Executive Summary

This report contains the current plans for this project to achieve certification under PHIUS+ 2021 standard. It is the outcome of a design charrette attended by the architect, owner's team representative, MEP design engineer, construction manager, the PHIUS+/ENERGY STAR verifier/rater, MASS SAVE representative, and facilitated by the PHIUS certified Passive House consultant (CPHC).

The PHIUS+ 2021 certification requirements are performance-based criteria addressing per occupant energy consumption (i.e. Source Energy), annual energy consumption for both heating and cooling (i.e. Heating and Cooling Demand), maximum heating and cooling energy at design temperatures (i.e. Peak Heating and Cooling Load), and airtightness, both at the building and individual unit levels. In addition to meeting these PHIUS+2021 specific requirements, PHIUS+2021 certification requires that the developer and project team meet the requirements for the following certifications.

- Energy Star Multi-family for New Construction, Version 1.1, Revision 02
- Indoor airPLUS Version 1 (Rev. 04)
- WaterSense® Program Guidelines Version 5.5
- DOE Zero Energy Ready Home National Program Requirements (Rev. 07)

These certifications are "check-list" based and will be managed by the PHIUS+/ENERGY STAR Verification Rater engaged by the developer (Sustainable Energy Analytics). A copy of the checklists is included for reference in the appendix.

PHIUS+ 2021 Certification is a two-step process that requires approval from PHIUS at the conclusion of both the design and construction phases. During design, the CPHC facilitates the passive house aspect of the design process and creates a detailed energy model that meets the PHIUS+ 2021 certification requirements. When the project receives design approval from PHIUS a copy of the submission and approval will be provided to the City of Somerville along with any design-related checklists for the other certifications.

The second step of the certification process is facilitated by the PHIUS+ Verifier/rate and the requirements are validated by on-site inspections and testing. The verifier/rater provides the project CPHC with the testing results and all the required checklists for the other certifications, the models are updated and submitted to PHIUS with the checklists for approval. Once accepted by PHIUS, project certification will be awarded to the team and provided to the City of Somerville.

PHIUS+ Requirements and Goals

At the design charrette initial construction specifications were reviewed. This building is a special situation because the ownership team decided to alter the project goals and redesign the building to meet Passive House requirements. All construction specifications were reviewed with the team deciding on the specifications outlined in the following report. Most of the discussions were focused on mechanical systems. With this building the major challenge is the domestic hot water system. The "All Electric" goal of the project pointed the team in the direction of various types of heat pump technologies, but a system with the correct performance and operations specifications could not be identified, so the team decided to use a centralized natural gas boiler augmented with a high efficiency recirculation loop. The system will be designed for easy conversion to an electric-based system when a suitable system is identified. From a certification perspective, particular attention will be paid to the Peak Cooling Load as this requirement has the smallest margin for error and will be improved to give the construction team more flexibility.

Summary of Upgrades (over code)

The following pages present a detailed report of the building envelope, systems, and modeled performance. The key assumptions are presented in the following paragraphs.

1) Building Envelope Improvements
   a) Foundations
      This building has no below grade basements. The slab will be insulated with 4" of XPS rigid foam for an effective R-18 or better. An advanced foam glass aggregate replacement product is being considered for use under the slab for better insulation/cost alternative.
   b) Walls
      Walls will be 2x6 wood and metal framed with cavities filled with a fiber based product with a 2" layer of rigid insulation on the exterior resulting in an effective R-value of approximately R31.
   c) Windows
      Windows will be triple pane for improved energy and sound dampening performance. U-value will be approximately .16 btu/h-ft@-F° and the SHGC will be approximately .23. These values might change slightly depending on window design details and manufacturer.
   d) Roofs
      The team is planning on installing a roof with a combination of both exterior rigid insulation and below deck cavity insulation. Specific roof assembly has not been determined, however, the effective R value will be approximately R52 or better and constructed to minimize any moisture risk and damage.
2) System
   a) Heating/Cooling
      Heating and cooling loads will be satisfied with appropriately sized, individual air-source heat pumps (ASHP) for each unit such as a Mitsubishi mini-split or similar.
   b) Ventilation
      Fresh air for occupants will be supplied with a centralized high performance ERV system. Modeled efficiencies are 1) Sensible Recovery efficiency is .84, 2) Humidity recovery is .4, and 3) Electrical efficiency is .62 W/CFM.
   c) Hot Water
      How water will be a centralized, gas-fired system designed for future conversion to electric when appropriate. Initial equipment will be (2) Lochinvar Water Heaters, model WAN201PM , with 96% Thermal Eff (or similar) supplying (2) Superstor storage tanks 80 gal. each, SSU-80CB. Distribution of the hot water will be via recirculation loop(s) equipped with a central pump from Grundfos that has an adapt function to learn the schedule of users.

3) Fixtures
   a) Bathroom
      All bathroom fixtures will be low flow WaterSense labeled.
   b) Appliances
      All appliances will be ENERGY STAR certified. Internal heat gains generated by in unit appliances is a major source (50%) of cooling loads during the summer months. These loads will be an important focus for the design team to develop original strategies that minimize the internal heat gains.
4) Air Tightness
   This building has a relatively complex envelop design so particular attention will be paid to air tightness. The air tightness has been modeled at the maximin allowed value of .06 cfm/sq. ft.

enclosure. A special set of drawings will be generated to detail all assemblies and air barrier locations. Products used as part of the air barrier will be checked for compatibility and any substitutions will require approval by the design team. During construction there will be at least one preliminary blower door test to check the building envelope quality. Passive house certification also requires that demising walls (both between units and with the corridors) be tested. The team will follow the ENERGY STAR Multi-family protocol to ensure the air tightness of 0.30 CFM^{50}/sqft unit enclosure is satisfied. This is called "compartmentalization testing" and is critical for both air quality and health issues.

BUILDING INFORMATION

Category:	**Residential**
Status:	**In planning**
Building type:	**New construction**
Year of construction:	**2023**
Units:	**51**
Number of occupants:	**114 (Design)**
Occupant density:	**380.9** ft²/Person

Boundary conditions

Climate:	**MA - BOSTON LOGAN INT ARPT (Monthly)**
Internal heat gains:	**1.5** Btu/hr ft²
Interior temperature:	**68** °F
Overheat temperature:	**77** °F

Building geometry

Enclosed volume:	**518,535** ft³
Net-volume:	**488,515** ft³
Total area envelope:	**53,585.4** ft²
Area/Volume Ratio:	**0.1** 1/ft
Floor area:	**43,419** ft²
Envelope area/iCFA:	**1.234**

PASSIVEHOUSE REQUIREMENTS

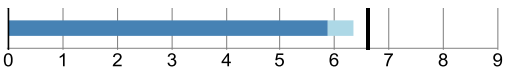
Certificate criteria: PHIUS+ 2021

Heating demand

specific:	**2.25** kBtu/ft²yr
target:	**5.3** kBtu/ft²yr
total:	97,756.04 kBtu/yr

Cooling demand

sensible:	**5.87** kBtu/ft²yr
latent:	**0.47** kBtu/ft²yr
specific:	**6.34** kBtu/ft²yr
target:	**6.6** kBtu/ft²yr
total:	275,127.92 kBtu/yr

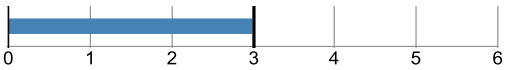


Heating load

specific:	**3.35** Btu/hr ft²
target:	**4.2** Btu/hr ft²
total:	145,275.15 Btu/hr

Cooling load

specific:	**2.99** Btu/hr ft²
target:	**3** Btu/hr ft²
total:	129,871.61 Btu/hr

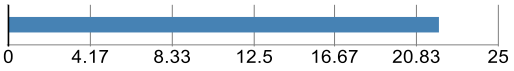


Source energy

total:	**452,500.97**	kWh/yr
specific:	**3,969**	kWh/Person yr
target:	**4,900**	kWh/Person yr
total:	**1,543,845.01**	kBtu/yr
specific:	35.56	kBtu/ft²yr

Site energy

total:	953,061.53	kBtu/yr
specific:	21.95	kBtu/ft²yr
total:	279,342.33	kWh/yr
specific:	6.43	kWh/ft²



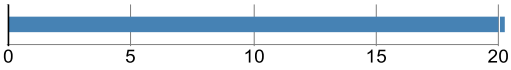
Air tightness

ACH50:	**0.43**	1/hr
CFM50 per envelope area:	**0.06**	cfm/ft²
target:	**0.43**	1/hr
target CFM50:	**0.06**	cfm/ft²

PASSIVEHOUSE RECOMMENDATIONS

Sensible recovery efficiency:	**86**	%
Frequency of overheating: Cooling system is required	**50.4**	%

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

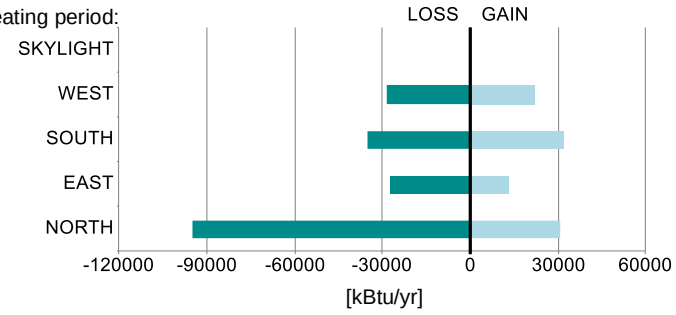


BUILDING ELEMENTS

Windows

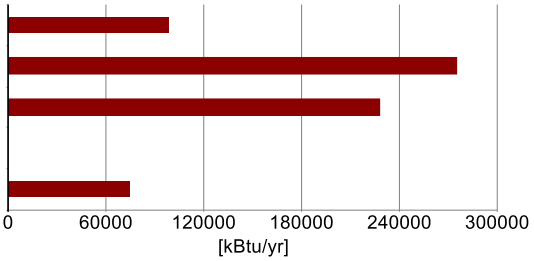
Average SHGC:	**0.26**	
Average solar reduction factor heating:	**0.45**	
Average solar reduction factor cooling:	**0.48**	
Average U-value:	**0.168**	Btu/hr ft² °F
Total glazing area:	**5,435.3**	ft²
Total window area:	**7,845.2**	ft²

Heat gain/loss heating period:



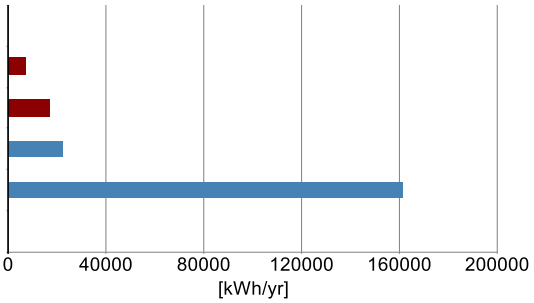
HVAC

Total heating demand:	**97,756**	kBtu/yr
Total cooling demand:	**275,128**	kBtu/yr
Total DHW energy demand:	**228,401**	kBtu/yr
Solar DHW contribution:	**0**	kBtu/yr
Auxiliary electricity:	**74,546**	kBtu/yr



