14 ft², width 3.789 ft)	162.1	0.036	0.4	0.9	100	919	1400.6
VC.1: 1st Floor - 4th Floor Exterior Walls: West (A270°, 1042.82 ft², width 27.917 ft)	1042.8	0.036	0.4	0.9	100	5910.2	9008.1
VC.1: 1st Floor - 4th Floor Exterior Walls: West (A270°, 159.96 ft², width 15.417 ft)	160	0.036	0.4	0.9	100	906.6	1381.8
VC.1: 1st Floor - 4th Floor Exterior Walls: North (A360°, 790.91 ft², width 88.445 ft)	790.9	0.036	0.4	0.9	100	4482.5	6832
VC.1: 1st Floor - 4th Floor Exterior Walls: East (A90°, 107.8 ft², width 3.445 ft)	107.8	0.036	0.4	0.9	100	610.9	931.2
VC.1: 1st Floor - 4th Floor Exterior Walls: South (A180°, 208.92 ft², width 10 ft)	208.9	0.036	0.4	0.9	100	1184	1804.7
VC.1: 1st Floor - 4th Floor Exterior Walls: South (A180°, 179.28 ft², width 4.19 ft)	179.3	0.036	0.4	0.9	100	1016.1	1548.7
VC.1: 1st Floor - 4th Floor Exterior Walls: South (A180°, 536.78 ft², width 16.915 ft)	536.8	0.036	0.4	0.9	100	3042.2	4636.8
VC.1: 1st Floor - 4th Floor Exterior Walls: West (A270°, 39.85 ft², width 3.465 ft)	39.9	0.036	0.4	0.9	100	225.9	344.2
VC.1: 1st Floor - 4th Floor Exterior Walls: West (A270°, 57.84 ft², width 8.988 ft)	57.8	0.036	0.4	0.9	100	327.8	499.6
VC.1: 1st Floor - 4th Floor Exterior Walls: South (A180°, 106.47 ft², width 12.227 ft)	106.5	0.036	0.4	0.9	100	603.4	919.7
VC.1: 1st Floor - 4th Floor Exterior Walls: West (A270°, 108.43 ft², width 3.465 ft)	108.4	0.036	0.4	0.9	100	614.6	936.7
VC.1: 1st Floor - 4th Floor Exterior Walls: South (A180°, 80.33 ft², width 10 ft)	80.3	0.036	0.4	0.9	100	455.3	693.9
VC.1: 1st Floor - 4th Floor Exterior Walls: East (A90°, 48.56 ft², width 8.988 ft)	48.6	0.036	0.4	0.9	100	275.2	419.5
VC.1: 1st Floor - 4th Floor Exterior Walls: North (A0°, 51.98 ft², width 12.227 ft)	52	0.036	0.4	0.9	100	294.6	449
VC.1: 1st Floor - 4th Floor Exterior Walls: West (A270°, 78.27 ft², width 8.988 ft)	78.3	0.036	0.4	0.9	100	443.6	676.1
VC.1: 1st Floor - 4th Floor Exterior Walls: South (A180°, 83.56 ft², width 12.227 ft)	83.6	0.036	0.4	0.9	100	473.6	721.8
VC.1: 1st Floor - 4th Floor Exterior Walls: North (A0°, 449.43 ft², width 23.665 ft)	449.4	0.036	0.4	0.9	100	2547.1	3882.2
VC.1: 1st Floor - 4th Floor Exterior Walls: East (A90°, 645.64 ft², width 68.041 ft)	645.6	0.036	0.4	0.9	100	3659.2	5577.2
VC.1: 1st Floor - 4th Floor Exterior Walls: East (A90°, 1588.3 ft², width 68.041 ft)	1588.3	0.036	0.4	0.9	100	9001.7	13720
VC.2: Slab on Grade: Horizontal (86.85 ft², width 9.864 ft)	86.9	0.057	0	0	0	620.9	983.6
VC.2: Slab on Grade: Horizontal (6178.18 ft², width 92.234 ft)	6178.2	0.057	0	0	0	44168.2	69965.3
VC.3: Elevator Pit Walls & Slab: East (A90°, 22.01 ft², width 8.805 ft)	22	0.058	0	0	0	159.4	252.6
VC.3: Elevator Pit Walls & Slab: West (A270°, 22.01 ft², width 8.805 ft)	22	0.058	0	0	0	159.4	252.6
VC.3: Elevator Pit Walls & Slab: South (A180°, 24.66 ft², width 9.864 ft)	24.7	0.058	0	0	0	178.6	282.9
VC.3: Elevator Pit Walls & Slab: North (A0°, 24.66 ft², width 9.864 ft)	24.7	0.058	0	0	0	178.6	282.9
VC.10: Metal Doors: West (A270°, 20.43 ft², width 2.958 ft)	20.4	0.147	0.4	0.9	100	469.9	716.2
VC.11: Exposed Floor Assembly: Horizontal (77.82 ft², width 22.59 ft)	77.8	0.03	0.4	0.9	100	360.5	549.5
VC.12: Roof Assembly: Horizontal (5903.28 ft², width 92.234 ft)	5903.3	0.013	0.4	0.9	100	12465.6	18999.6
VC.12: Roof Assembly: Horizontal (439.57 ft², width 24.453 ft)	439.6	0.013	0.4	0.9	100	928.2	1414.8