Electricity

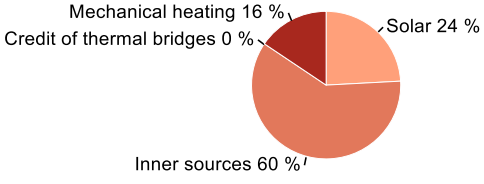
Direct heating / DHW:	**0**	kWh/yr
Heatpump heating:	**7,051**	kWh/yr
Cooling:	**16,995**	kWh/yr
HVAC auxiliary energy:	**21,849**	kWh/yr
Appliances:	**161,568**	kWh/yr
Renewable generation, coincident production and use:	**0**	kWh/yr
Total electricity demand:	**207,463**	kWh/yr



HEAT FLOW - HEATING PERIOD

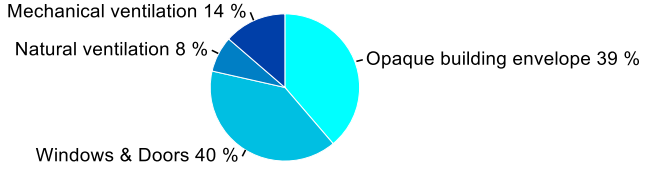
Heat gains

Solar:	**120,974**	kBtu/yr
Inner sources:	**302,208**	kBtu/yr
Credit of thermal bridges:	**0**	kBtu/yr
Mechanical heating:	**97,756**	kBtu/yr



Heat losses

Opaque building envelope:	**202,248**	kBtu/yr
Windows & Doors:	**207,124**	kBtu/yr
Natural ventilation:	**40,987**	kBtu/yr
Mechanical ventilation:	**70,580**	kBtu/yr

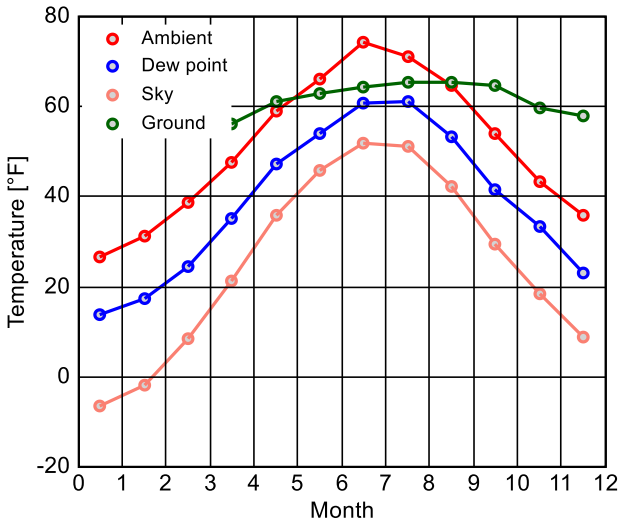


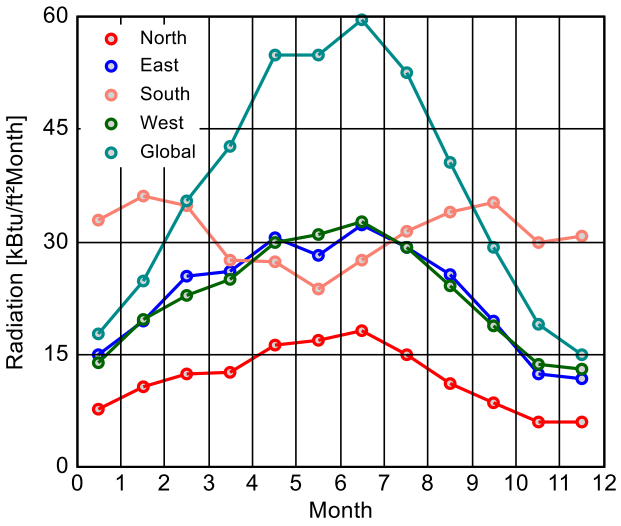
CLIMATE

Latitude:	**42.4**	°
Longitude:	**-71**	°
Elevation of weather station:	**19.7**	ft
Elevation of building site:	**11**	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	**141**	kFh/a
Phase shift months	**1.3**	mths
Time constant heating demand	**139.5**	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

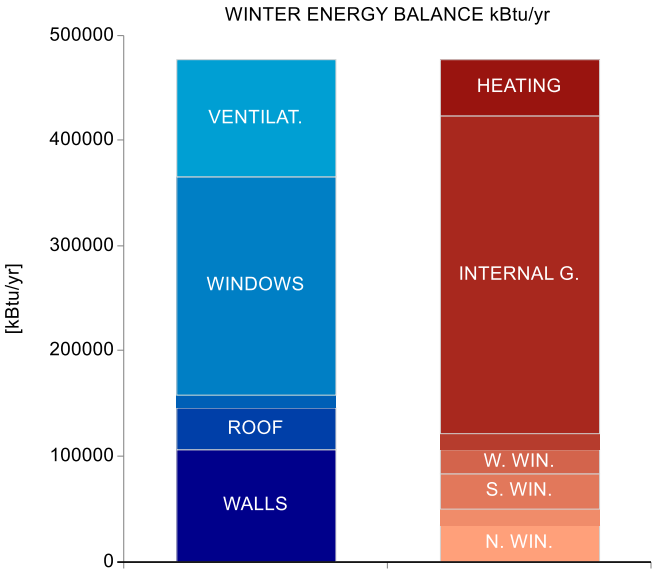
Relevant boundary conditions for heating load calculation: Heating load 1

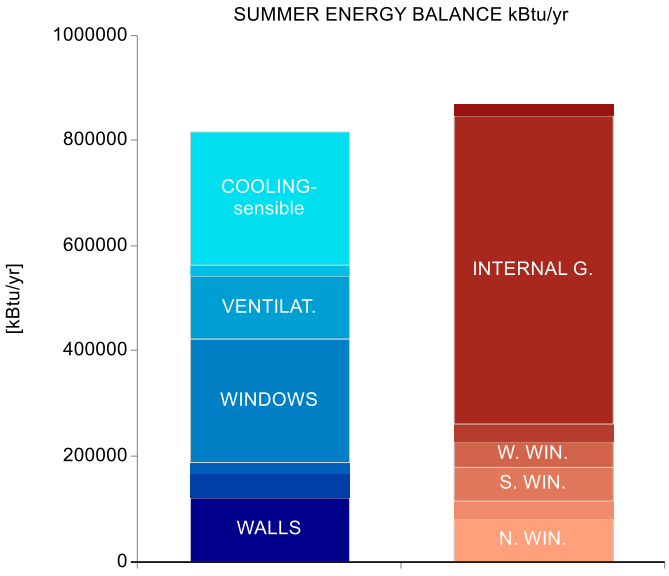
ANNUAL HEAT DEMAND

Transmission losses :	**409,372**	kBtu/yr
Ventilation losses:	**111,566**	kBtu/yr
Total heat losses:	**520,939**	kBtu/yr
Solar heat gains:	**151,918**	kBtu/yr
Internal heat gains:	**379,510**	kBtu/yr
Total heat gains:	**531,428**	kBtu/yr
Utilization factor:	**79.6**	%
Useful heat gains:	**423,182**	kBtu/yr
Annual heat demand:	**97,756**	kBtu/yr
Specific annual heat demand:	**2,251.7**	Btu/ft²yr

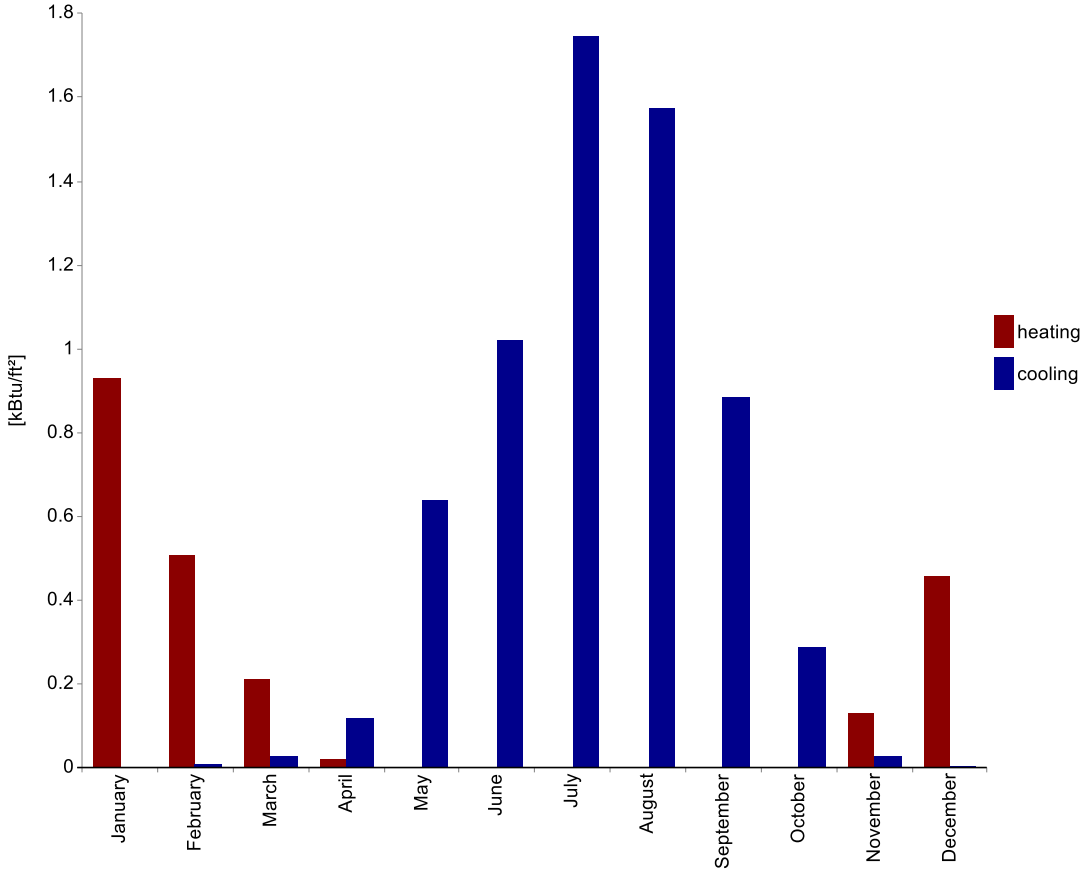
ANNUAL COOLING DEMAND

Solar heat gains:	**260,226**	kBtu/yr
Internal heat gains:	**587,082**	kBtu/yr
Total heat gains:	**847,309**	kBtu/yr
Transmission losses :	**629,412**	kBtu/yr
Ventilation losses:	**160,785**	kBtu/yr
Total heat losses:	**790,197**	kBtu/yr
Utilization factor:	**75**	%
Useful heat losses:	**592,419**	kBtu/yr
Cooling demand - sensible:	**254,889**	kBtu/yr
Cooling demand - latent:	**20,238**	kBtu/yr
Annual cooling demand:	**275,128**	kBtu/yr
Specific annual cooling demand:	**6.3**	kBtu/ft²yr





SPECIFIC HEAT/COOLING DEMAND MONTHLY



Month	Heating [kBtu/ft²]	Cooling [kBtu/ft²]
January	0.9	0
February	0.5	0
March	0.2	0
April	0	0.1
May	0	0.6
June	0	1
July	0	1.7
August	0	1.6
September	0	0.9
October	0	0.3
November	0.1	0
December	0.5	0

HEATING LOAD

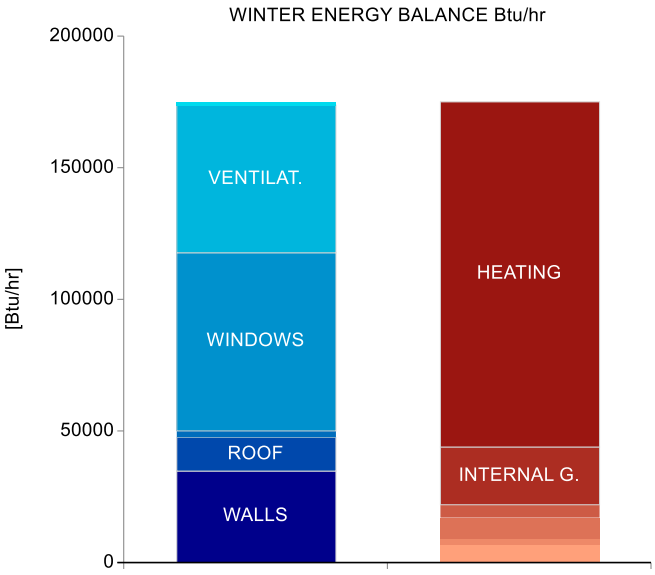
	First climate	Second climate
Transmission heat losses:	**132,911.8** Btu/hr	**95,533.8** Btu/hr
Ventilation heat losses:	**56,238.9** Btu/hr	**39,991.8** Btu/hr
Total heat loss:	**189,150.7** Btu/hr	**135,525.6** Btu/hr
Solar heat gain:	**21,853.5** Btu/hr	**12,499.1** Btu/hr
Internal heat gain:	**22,022** Btu/hr	**22,022** Btu/hr
Total heat gains heating:	**43,875.5** Btu/hr	**34,521.1** Btu/hr
Heating load:	**145,275.1** Btu/hr	**101,004.5** Btu/hr

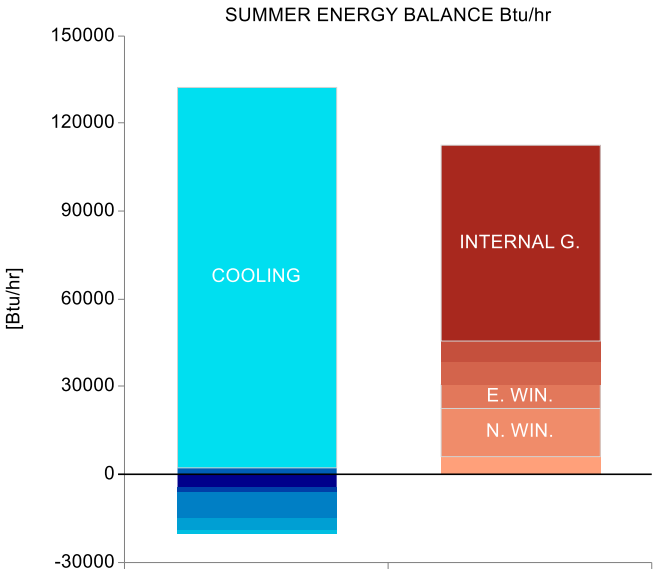
Relevant heating load: **145,275.1** Btu/hr
Specific heating load: **3.3** Btu/hr ft²

COOLING LOAD

Solar heat gain:	**45,399** Btu/hr
Internal heat gain:	**67,025.1** Btu/hr
Total heat gains cooling:	**112,424.1** Btu/hr
Transmission heat losses:	**-12,828.5** Btu/hr
Ventilation heat losses:	**-4,619** Btu/hr
Total heat loss:	**-17,447.5** Btu/hr
Cooling load - sensible:	**129,871.6** Btu/hr
Cooling load - latent:	**0** Btu/hr

Relevant cooling load: **129,871.6** Btu/hr
Specific maximum cooling load: **3** Btu/hr ft²