Degree hours [kFh/a]

	Heating	Cooling
Ambient heating	87.1	132.7
Ground heating	69.5	110.1



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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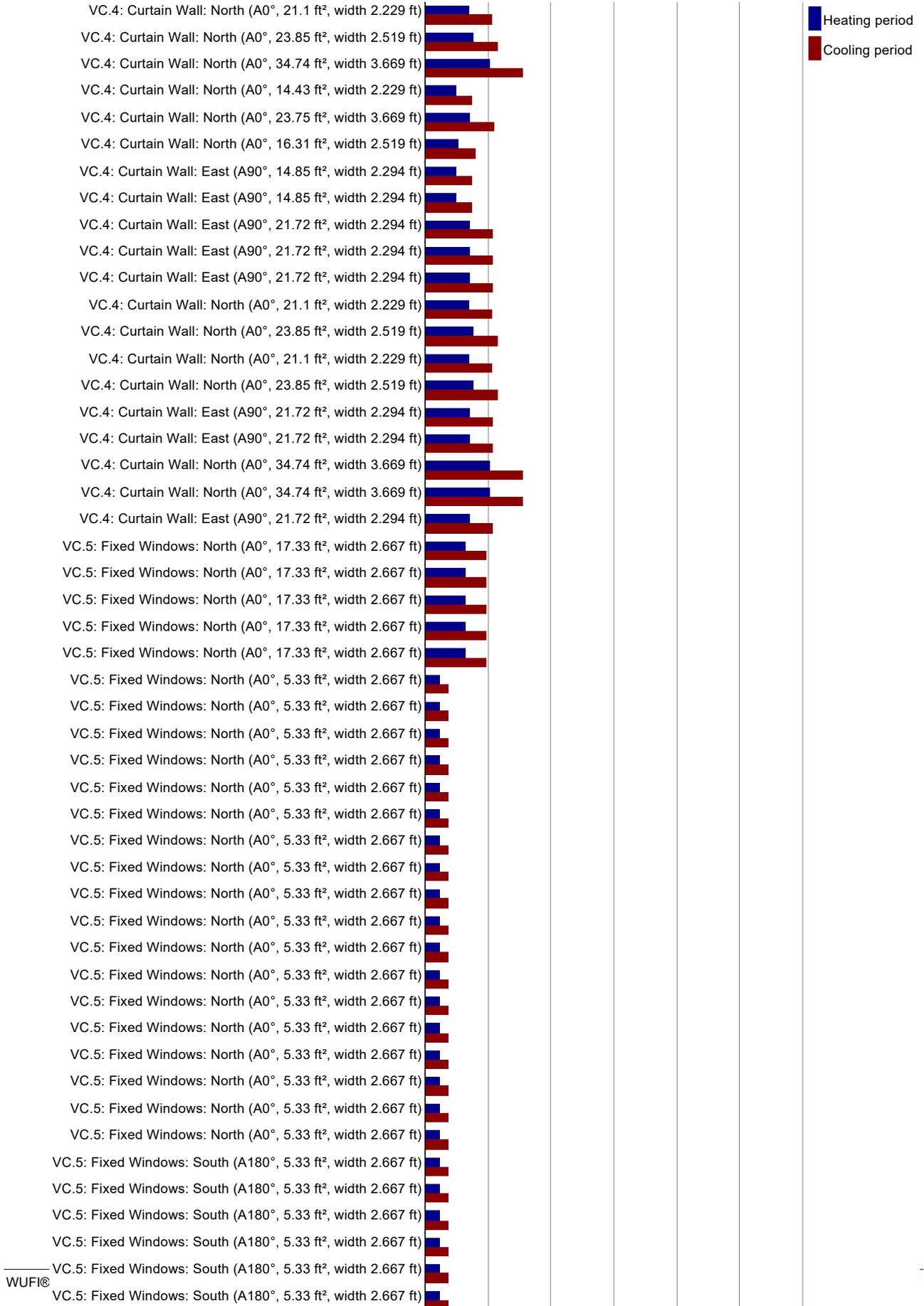
WINDOWS

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.4: Curtain Wall: North (A0°, 21.1 ft², width 2.229 ft)	1	90	0.168	0.3	98	82.4	349.9	552.5	556.3	848
VC.4: Curtain Wall: North (A0°, 23.85 ft², width 2.519 ft)	1	90	0.163	0.3	97.7	81.9	403.1	636.6	608.6	927.7
VC.4: Curtain Wall: North (A0°, 34.74 ft², width 3.669 ft)	1	90	0.15	0.3	97.8	82	620	979	816.1	1,243.8
VC.4: Curtain Wall: North (A0°, 14.43 ft², width 2.229 ft)	1	90	0.173	0.3	89.6	75.5	215.4	338.7	390.2	594.7
VC.4: Curtain Wall: North (A0°, 23.75 ft², width 3.669 ft)	1	90	0.155	0.3	88	73.9	377.6	591.4	575.5	877.2
VC.4: Curtain Wall: North (A0°, 16.31 ft², width 2.519 ft)	1	90	0.167	0.3	87.8	73.5	245.9	384	427.5	651.6
VC.4: Curtain Wall: East (A90°, 14.85 ft², width 2.294 ft)	1	90	0.171	0.3	82.9	72.8	397.7	632.2	398.6	607.6
VC.4: Curtain Wall: East (A90°, 14.85 ft², width 2.294 ft)	1	90	0.171	0.3	82.4	72.6	394.5	628.6	398.6	607.6
VC.4: Curtain Wall: East (A90°, 21.72 ft², width 2.294 ft)	1	90	0.167	0.3	90.8	83.6	629.1	1,031.9	568.1	865.9
VC.4: Curtain Wall: East (A90°, 21.72 ft², width 2.294 ft)	1	90	0.167	0.3	77.5	73.5	521.2	880.5	568.1	865.9
VC.4: Curtain Wall: East (A90°, 21.72 ft², width 2.294 ft)	1	90	0.167	0.3	59.6	59.2	382.8	677.9	568.1	865.9
VC.4: Curtain Wall: North (A0°, 21.1 ft², width 2.229 ft)	1	90	0.168	0.3	94.3	77.4	346	531.6	556.3	848
VC.4: Curtain Wall: North (A0°, 23.85 ft², width 2.519 ft)	1	90	0.163	0.3	94.1	77.1	399.8	613.3	608.6	927.7
VC.4: Curtain Wall: North (A0°, 21.1 ft², width 2.229 ft)	1	90	0.168	0.3	81.5	66.7	297.6	459.3	556.3	848
VC.4: Curtain Wall: North (A0°, 23.85 ft², width 2.519 ft)	1	90	0.163	0.3	81.6	67.1	343.6	532.1	608.6	927.7
VC.4: Curtain Wall: East (A90°, 21.72 ft², width 2.294 ft)	1	90	0.167	0.3	80.6	76.8	535.4	916.7	568.1	865.9
VC.4: Curtain Wall: East (A90°, 21.72 ft², width 2.294 ft)	1	90	0.167	0.3	61.5	60.8	395.5	699.3	568.1	865.9
VC.4: Curtain Wall: North (A0°, 34.74 ft², width 3.669 ft)	1	90	0.15	0.3	93.9	76.9	613.6	940.5	816.1	1,243.8
VC.4: Curtain Wall: North (A0°, 34.74 ft², width 3.669 ft)	1	90	0.15	0.3	80.5	65.9	522.4	806.3	816.1	1,243.8
VC.4: Curtain Wall: East (A90°, 21.72 ft², width 2.294 ft)	1	90	0.167	0.3	91	83.6	632.8	1,034.7	568.1	865.9
VC.5: Fixed Windows: North (A0°, 17.33 ft², width 2.667 ft)	1	90	0.188	0.4	73.6	60.1	210.1	321.6	509.3	776.2
VC.5: Fixed Windows: North (A0°, 17.33 ft², width 2.667 ft)	1	90	0.188	0.4	72.7	58.3	211.7	317.7	509.3	776.2
VC.5: Fixed Windows: North (A0°, 17.33 ft², width 2.667 ft)	1	90	0.188	0.4	72.1	57.9	209.9	315.1	509.3	776.2
VC.5: Fixed Windows: North (A0°, 17.33 ft², width 2.667 ft)	1	90	0.188	0.4	63.7	51.5	183.8	278.2	509.3	776.2
VC.5: Fixed Windows: North (A0°, 17.33 ft², width 2.667 ft)	1	90	0.188	0.4	63.2	51.3	180.8	276	509.3	776.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	64.8	53.5	39.5	61.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	66.5	54.8	40.6	62.7	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	77.9	63.3	48.3	73.5	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	65.8	54.1	40.3	62	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	65.5	54.1	39.9	61.8	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	66.5	54.8	40.6	62.7	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	71.1	58.5	43.5	67.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	71	58.3	43.4	66.9	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.7	66.3	49.5	76.1	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	69.8	57.5	42.6	65.8	196.3	299.2
VC.5: Fixed Windows: North (A0°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	71.7	58.9	43.9	67.6	196.3	299.2
VC.5: Fixed Windows: South (A180°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	82.4	62.6	163.6	204.6	196.3	299.2
VC.5: Fixed Windows: South (A180°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	82.4	62.6	163.6	204.6	196.3	299.2
VC.5: Fixed Windows: South (A180°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	80.4	62	158.5	199.4	196.3	299.2
VC.5: Fixed Windows: South (A180°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	62.6	56.5	115.2	155.3	196.3	299.2
VC.5: Fixed Windows: South (A180°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	82.4	62.6	163.5	204.5	196.3	299.2
VC.5: Fixed Windows: South (A180°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	82.4	62.6	163.5	204.5	196.3	299.2
VC.5: Fixed Windows: South (A180°, 5.33 ft², width 2.667 ft)	1	90	0.235	0.4	82.4	62.6	163.5	204.5	196.3	299.2