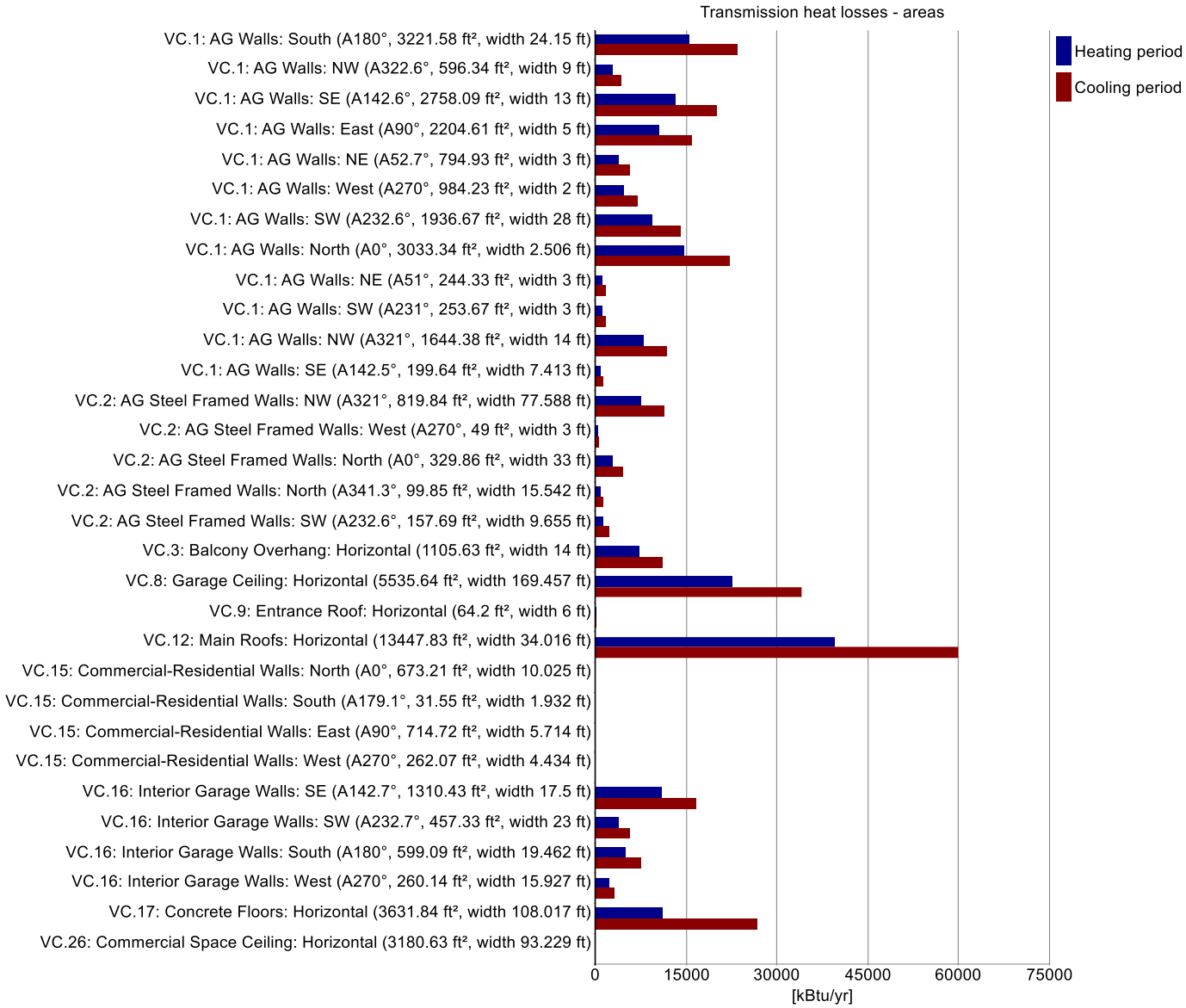
AREAS

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: AG Walls: South (A180°, 3221.58 ft², width 24.15 ft)	3221.6	0.031	0.4	0.9	100	15489.6	23446.6
VC.1: AG Walls: NW (A322.6°, 596.34 ft², width 9 ft)	596.3	0.031	0.4	0.9	100	2867.3	4340.2
VC.1: AG Walls: SE (A142.6°, 2758.09 ft², width 13 ft)	2758.1	0.031	0.4	0.9	100	13261.2	20073.3
VC.1: AG Walls: East (A90°, 2204.61 ft², width 5 ft)	2204.6	0.031	0.4	0.9	100	10599.9	16045
VC.1: AG Walls: NE (A52.7°, 794.93 ft², width 3 ft)	794.9	0.031	0.4	0.9	100	3822.1	5785.5
VC.1: AG Walls: West (A270°, 984.23 ft², width 2 ft)	984.2	0.031	0.4	0.9	100	4732.3	7163.2
VC.1: AG Walls: SW (A232.6°, 1936.67 ft², width 28 ft)	1936.7	0.031	0.4	0.9	100	9311.7	14095
VC.1: AG Walls: North (A0°, 3033.34 ft², width 2.506 ft)	3033.3	0.031	0.4	0.9	100	14584.6	22076.6
VC.1: AG Walls: NE (A51°, 244.33 ft², width 3 ft)	244.3	0.031	0.4	0.9	100	1174.8	1778.2
VC.1: AG Walls: SW (A231°, 253.67 ft², width 3 ft)	253.7	0.031	0.4	0.9	100	1219.7	1846.2
VC.1: AG Walls: NW (A321°, 1644.38 ft², width 14 ft)	1644.4	0.031	0.4	0.9	100	7906.3	11967.7
VC.1: AG Walls: SE (A142.5°, 199.64 ft², width 7.413 ft)	199.6	0.031	0.4	0.9	100	959.9	1453
VC.2: AG Steel Framed Walls: NW (A321°, 819.84 ft², width 77.588 ft)	819.8	0.058	0.4	0.9	100	7484.7	11329.5
VC.2: AG Steel Framed Walls: West (A270°, 49 ft², width 3 ft)	49	0.058	0.4	0.9	100	447.3	677.1
VC.2: AG Steel Framed Walls: North (A0°, 329.86 ft², width 33 ft)	329.9	0.058	0.4	0.9	100	3011.4	4558.3
VC.2: AG Steel Framed Walls: North (A341.3°, 99.85 ft², width 15.542 ft)	99.8	0.058	0.4	0.9	100	911.6	1379.8
VC.2: AG Steel Framed Walls: SW (A232.6°, 157.69 ft², width 9.655 ft)	157.7	0.058	0.4	0.9	100	1439.7	2179.2
VC.3: Balcony Overhang: Horizontal (1105.63 ft², width 14 ft)	1105.6	0.042	0.4	0.9	100	7375	11163.5
VC.8: Garage Ceiling: Horizontal (5535.64 ft², width 169.457 ft)	5535.6	0.027	0	0	0	22535	34111.1
VC.9: Entrance Roof: Horizontal (64.2 ft², width 6 ft)	64.2	0.019	0.4	0.9	100	189.3	286.5
VC.12: Main Roofs: Horizontal (13447.83 ft², width 34.016 ft)	13447.8	0.019	0.4	0.9	100	39644.4	60009.4
VC.15: Commercial-Residential Walls: North (A0°, 673.21 ft², width 10.025 ft)	673.2	0.052	0	0	0	0	0
VC.15: Commercial-Residential Walls: South (A179.1°, 31.55 ft², width 1.932 ft)	31.6	0.052	0	0	0	0	0
VC.15: Commercial-Residential Walls: East (A90°, 714.72 ft², width 5.714 ft)	714.7	0.052	0	0	0	0	0
VC.15: Commercial-Residential Walls: West (A270°, 262.07 ft², width 4.434 ft)	262.1	0.052	0	0	0	0	0
VC.16: Interior Garage Walls: SE (A142.7°, 1310.43 ft², width 17.5 ft)	1310.4	0.056	0	0	0	10983.3	16625.3
VC.16: Interior Garage Walls: SW (A232.7°, 457.33 ft², width 23 ft)	457.3	0.056	0	0	0	3833.1	5802.1
VC.16: Interior Garage Walls: South (A180°, 599.09 ft², width 19.462 ft)	599.1	0.056	0	0	0	5021.2	7600.6
VC.16: Interior Garage Walls: West (A270°, 260.14 ft², width 15.927 ft)	260.1	0.056	0	0	0	2180.3	3300.3
VC.17: Concrete Floors: Horizontal (3631.84 ft², width 108.017 ft)	3631.8	0.051	0	0	0	11262.8	26796.5
VC.26: Commercial Space Ceiling: Horizontal (3180.63 ft², width 93.229 ft)	3180.6	0.042	0	0	0	0	0

Degree hours [kFh/a]

	Heating	Cooling
Ambient heating	87.3	132.2
Ground heating	33.9	80.7



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]

WINDOWS

Name	Quan-tity	Incli-nation [°]	U-value total [Btu/hr ft² °F]	SHGC (perpen-dicular)	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: Windows - LRTB: North (A0°, 1.5 ft², width 1.5 ft)	6	90	0.279	0.2	61.4	60.2	10	19.9	394.7	597.5
VC.4: Windows - LRTB: NW (A321°, 15 ft², width 3 ft)	3	90	0.17	0.2	97.2	100	482.8	845.4	1,201.8	1,819.1
VC.4: Windows - LRTB: South (A180°, 15 ft², width 3 ft)	23	90	0.17	0.2	85.7	83.5	9,058.5	13,564.1	9,213.5	13,946.4
VC.4: Windows - LRTB: SE (A142.7°, 15 ft², width 3 ft)	24	90	0.17	0.2	87.3	84.4	8,913	14,455.7	9,614.1	14,552.7
VC.4: Windows - LRTB: SE (A142.5°, 15 ft², width 3 ft)	3	90	0.17	0.2	64.3	71.8	761.7	1,319.5	1,201.8	1,819.1
VC.4: Windows - LRTB: East (A90°, 15 ft², width 3 ft)	8	90	0.17	0.2	82	86.9	1,789.9	3,270.5	3,204.7	4,850.9
VC.5: Main Entrance Doors: North (A341.3°, 20.5 ft², width 3 ft)	2	90	0.195	0.5	100	100	924.8	1,804.3	1,255.8	1,901
VC.6: Windows Fixed - T: North (A0°, 6 ft², width 3 ft)	2	90	0.176	0.2	93.1	89.2	117.7	229.1	331.3	501.5
VC.6: Windows Fixed - T: North (A0°, 15 ft², width 3 ft)	12	90	0.149	0.2	100	100	2,122.5	4,305.9	4,202.2	6,360.8
VC.6: Windows Fixed - T: North (A0°, 3 ft², width 3 ft)	9	90	0.221	0.2	58.4	56.8	118.5	234	937.4	1,418.9
VC.6: Windows Fixed - T: NW (A321°, 6 ft², width 3 ft)	4	90	0.176	0.2	89.3	87.7	260.3	440.1	662.6	1,003
VC.6: Windows Fixed - T: NW (A321°, 15 ft², width 3 ft)	9	90	0.149	0.2	100	100	1,886.2	3,229.4	3,151.6	4,770.6
VC.6: Windows Fixed - T: North (A341.3°, 9 ft², width 3 ft)	2	90	0.161	0.2	95.7	98.8	193.8	386	454.3	687.7
VC.6: Windows Fixed - T: NW (A321°, 3 ft², width 3 ft)	6	90	0.221	0.2	63	61.2	100.5	168.6	624.9	945.9
VC.6: Windows Fixed - T: SW (A232.7°, 15 ft², width 3 ft)	9	90	0.149	0.2	98.7	100	4,146.4	6,904.3	3,151.6	4,770.6
VC.6: Windows Fixed - T: SW (A232.6°, 3 ft², width 3 ft)	6	90	0.221	0.2	49.4	48.2	175.7	285.9	624.9	945.9
VC.6: Windows Fixed - T: East (A90°, 15 ft², width 3 ft)	6	90	0.149	0.2	96.2	93.8	2,045.1	3,549.5	2,101.1	3,180.4
VC.6: Windows Fixed - T: South (A180°, 3 ft², width 3 ft)	1	90	0.221	0.2	65.2	65.5	45.3	68.9	104.2	157.7
VC.6: Windows Fixed - T: East (A90°, 3 ft², width 3 ft)	3	90	0.221	0.2	65.9	64	88	151.1	312.5	473
VC.7: Windows Fixed - RT: North (A0°, 6 ft², width 3 ft)	2	90	0.176	0.2	83.8	82.9	102.7	206.4	331.3	501.5
VC.7: Windows Fixed - RT: North (A0°, 15 ft², width 3 ft)	15	90	0.149	0.2	100	100	2,653.2	5,382.4	5,252.7	7,951
VC.7: Windows Fixed - RT: North (A0°, 3 ft², width 3 ft)	9	90	0.221	0.2	54	53.1	108.6	216.5	937.4	1,418.9
VC.7: Windows Fixed - RT: NW (A321°, 6 ft², width 3 ft)	5	90	0.176	0.2	84.5	83.4	306.6	520.5	828.3	1,253.8
VC.7: Windows Fixed - RT: NW (A321°, 15 ft², width 3 ft)	9	90	0.149	0.2	100	100	1,886.2	3,229.4	3,151.6	4,770.6
VC.7: Windows Fixed - RT: North (A341.3°, 9 ft², width 3 ft)	1	90	0.161	0.2	100	100	103.4	201.7	227.2	343.9
VC.7: Windows Fixed - RT: NW (A321°, 3 ft², width 3 ft)	6	90	0.221	0.2	57.9	57.6	89.8	154.5	624.9	945.9
VC.7: Windows Fixed - RT: SW (A232.6°, 15 ft², width 3 ft)	9	90	0.149	0.2	100	100	4,232.2	6,993.1	3,151.6	4,770.6
VC.7: Windows Fixed - RT: SW (A232.6°, 3 ft², width 3 ft)	6	90	0.221	0.2	46.3	45.9	163.5	268.1	624.9	945.9
VC.7: Windows Fixed - RT: South (A180°, 19.5 ft², width 3 ft)	2	90	0.144	0.2	97.8	95.3	1,477.6	2,210.6	884.9	1,339.4
VC.7: Windows Fixed - RT: NE (A52.7°, 15 ft², width 3 ft)	1	90	0.149	0.2	98.7	98.1	242	607.3	350.2	530.1
VC.7: Windows Fixed - RT: SE (A142.6°, 15 ft², width 3 ft)	1	90	0.149	0.2	100	100	516.3	851	350.2	530.1
VC.7: Windows Fixed - RT: South (A180°, 3 ft², width 3 ft)	1	90	0.221	0.2	47.8	44.3	34.4	50.4	104.2	157.7
VC.7: Windows Fixed - RT: East (A90°, 15 ft², width 3 ft)	6	90	0.149	0.2	96.2	93.9	2,045.2	3,549.7	2,101.1	3,180.4
VC.7: Windows Fixed - RT: East (A90°, 3 ft², width 3 ft)	3	90	0.221	0.2	55	49.7	76.8	125.9	312.5	473
VC.10: Windows Fixed - L: North (A0°, 6 ft², width 3 ft)	6	90	0.176	0.2	96.2	94.1	356.8	710.8	994	1,504.6
VC.10: Windows Fixed - L: NW (A321°, 5.91 ft², width 3 ft)	15	90	0.176	0.2	100	100	1,058.9	1,813.1	2,458.6	3,721.5
VC.10: Windows Fixed - L: North (A341.3°, 13 ft², width 3 ft)	1	90	0.151	0.2	96.2	98.9	148.4	294.8	309.2	468
VC.10: Windows Fixed - L: North (A341.3°, 9 ft², width 3 ft)	1	90	0.161	0.2	95.8	98.8	97.1	193.2	227.2	343.9
VC.11: Windows Fixed - R: North (A0°, 6 ft², width 3 ft)	6	90	0.176	0.2	96.8	95	357.7	715.2	994	1,504.6
VC.11: Windows Fixed - R: NW (A321°, 6 ft², width 3 ft)	15	90	0.176	0.2	100	100	1,078.6	1,846.7	2,484.9	3,761.4
VC.11: Windows Fixed - R: North (A341.3°, 9 ft², width 3 ft)	1	90	0.161	0.2	100	100	103.4	201.7	227.2	343.9
VC.11: Windows Fixed - R: North (A341.3°, 13 ft², width 3 ft)	1	90	0.151	0.2	100	100	157.1	306.4	309.2	468
VC.13: Windows Fixed - LT: North (A0°, 6 ft², width 3 ft)	2	90	0.205	0.2	86.1	84.5	73.3	146.2	386.5	585.1
VC.13: Windows Fixed - LT: North (A0°, 15 ft², width 3 ft)	15	90	0.17	0.2	100	100	2,147.8	4,357.2	6,008.8	9,095.5
VC.13: Windows Fixed - LT: North (A0°, 3 ft², width 3 ft)	9	90	0.263	0.2	60.3	58.4	45.2	88.8	1,117.4	1,691.4
VC.13: Windows Fixed - LT: NW (A321°, 6 ft², width 3 ft)	5	90	0.205	0.2	86.1	85.8	213.8	365.6	966.3	1,462.7
VC.13: Windows Fixed - LT: NW (A321°, 15 ft², width 3 ft)	9	90	0.17	0.2	100	100	1,526.9	2,614.3	3,605.3	5,457.3
VC.13: Windows Fixed - LT: North (A341.3°, 9 ft², width 3 ft)	1	90	0.185	0.2	86	86.1	67.7	131.9	262.4	397.1
VC.13: Windows Fixed - LT: NW (A321°, 3 ft², width 3 ft)	6	90	0.263	0.2	70.1	70.9	39.8	68.8	744.9	1,127.6
VC.13: Windows Fixed - LT: SW (A232.7°, 15 ft², width 3 ft)	9	90	0.17	0.2	99.5	100	3,396.4	5,630.5	3,605.3	5,457.3