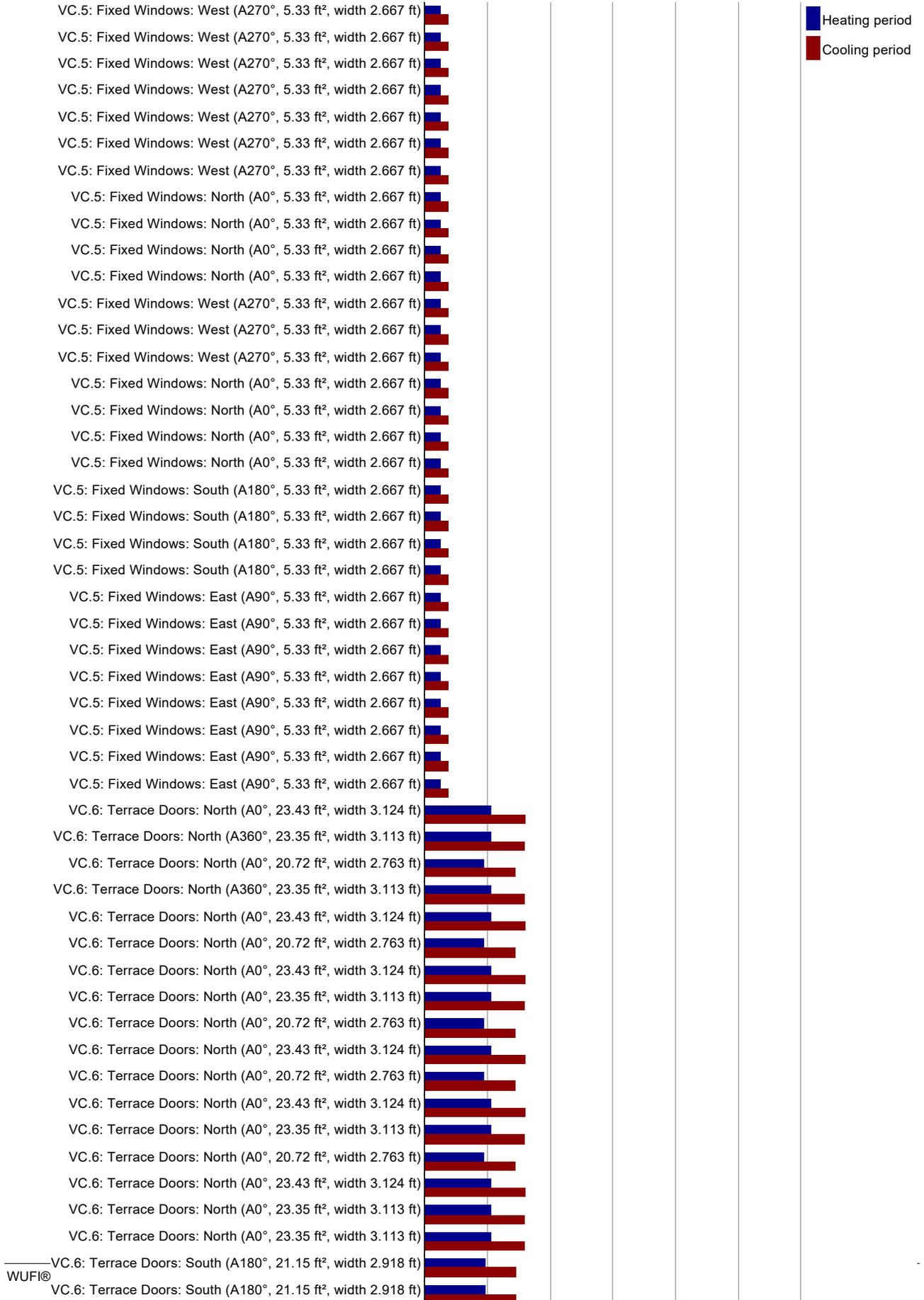
Transmission heat losses - windows (continue)

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.9: Casement Windows: East (A90°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	56	56.8	170.9	310.8	370.2	564.2
VC.9: Casement Windows: East (A90°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	67.9	70.2	207.2	376.9	370.2	564.2
VC.9: Casement Windows: East (A90°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	65	67.7	195.2	360.7	370.2	564.2
VC.9: Casement Windows: East (A90°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	44.9	40.6	149.4	249.1	370.2	564.2
VC.9: Casement Windows: East (A90°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	38.3	31.9	136.3	212.2	370.2	564.2
VC.9: Casement Windows: East (A90°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	37.8	29.2	142.9	209.8	370.2	564.2
VC.9: Casement Windows: East (A90°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	43.9	30.1	177.4	243.4	370.2	564.2
VC.9: Casement Windows: East (A90°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	46.8	36	178.7	259.7	370.2	564.2
VC.9: Casement Windows: East (A90°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	43.7	38.5	150	242.6	370.2	564.2
VC.9: Casement Windows: East (A90°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	38.7	35	130.2	214.9	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	80.2	68.3	281	442.6	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	69.1	54.9	253.4	381.8	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	87.7	76.5	302	484.2	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	75.7	62	274.5	418.1	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	82.7	70.5	289.9	456.6	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	88.6	77.2	305.6	489.4	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	60.3	45.5	228.5	332.7	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	71.3	58.6	259.9	393.9	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	71.5	59.8	256.9	394.9	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	83.2	70.9	291.9	459.5	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	89	77.5	306.9	491.3	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	76.6	62.9	277.3	422.9	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	74.3	69.6	239.2	410.1	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	85.4	76.9	286.9	471.7	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	56.9	53.7	181.3	313.9	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	44.8	41.4	143	247.1	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	59.6	51.9	205.7	329.2	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	77.6	68.6	264.6	428.4	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	77.6	68.6	264.6	428.4	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	89	77.5	306.9	491.3	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	59.5	51.7	205.4	328.5	370.2	564.2
VC.9: Casement Windows: West (A270°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	89	77.5	306.9	491.4	370.2	564.2
VC.9: Casement Windows: East (A90°, 12 ft², width 2.667 ft)	1	90	0.197	0.4	57.8	59	176	320.4	370.2	564.2