Transmission heat losses - windows (continue)

Name	Quan-tity	Incli-nation [°]	U-value total [Btu/hr ft² °F]	SHGC (perpen-dicular)	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.13: Windows Fixed - LT: SW (A232.7°, 3 ft², width 3 ft)	6	90	0.263	0.2	50.1	48.4	65.6	106.5	744.9	1,127.6
VC.13: Windows Fixed - LT: NE (A52.6°, 15 ft², width 3 ft)	1	90	0.17	0.2	95.3	95.6	185.7	474	400.6	606.4
VC.13: Windows Fixed - LT: SE (A142.7°, 15 ft², width 3 ft)	1	90	0.17	0.2	97.5	100	401.8	670	400.6	606.4
VC.13: Windows Fixed - LT: South (A180°, 3 ft², width 3 ft)	1	90	0.263	0.2	71.4	71.7	18.3	27.7	124.2	187.9
VC.13: Windows Fixed - LT: East (A90°, 15 ft², width 3 ft)	6	90	0.17	0.2	96.2	93.9	1,656	2,873.8	2,403.5	3,638.2
VC.13: Windows Fixed - LT: East (A90°, 3 ft², width 3 ft)	3	90	0.263	0.2	62.7	64.9	29.3	52.9	372.5	563.8
VC.14: Windows Fixed - Middle: North (A0°, 6 ft², width 3 ft)	6	90	0.176	0.2	96	93.8	356.7	709.4	994	1,504.6
VC.14: Windows Fixed - Middle: NW (A321°, 6 ft², width 3 ft)	12	90	0.176	0.2	100	100	862.9	1,477.4	1,987.9	3,009.1
VC.14: Windows Fixed - Middle: North (A341.3°, 9 ft², width 3 ft)	2	90	0.161	0.2	100	100	206.7	403.4	454.3	687.7
VC.18: Windows Fixed - LR: North (A0°, 5.91 ft², width 3 ft)	3	90	0.176	0.2	100	100	178.7	362.6	491.7	744.3
VC.18: Windows Fixed - LR: North (A0°, 12.25 ft², width 3.5 ft)	6	90	0.152	0.2	82.5	79.7	724.8	1,424.8	1,754	2,655
VC.18: Windows Fixed - LR: NW (A321°, 12.25 ft², width 3.5 ft)	6	90	0.152	0.2	86.6	86.1	873.9	1,495.7	1,754	2,655
VC.18: Windows Fixed - LR: NW (A321°, 6 ft², width 3 ft)	3	90	0.176	0.2	100	100	215.7	369.3	497	752.3
VC.19: Windows Fixed - LRB: North (A0°, 5.91 ft², width 3 ft)	1	90	0.176	0.2	100	100	59.6	120.9	163.9	248.1
VC.19: Windows Fixed - LRB: North (A0°, 7.5 ft², width 3 ft)	3	90	0.167	0.2	68	66.3	167.4	331.2	589.2	891.9
VC.19: Windows Fixed - LRB: North (A0°, 8.75 ft², width 3.5 ft)	6	90	0.162	0.2	82.9	80.3	490.1	965	1,339.9	2,028.3
VC.19: Windows Fixed - LRB: NW (A321°, 5.91 ft², width 3 ft)	1	90	0.176	0.2	100	100	70.6	120.9	163.9	248.1
VC.19: Windows Fixed - LRB: NW (A321°, 8.75 ft², width 3.5 ft)	6	90	0.162	0.2	86.5	85.8	589.3	1,006.7	1,339.9	2,028.3
VC.19: Windows Fixed - LRB: South (A180°, 7.5 ft², width 3 ft)	3	90	0.167	0.2	77.1	74.5	595.9	889.5	589.2	891.9
VC.19: Windows Fixed - LRB: NW (A322.7°, 7.5 ft², width 3 ft)	3	90	0.167	0.2	84.2	88.9	224.9	408.6	589.2	891.9
VC.20: Windows Fixed - RB: North (A0°, 7.5 ft², width 3 ft)	15	90	0.167	0.2	100	100	1,200.8	2,436	2,946.2	4,459.7
VC.20: Windows Fixed - RB: North (A0°, 5.91 ft², width 3 ft)	2	90	0.176	0.2	100	100	119.2	241.7	327.8	496.2
VC.20: Windows Fixed - RB: North (A0°, 20.5 ft², width 3 ft)	6	90	0.144	0.2	52.2	48	840.7	1,574.8	2,777.7	4,204.5
VC.20: Windows Fixed - RB: NW (A321°, 5.91 ft², width 3 ft)	5	90	0.176	0.2	100	100	353	604.4	819.5	1,240.5
VC.20: Windows Fixed - RB: NW (A321°, 7.5 ft², width 3 ft)	9	90	0.167	0.2	100	100	853.7	1,461.6	1,767.7	2,675.8
VC.20: Windows Fixed - RB: North (A341.3°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	83.2	162.4	196.4	297.3
VC.20: Windows Fixed - RB: SW (A232.6°, 7.5 ft², width 3 ft)	9	90	0.167	0.2	95.7	98.6	1,808.4	3,030.3	1,767.7	2,675.8
VC.20: Windows Fixed - RB: SE (A142.6°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	97.6	100	225.2	375.2	196.4	297.3
VC.20: Windows Fixed - RB: NE (A52.7°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	97.6	96.4	107.6	271.7	196.4	297.3
VC.20: Windows Fixed - RB: East (A90°, 7.5 ft², width 3 ft)	6	90	0.167	0.2	94.1	90.6	923	1,571.7	1,178.5	1,783.9
VC.21: Windows Fixed - B: North (A0°, 5.91 ft², width 3 ft)	2	90	0.176	0.2	100	100	119.2	241.7	327.8	496.2
VC.21: Windows Fixed - B: North (A0°, 7.5 ft², width 3 ft)	12	90	0.167	0.2	100	100	960.6	1,948.8	2,357	3,567.7
VC.21: Windows Fixed - B: North (A0°, 20.5 ft², width 3 ft)	9	90	0.144	0.2	62.2	57.3	1,497.3	2,813.3	4,166.5	6,306.8
VC.21: Windows Fixed - B: NW (A321°, 5.91 ft², width 3 ft)	4	90	0.176	0.2	100	100	282.4	483.5	655.6	992.4
VC.21: Windows Fixed - B: NW (A321°, 7.5 ft², width 3 ft)	9	90	0.167	0.2	100	100	853.7	1,461.6	1,767.7	2,675.8
VC.21: Windows Fixed - B: NW (A321°, 20.5 ft², width 3 ft)	6	90	0.144	0.2	75.2	76.5	1,309.9	2,265.1	2,777.7	4,204.5
VC.21: Windows Fixed - B: SW (A232.6°, 7.5 ft², width 3 ft)	9	90	0.167	0.2	95.2	98.7	1,792.2	3,014.5	1,767.7	2,675.8
VC.21: Windows Fixed - B: SW (A232.7°, 20.5 ft², width 3 ft)	6	90	0.144	0.2	66.3	64.4	2,691.9	4,330.4	2,777.7	4,204.5
VC.21: Windows Fixed - B: South (A180°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	44.3	46.1	339.7	529.7	462.9	700.8
VC.21: Windows Fixed - B: East (A90°, 7.5 ft², width 3 ft)	6	90	0.167	0.2	94.1	90.5	922.9	1,571.4	1,178.5	1,783.9
VC.21: Windows Fixed - B: East (A90°, 20.5 ft², width 3 ft)	3	90	0.144	0.2	72.9	77.2	1,035.5	1,887.6	1,388.8	2,102.3
VC.22: Windows Fixed - LRT: North (A0°, 6 ft², width 3 ft)	1	90	0.176	0.2	94.7	91.6	59.3	116.5	165.7	250.8
VC.22: Windows Fixed - LRT: North (A0°, 15 ft², width 3 ft)	3	90	0.149	0.2	68	65.9	371.7	731.5	1,050.5	1,590.2
VC.22: Windows Fixed - LRT: North (A0°, 8.75 ft², width 3.5 ft)	6	90	0.162	0.2	84.6	82.1	498.9	984.5	1,339.9	2,028.3
VC.22: Windows Fixed - LRT: NW (A321°, 8.75 ft², width 3.5 ft)	6	90	0.162	0.2	91.5	92.1	609.5	1,063.3	1,339.9	2,028.3
VC.22: Windows Fixed - LRT: NW (A321°, 6 ft², width 3 ft)	1	90	0.176	0.2	86.7	83.8	64	107	165.7	250.8
VC.22: Windows Fixed - LRT: South (A180°, 15 ft², width 3 ft)	3	90	0.149	0.2	77.8	75.6	1,328.5	1,984.8	1,050.5	1,590.2
VC.22: Windows Fixed - LRT: SE (A142.7°, 3 ft², width 3 ft)	6	90	0.221	0.2	50.5	47.2	200.9	321.8	624.9	945.9
VC.22: Windows Fixed - LRT: NE (A52.7°, 3 ft², width 3 ft)	1	90	0.221	0.2	76.9	75	23.7	58.9	104.2	157.7
VC.22: Windows Fixed - LRT: South (A180°, 3 ft², width 3 ft)	8	90	0.221	0.2	66.9	63.1	382.7	564.3	833.2	1,261.3

Transmission heat losses - windows (continue)