Transmission heat losses - windows



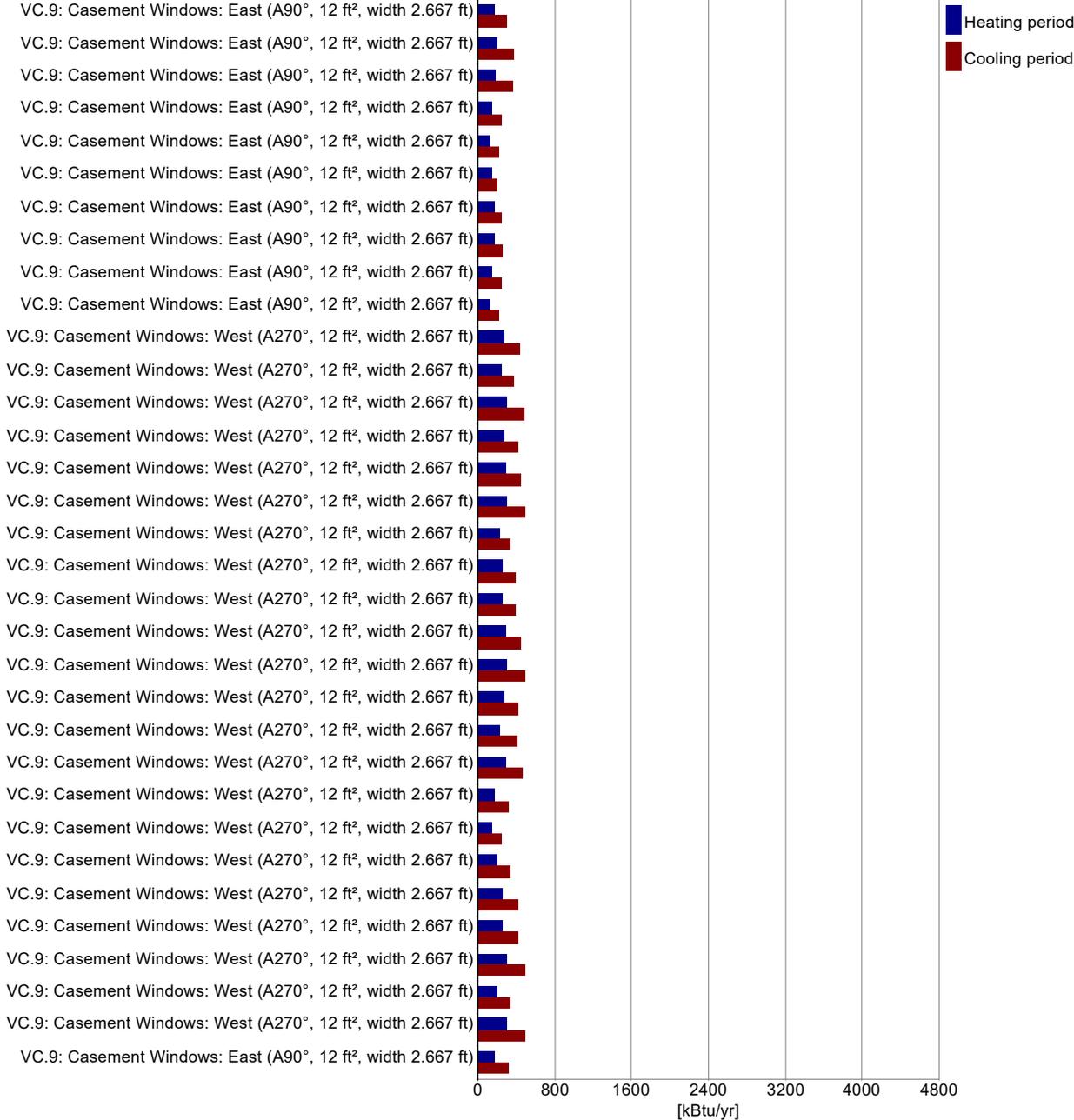
Transmission heat losses - windows (continue)



Transmission heat losses - windows (continue)



Solar gain by windows (continue)



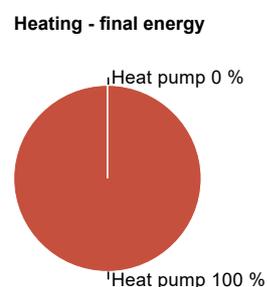
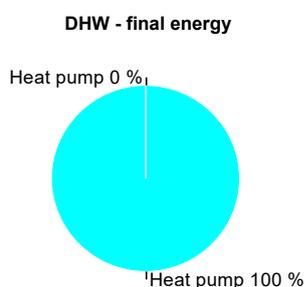
Summary building envelope