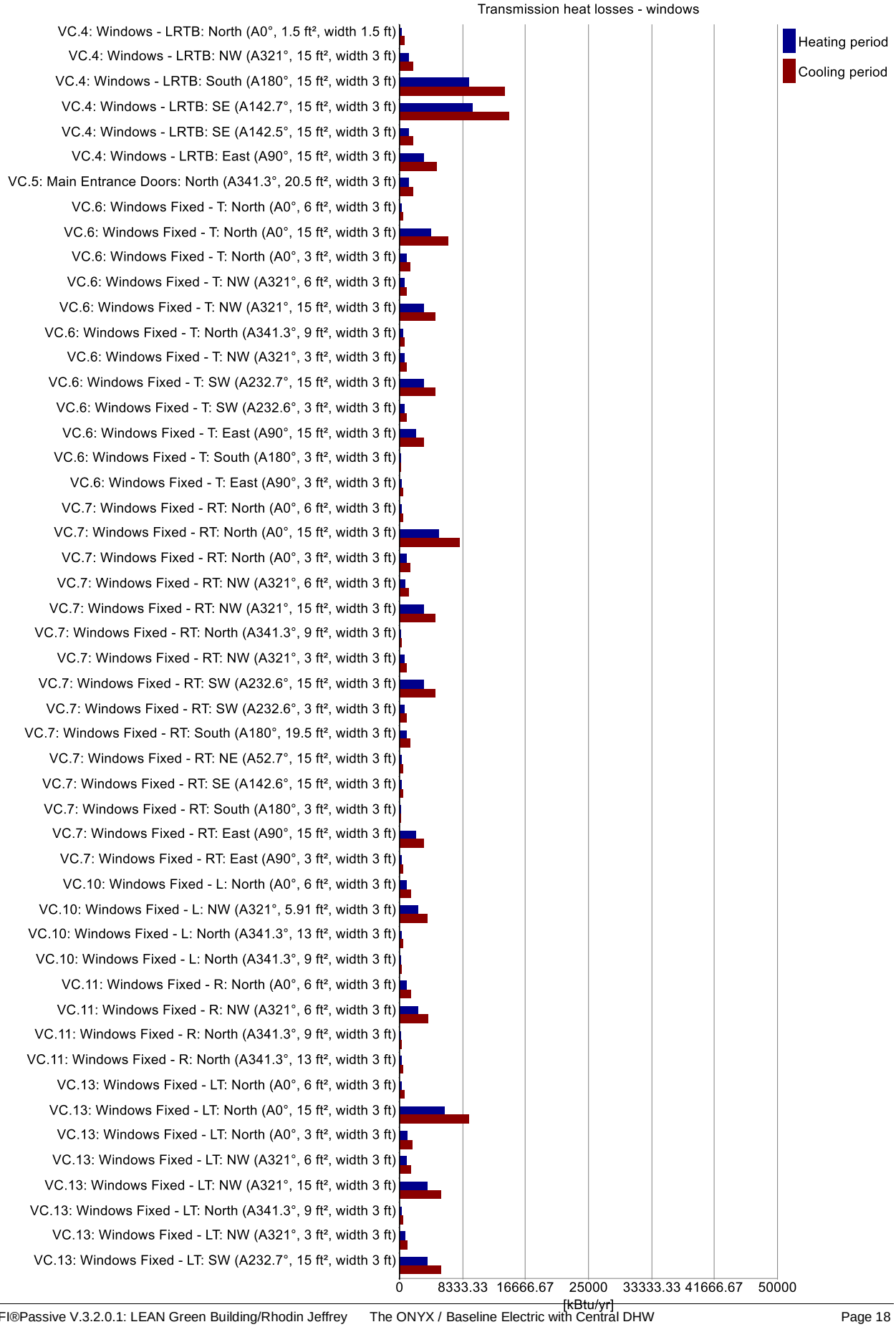
Name	Quan-tity	Incli-nation [°]	U-value total [Btu/hr ft² °F]	SHGC (perpen-dicular)	Reduction factor shading [%]	Reduction factor shading summer [%]	Solar gain heating [kBtu/yr]	Solar gain cooling [kBtu/yr]	Transmission losses heating [kBtu/yr]	Transmission losses cooling [kBtu/yr]
VC.22: Windows Fixed - LRT: NW (A322.7°, 15 ft², width 3 ft)	3	90	0.149	0.2	83.9	88.8	494.7	899.9	1,050.5	1,590.2
VC.23: Balcony Doors - Frt Access: North (A0°, 20.5 ft², width 3 ft)	3	90	0.195	0.5	57.7	54.9	805.4	1,561.4	1,883.8	2,851.4
VC.23: Balcony Doors - Frt Access: NW (A321°, 20.5 ft², width 3 ft)	6	90	0.195	0.5	58.1	54.8	1,883.8	3,150.4	3,767.5	5,702.9
VC.23: Balcony Doors - Frt Access: SW (A232.6°, 20.5 ft², width 3 ft)	6	90	0.195	0.5	57.8	61.6	3,965.2	6,781	3,767.5	5,702.9
VC.23: Balcony Doors - Frt Access: SE (A142.7°, 19.5 ft², width 3 ft)	6	90	0.196	0.5	64.9	55.3	5,140.8	7,939.8	3,604.9	5,456.8
VC.23: Balcony Doors - Frt Access: NE (A52.7°, 19.5 ft², width 3 ft)	1	90	0.196	0.5	95.7	96.5	545.6	1,395.8	600.8	909.5
VC.23: Balcony Doors - Frt Access: South (A180°, 19.5 ft², width 3 ft)	4	90	0.196	0.5	70	55.7	4,082.9	5,620	2,403.3	3,637.8
VC.23: Balcony Doors - Frt Access: South (A180°, 20.5 ft², width 3 ft)	3	90	0.195	0.5	57.2	49.3	2,576.2	3,654.3	1,883.8	2,851.4
VC.23: Balcony Doors - Frt Access: East (A90°, 20.5 ft², width 3 ft)	3	90	0.195	0.5	72.3	71.6	1,939.6	3,355.2	1,883.8	2,851.4
VC.24: Windows Fixed - LTB: South (A180°, 15 ft², width 3 ft)	5	90	0.149	0.2	95.8	100	2,635.7	4,084.4	1,750.9	2,650.3
VC.25: Windows Operable - RTB: South (A180°, 15 ft², width 3 ft)	5	90	0.17	0.2	95.7	100	2,131.3	3,304	2,002.9	3,031.8
VC.27: Windows Fixed-Side Shade: East (A90°, 7.5 ft², width 1 ft)	6	90	0.209	0.2	59	66.2	384.2	746	1,477.5	2,236.4
VC.27: Windows Fixed-Side Shade: West (A270°, 7.5 ft², width 1 ft)	6	90	0.209	0.2	53.3	58.6	343.6	824.7	1,477.5	2,236.4
VC.28: Windows - Balcony Side Shaded: North (A0°, 2.92 ft², width 2.5 ft)	3	90	0.213	0.2	59.8	60.1	40.9	83.3	292.5	442.7
VC.28: Windows - Balcony Side Shaded: South (A180°, 2.92 ft², width 2.5 ft)	3	90	0.213	0.2	54	56.4	115.3	178.6	292.5	442.7
VC.28: Windows - Balcony Side Shaded: West (A270°, 2.92 ft², width 2.5 ft)	6	90	0.213	0.2	45.2	46.4	117.7	270.4	585	885.5
VC.28: Windows - Balcony Side Shaded: East (A90°, 3.5 ft², width 3 ft)	6	90	0.208	0.2	42.6	44	140.1	253	686.4	1,039
VC.28: Windows - Balcony Side Shaded: East (A90°, 12.92 ft², width 2.5 ft)	3	90	0.154	0.2	32.7	36.4	259.2	505.4	940.5	1,423.7
VC.28: Windows - Balcony Side Shaded: SW (A231°, 2.92 ft², width 2.5 ft)	6	90	0.213	0.2	54.4	63.2	182	329.4	585	885.5
VC.28: Windows - Balcony Side Shaded: NE (A51°, 2.92 ft², width 2.5 ft)	3	90	0.213	0.2	44.4	42.6	42.4	106.7	292.5	442.7
VC.28: Windows - Balcony Side Shaded: NE (A51°, 8.61 ft², width 1.667 ft)	3	90	0.174	0.2	36.6	33.2	140.7	341.4	705.9	1,068.6
VC.28: Windows - Balcony Side Shaded: SE (A142.7°, 2.92 ft², width 2.5 ft)	6	90	0.213	0.2	55.2	47.1	237.7	367.9	585	885.5
VC.28: Windows - Balcony Side Shaded: NW (A322.7°, 12.92 ft², width 2.5 ft)	3	90	0.154	0.2	64	73.4	291.2	569.6	940.5	1,423.7
VC.28: Windows - Balcony Side Shaded: NW (A322.7°, 3.5 ft², width 3 ft)	3	90	0.208	0.2	60.5	65.3	56.8	104.3	343.2	519.5
VC.28: Windows - Balcony Side Shaded: NE (A52.6°, 8.61 ft², width 1.667 ft)	3	90	0.174	0.2	63.5	64.9	225.5	580.7	705.9	1,068.6
VC.28: Windows - Balcony Side Shaded: SW (A232.6°, 8.61 ft², width 1.667 ft)	3	90	0.174	0.2	50.3	35.2	414.5	582.2	705.9	1,068.6
VC.28: Windows - Balcony Side Shaded: West (A270°, 8.61 ft², width 1.667 ft)	3	90	0.174	0.2	64	56.3	363.1	768.8	705.9	1,068.6
VC.29: Balcony Doors - Side Access: East (A90°, 20.5 ft², width 3 ft)	6	90	0.195	0.5	27.6	30.1	1,330.2	2,567.4	3,767.5	5,702.9
VC.29: Balcony Doors - Side Access: NW (A322.7°, 20.5 ft², width 3 ft)	3	90	0.195	0.5	64.7	75.1	875	1,733.6	1,883.8	2,851.4
VC.30: Windows Fixed - Side Shaded: West (A270°, 2.94 ft², width 2.484 ft)	3	90	0.212	0.2	68.7	79.4	82.2	201	293.4	444.2
VC.30: Windows Fixed - Side Shaded: NE (A51°, 6.03 ft², width 1.167 ft)	3	90	0.199	0.2	49.4	44.6	113.3	274	565.2	855.5
VC.30: Windows Fixed - Side Shaded: SW (A231°, 8.61 ft², width 1.667 ft)	3	90	0.174	0.2	70.9	83.6	451.3	826.2	705.9	1,068.6
VC.30: Windows Fixed - Side Shaded: NE (A52.6°, 8.61 ft², width 1.667 ft)	3	90	0.174	0.2	69.6	73.1	242.2	634.5	705.9	1,068.6
VC.32: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.33: Windows Fixed - LB: North (A0°, 5.91 ft², width 3 ft)	1	90	0.176	0.2	100	100	59.6	120.9	163.9	248.1
VC.34: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.35: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.36: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.37: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.38: Windows Fixed - LB: North (A0°, 5.91 ft², width 3 ft)	1	90	0.176	0.2	100	100	59.6	120.9	163.9	248.1
VC.39: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.40: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.41: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	58.8	53.9	158.1	295.6	462.9	700.8
VC.42: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	58.5	53.6	157.2	294	462.9	700.8
VC.43: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.44: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	57.8	53	155.2	290.3	462.9	700.8
VC.45: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	59.3	54.3	159.3	297.9	462.9	700.8
VC.46: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	60.3	55.3	162.2	303.4	462.9	700.8
VC.47: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.48: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	59.7	54.8	160.4	300.3	462.9	700.8

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.49: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.50: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.51: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.52: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	70.2	64.1	189.2	352.7	462.9	700.8
VC.53: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.54: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	69.2	63.1	186.9	347.8	462.9	700.8
VC.55: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	69.1	63	186.6	347.3	462.9	700.8
VC.56: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.57: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	80.1	162.4	196.4	297.3
VC.58: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)	1	90	0.176	0.2	100	100	70.6	120.9	163.9	248.1
VC.59: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)	1	90	0.176	0.2	100	100	70.6	120.9	163.9	248.1
VC.60: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)	1	90	0.176	0.2	100	100	70.6	120.9	163.9	248.1
VC.61: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	94.9	162.4	196.4	297.3
VC.62: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	94.9	162.4	196.4	297.3
VC.63: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)	1	90	0.176	0.2	100	100	70.6	120.9	163.9	248.1
VC.64: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)	1	90	0.176	0.2	100	100	70.6	120.9	163.9	248.1
VC.65: Windows Fixed - LB: North (A341.3°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	99.2	100	82.1	161.2	196.4	297.3
VC.66: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	73.1	74.7	210.3	366.9	462.9	700.8
VC.67: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	94.9	162.4	196.4	297.3
VC.68: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	94.9	162.4	196.4	297.3
VC.69: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	94.9	162.4	196.4	297.3
VC.70: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	67.9	69.4	196	341.1	462.9	700.8
VC.71: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	73.7	75.3	212	369.9	462.9	700.8
VC.72: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	94.9	162.4	196.4	297.3
VC.73: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	72.9	74.4	210	366	462.9	700.8
VC.74: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	94.9	162.4	196.4	297.3
VC.75: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	94.9	162.4	196.4	297.3
VC.76: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	94.9	162.4	196.4	297.3
VC.77: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	72.5	74.2	208.3	364.1	462.9	700.8
VC.78: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	97.4	100	204.1	342.6	196.4	297.3
VC.79: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	96.8	100	202.1	340.6	196.4	297.3
VC.80: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	74	75.8	212.3	371.3	462.9	700.8
VC.81: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	212.8	351.7	196.4	297.3
VC.82: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	86.4	90.8	178.6	304.1	196.4	297.3
VC.83: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	89.2	100	176.5	314.1	196.4	297.3
VC.84: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	100	100	212.8	351.7	196.4	297.3
VC.85: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	97.3	100	203.6	342.2	196.4	297.3
VC.86: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	97.6	100	204.7	343.3	196.4	297.3
VC.87: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	99.1	98.6	159.2	276.1	196.4	297.3
VC.88: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	61.5	50.9	449.8	667.8	462.9	700.8
VC.89: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	99.1	98.6	159.2	276.1	196.4	297.3
VC.90: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	57.4	47.9	416.7	623.2	462.9	700.8
VC.91: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	63.5	52.5	463.2	690.3	462.9	700.8
VC.92: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	52.4	46.7	370.7	569.4	462.9	700.8
VC.93: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	90.7	89.1	146.4	252.5	196.4	297.3
VC.94: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	97.3	95.7	157	271.1	196.4	297.3
VC.95: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	66.3	55.3	481.6	720.5	462.9	700.8
VC.96: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	63.6	53.1	463.2	691.5	462.9	700.8
VC.97: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	96.1	92.7	207.8	337.8	196.4	297.3
VC.98: Windows Fixed - LB: NE (A52.6°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	96	94.1	106.7	267.5	196.4	297.3

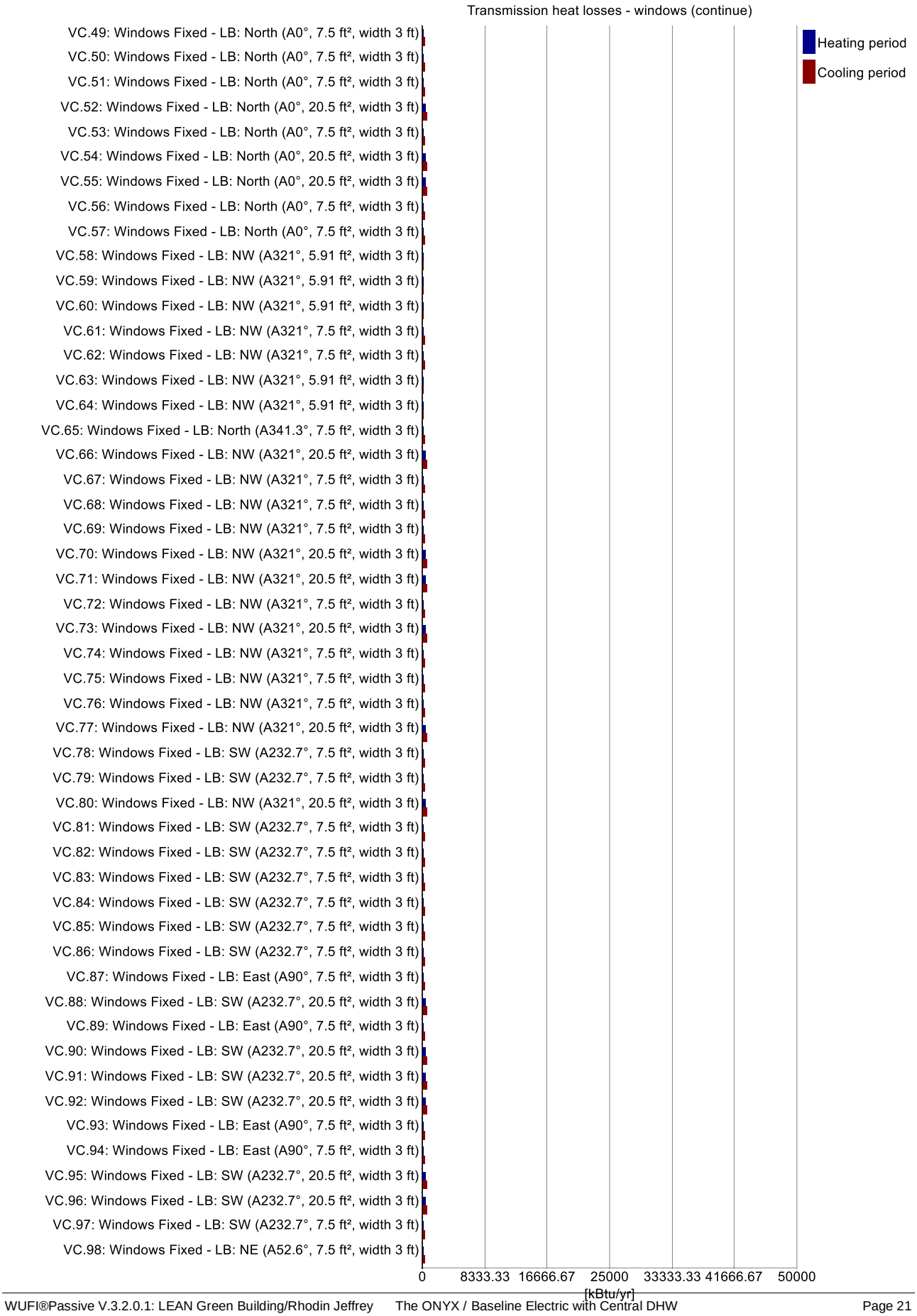
Transmission heat losses - windows (continue)

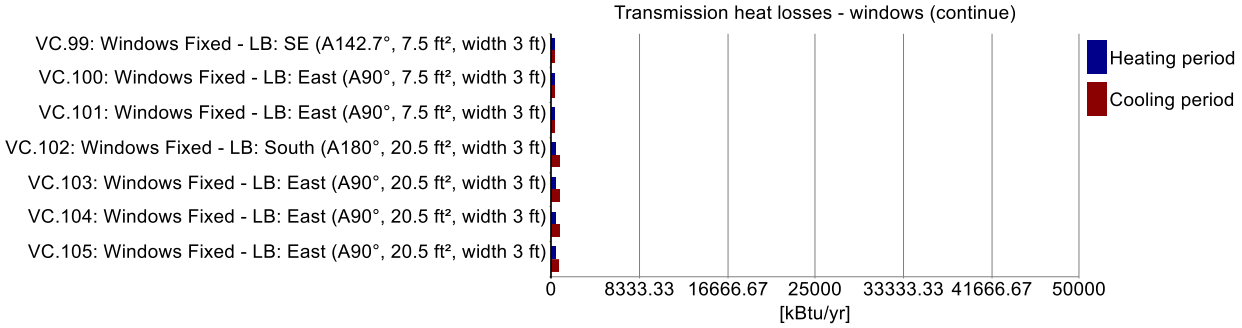
Name	Quan-tity	Incli-nation [°]	U-value total [Btu/hr ft² °F]	SHGC (perpen-dicular)	Reduction factor shading [%]	Reduction factor shading summer [%]	Solar gain heating [kBtu/yr]	Solar gain cooling [kBtu/yr]	Transmission losses heating [kBtu/yr]	Transmission losses cooling [kBtu/yr]
VC.99: Windows Fixed - LB: SE (A142.7°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	92.5	98.4	210	354.8	196.4	297.3
VC.100: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	90.6	84.9	150.3	252	196.4	297.3
VC.101: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)	1	90	0.167	0.2	87.7	80.3	148.1	243.9	196.4	297.3
VC.102: Windows Fixed - LB: South (A180°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	46.3	51.5	346.8	554.7	462.9	700.8
VC.103: Windows Fixed - LB: East (A90°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	65.7	77.3	283.2	567.9	462.9	700.8
VC.104: Windows Fixed - LB: East (A90°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	63.6	74.6	274.5	549.7	462.9	700.8
VC.105: Windows Fixed - LB: East (A90°, 20.5 ft², width 3 ft)	1	90	0.144	0.2	57.6	66.3	253.6	497.7	462.9	700.8