	Total area / length	Average U-value / Psi value	Transmission losses
Exterior wall ambient:	12,084.1 ft ²	0.036 Btu/hr ft ² °F	68,406.5 kBtu/yr
Exterior wall ground:	93.3 ft ²	0.058 Btu/hr ft ² °F	676.1 kBtu/yr
Basement:	6,265 ft ²	0.057 Btu/hr ft ² °F	44,789.1 kBtu/yr
Roof:	6,342.9 ft ²	0.013 Btu/hr ft ² °F	13,393.9 kBtu/yr
Windows:	3,524.2 ft ²	0.207 Btu/hr ft ² °F	114,442 kBtu/yr
Doors:	20.4 ft ²	0.147 Btu/hr ft ² °F	469.9 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:	71.5 %	58.7 %
Reduction factor East:	59.7 %	56.9 %
Reduction factor South:	73.7 %	54.6 %
Reduction factor West:	70.5 %	60.1 %
Reduction factor Horizontal:	100 %	100 %

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]	Source energy demand [kBtu/yr]
Heat pump, Mitsubishi Split System	100	0	37,575.7	0	0	0	0.4	16,510,904	75,151.5
Heat pump, Mitsubishi Split System	0	0	0	100	0	54,451.5	0	23,926,158.2	108,902.9
Σ	100	0	37,575.7	100	0	54,451.5		40,437,062.3	184,054.4



COOLING UNITS

	sensible	latent
Air cooling:	0 kBtu/ft ² yr	0 kBtu/ft ² yr
Recirculation cooling:	4 kBtu/ft ² yr	3.2 kBtu/ft ² yr
Additional dehumidification:		0 kBtu/ft ² yr
Panel cooling:	0 kBtu/ft ² yr	
Sum:	4 kBtu/ft ² yr	3.2 kBtu/ft ² yr

VENTILATION

Energy transportable by supply air

Heating energy

transportable: **1.53 W/ft²**
 load: **1.09 W/ft²**



Cooling energy

transportable: **0.87 W/ft²**
 load: **0.76 W/ft²**



Infiltration pressure test ACH50: **0.41 1/hr**
 Total extract air demand: **1,650 cfm**
 Supply air per person: **18 cfm**
 Occupancy: **53**

Average air flow rate: **1,650 cfm**
 Average air change rate: **0.48 1/hr**
 Effective ACH ambient: **0.17 1/hr**
 Effective ACH ground: **0 1/hr**
 Energetically effective air exchange: **0.17 1/hr**
 Infiltration air change rate: **0.03 1/hr**
 Infiltration air change rate (heating load): **0.07 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: **87,788.71 kBtu/yr**

Devices

Name	Sensible recovery efficiency [-]	Electric efficiency [W/cfm]	Heat recovery efficiency SHX [-]	Effective recovery efficiency [-]
Individual Apartment ERV	0.8	0.03	0	0.7
Corridor ERV	0.8	0.03	0	0.6
Altogether	0.8	0.03	0	0.7

Ducts

Name	Length (total) [ft]	Clear cross-section [ft ²]	U-value [Btu/hr ft ² °F]	Assigned ventilation units
Apartment OA (ave)	15	0.3333	1.51	Individual Apartment ERV
Apartment EA (ave)	15	0.3333	1.51	Individual Apartment ERV
Corridor OA	15	0.3333	1.2	Corridor ERV
Corridor EA	15	0.3333	1.2	Corridor ERV
Σ	60			

*length * quantity

** thermal conductivity / thickness

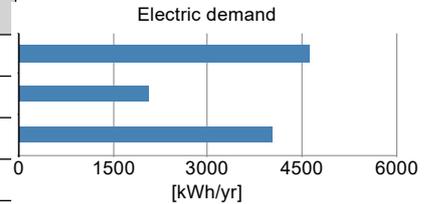
SUMMER VENTILATION

Overheating temperature:

77 °F

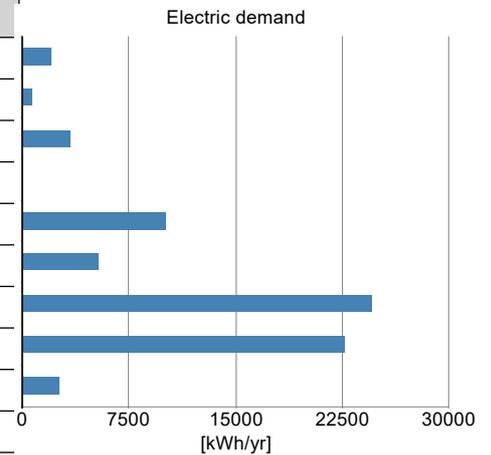
ELECTRICITY DEMAND - AUXILIARY ELECTRICITY

Type	Quantity	Indoor	Norm demand	Electric demand [kWh/yr]	Source energy [kBtu/yr]
Ventilation winter	1	yes	0.6 W/cfm	4632.7	31611.7
Ventilation Defrost	1	yes	8,785.3 W	2060.9	14063
Ventilation summer	1	yes	0.6 W/cfm	4039.7	27565.3
Σ				10733.3	73240.1



ELECTRICITY DEMAND RESIDENTIAL BUILDING

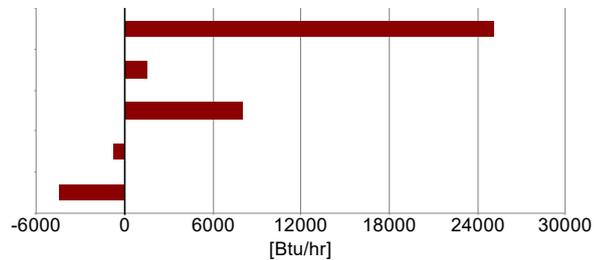
Type	Quantity	Indoor	Norm demand	Electric demand [kWh/yr]	Non-electric demand [kWh/yr]	Source energy [kBtu/yr]
Kitchen dishwasher	1	yes	1.2	1955.8	0	13345.6
Laundry - washer	1	yes	0.3	634.3	0	4328.5
Laundry - dryer	1	yes	5.9	3381.5	0	23073.9
Energy consumed by evaporation	0	yes	3.1	0	848.8	5791.7
Kitchen fridge/freeze combo	1	yes	1.4	10000	0	68236.1
Kitchen cooking	1	yes	0.2	5300	0	36165.1
User defined MELs	1	yes	24,586	24586	0	167765.3
User defined lighting	1	yes	22,618	22618	0	154336.4
User defined lighting	1	no	2,588	2588	0	17659.5
Σ	8			71063.6	848.8	490702.1



INTERNAL HEAT GAINS

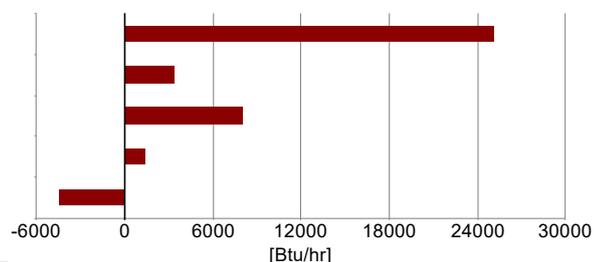
Heating season

Electricity total: **25,162.3** Btu/hr
 Auxiliary electricity: **1,502.8** Btu/hr
 People: **7,957.1** Btu/hr
 Cold water: **-737** Btu/hr
 Evaporation: **-4,521.1** Btu/hr
 Σ: **29,364** Btu/hr
 Specific internal heat gains: **1.2** Btu/hr ft²



Cooling season

Electricity total: **25,162.3** Btu/hr
 Auxiliary electricity: **3,378** Btu/hr
 People: **7,957.1** Btu/hr
 Cold and hot water: **1,476.1** Btu/hr
 Evaporation: **-4,521.1** Btu/hr
 Σ: **29,364** Btu/hr
 Specific internal heat gains: **1.2** Btu/hr ft²



DHW AND DISTRIBUTION

DHW consumption per person per day:	3.2 gal/Person/day
Average cold water temperature supply:	50 °F
Useful heat DHW:	96,096.4 kBtu/yr
Specific useful heat DHW:	3,924.5 Btu/ft²yr
Total heat losses of the DHW system:	10,544.4 kBtu/yr
Specific losses of the DHW system:	430.6 Btu/ft²yr
Performance ratio DHW distribution system and storage:	1.1
Utilization ratio DHW distribution system and storage:	0.9
Total heat demand of DHW system:	106,640.8 kBtu/yr
Total specific heat demand of DHW system:	4,355.1 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		
In conditioned space	0	0
Σ	0	0
Individual pipes		
In conditioned space		0
Σ		0
Water storage		
Σ		0