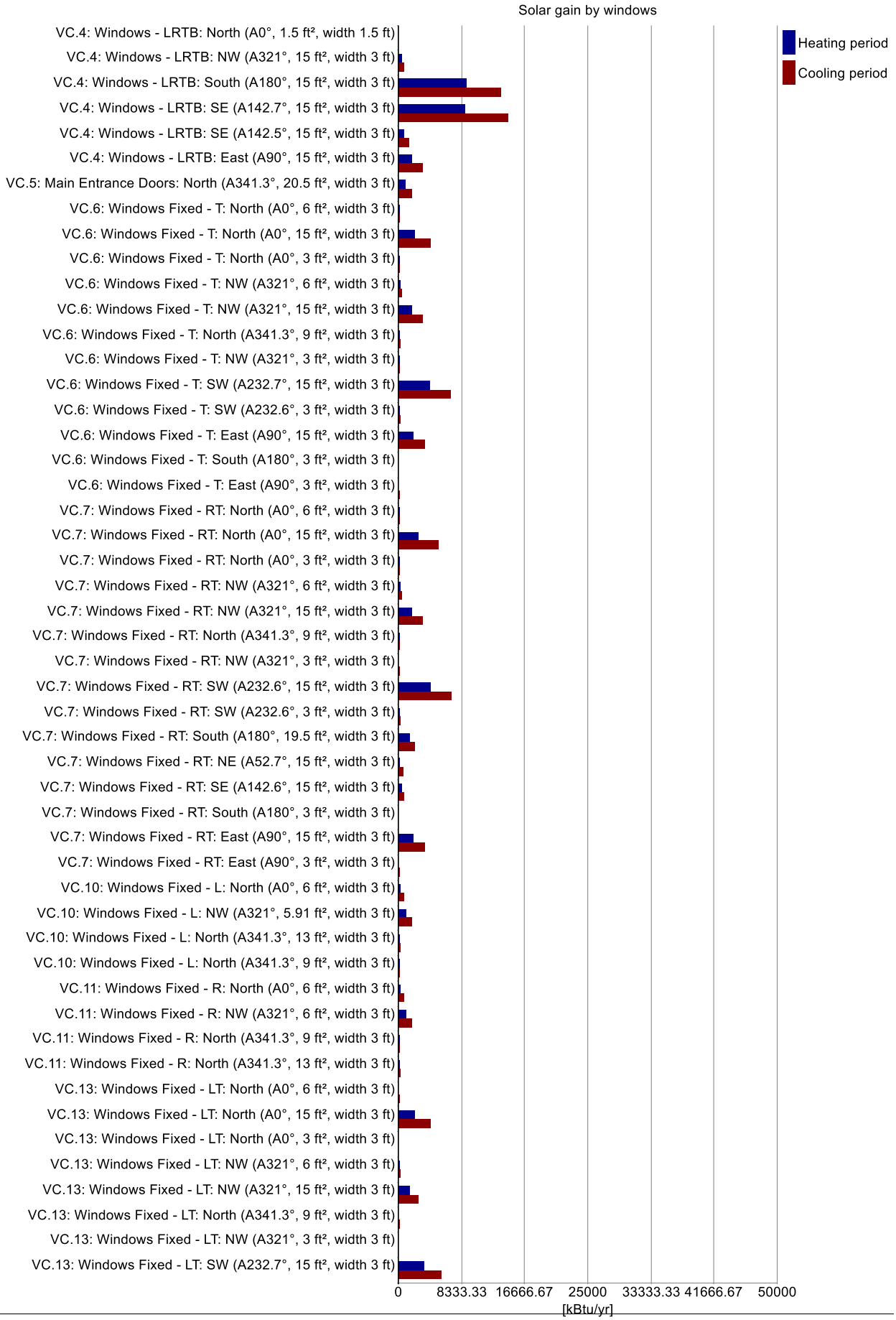

Transmission heat losses - windows
Heating period
Cooling period
VC.4: Windows - LRTB: North (A0°, 1.5 ft², width 1.5 ft)
VC.4: Windows - LRTB: NW (A321°, 15 ft², width 3 ft)
VC.4: Windows - LRTB: South (A180°, 15 ft², width 3 ft)
VC.4: Windows - LRTB: SE (A142.7°, 15 ft², width 3 ft)
VC.4: Windows - LRTB: SE (A142.5°, 15 ft², width 3 ft)
VC.4: Windows - LRTB: East (A90°, 15 ft², width 3 ft)
VC.5: Main Entrance Doors: North (A341.3°, 20.5 ft², width 3 ft)
VC.6: Windows Fixed - T: North (A0°, 6 ft², width 3 ft)
VC.6: Windows Fixed - T: North (A0°, 15 ft², width 3 ft)
VC.6: Windows Fixed - T: North (A0°, 3 ft², width 3 ft)
VC.6: Windows Fixed - T: NW (A321°, 6 ft², width 3 ft)
VC.6: Windows Fixed - T: NW (A321°, 15 ft², width 3 ft)
VC.6: Windows Fixed - T: North (A341.3°, 9 ft², width 3 ft)
VC.6: Windows Fixed - T: NW (A321°, 3 ft², width 3 ft)
VC.6: Windows Fixed - T: SW (A232.7°, 15 ft², width 3 ft)
VC.6: Windows Fixed - T: SW (A232.6°, 3 ft², width 3 ft)
VC.6: Windows Fixed - T: East (A90°, 15 ft², width 3 ft)
VC.6: Windows Fixed - T: South (A180°, 3 ft², width 3 ft)
VC.6: Windows Fixed - T: East (A90°, 3 ft², width 3 ft)
VC.7: Windows Fixed - RT: North (A0°, 6 ft², width 3 ft)
VC.7: Windows Fixed - RT: North (A0°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: North (A0°, 3 ft², width 3 ft)
VC.7: Windows Fixed - RT: NW (A321°, 6 ft², width 3 ft)
VC.7: Windows Fixed - RT: NW (A321°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: North (A341.3°, 9 ft², width 3 ft)
VC.7: Windows Fixed - RT: NW (A321°, 3 ft², width 3 ft)
VC.7: Windows Fixed - RT: SW (A232.6°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: SW (A232.6°, 3 ft², width 3 ft)
VC.7: Windows Fixed - RT: South (A180°, 19.5 ft², width 3 ft)
VC.7: Windows Fixed - RT: NE (A52.7°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: SE (A142.6°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: South (A180°, 3 ft², width 3 ft)
VC.7: Windows Fixed - RT: East (A90°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: East (A90°, 3 ft², width 3 ft)
VC.10: Windows Fixed - L: North (A0°, 6 ft², width 3 ft)
VC.10: Windows Fixed - L: NW (A321°, 5.91 ft², width 3 ft)
VC.10: Windows Fixed - L: North (A341.3°, 13 ft², width 3 ft)
VC.10: Windows Fixed - L: North (A341.3°, 9 ft², width 3 ft)
VC.11: Windows Fixed - R: North (A0°, 6 ft², width 3 ft)
VC.11: Windows Fixed - R: NW (A321°, 6 ft², width 3 ft)
VC.11: Windows Fixed - R: North (A341.3°, 9 ft², width 3 ft)
VC.11: Windows Fixed - R: North (A341.3°, 13 ft², width 3 ft)
VC.13: Windows Fixed - LT: North (A0°, 6 ft², width 3 ft)
VC.13: Windows Fixed - LT: North (A0°, 15 ft², width 3 ft)
VC.13: Windows Fixed - LT: North (A0°, 3 ft², width 3 ft)
VC.13: Windows Fixed - LT: NW (A321°, 6 ft², width 3 ft)
VC.13: Windows Fixed - LT: NW (A321°, 15 ft², width 3 ft)
VC.13: Windows Fixed - LT: North (A341.3°, 9 ft², width 3 ft)
VC.13: Windows Fixed - LT: NW (A321°, 3 ft², width 3 ft)
VC.13: Windows Fixed - LT: SW (A232.7°, 15 ft², width 3 ft)
0
8333.33
16666.67
25000
33333.33
41666.67
50000
[kBtu/yr]


Transmission heat losses - windows (continue)
Heating period
Cooling period
VC.13: Windows Fixed - LT: SW (A232.7°, 3 ft², width 3 ft)
VC.13: Windows Fixed - LT: NE (A52.6°, 15 ft², width 3 ft)
VC.13: Windows Fixed - LT: SE (A142.7°, 15 ft², width 3 ft)
VC.13: Windows Fixed - LT: South (A180°, 3 ft², width 3 ft)
VC.13: Windows Fixed - LT: East (A90°, 15 ft², width 3 ft)
VC.13: Windows Fixed - LT: East (A90°, 3 ft², width 3 ft)
VC.14: Windows Fixed - Middle: North (A0°, 6 ft², width 3 ft)
VC.14: Windows Fixed - Middle: NW (A321°, 6 ft², width 3 ft)
VC.14: Windows Fixed - Middle: North (A341.3°, 9 ft², width 3 ft)
VC.18: Windows Fixed - LR: North (A0°, 5.91 ft², width 3 ft)
VC.18: Windows Fixed - LR: North (A0°, 12.25 ft², width 3.5 ft)
VC.18: Windows Fixed - LR: NW (A321°, 12.25 ft², width 3.5 ft)
VC.18: Windows Fixed - LR: NW (A321°, 6 ft², width 3 ft)
VC.19: Windows Fixed - LRB: North (A0°, 5.91 ft², width 3 ft)
VC.19: Windows Fixed - LRB: North (A0°, 7.5 ft², width 3 ft)
VC.19: Windows Fixed - LRB: North (A0°, 8.75 ft², width 3.5 ft)
VC.19: Windows Fixed - LRB: NW (A321°, 5.91 ft², width 3 ft)
VC.19: Windows Fixed - LRB: NW (A321°, 8.75 ft², width 3.5 ft)
VC.19: Windows Fixed - LRB: South (A180°, 7.5 ft², width 3 ft)
VC.19: Windows Fixed - LRB: NW (A322.7°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: North (A0°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: North (A0°, 5.91 ft², width 3 ft)
VC.20: Windows Fixed - RB: North (A0°, 20.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: NW (A321°, 5.91 ft², width 3 ft)
VC.20: Windows Fixed - RB: NW (A321°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: North (A341.3°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: SW (A232.6°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: SE (A142.6°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: NE (A52.7°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: East (A90°, 7.5 ft², width 3 ft)
VC.21: Windows Fixed - B: North (A0°, 5.91 ft², width 3 ft)
VC.21: Windows Fixed - B: North (A0°, 7.5 ft², width 3 ft)
VC.21: Windows Fixed - B: North (A0°, 20.5 ft², width 3 ft)
VC.21: Windows Fixed - B: NW (A321°, 5.91 ft², width 3 ft)
VC.21: Windows Fixed - B: NW (A321°, 7.5 ft², width 3 ft)
VC.21: Windows Fixed - B: NW (A321°, 20.5 ft², width 3 ft)
VC.21: Windows Fixed - B: SW (A232.6°, 7.5 ft², width 3 ft)
VC.21: Windows Fixed - B: SW (A232.7°, 20.5 ft², width 3 ft)
VC.21: Windows Fixed - B: South (A180°, 20.5 ft², width 3 ft)
VC.21: Windows Fixed - B: East (A90°, 7.5 ft², width 3 ft)
VC.21: Windows Fixed - B: East (A90°, 20.5 ft², width 3 ft)
VC.22: Windows Fixed - LRT: North (A0°, 6 ft², width 3 ft)
VC.22: Windows Fixed - LRT: North (A0°, 15 ft², width 3 ft)
VC.22: Windows Fixed - LRT: North (A0°, 8.75 ft², width 3.5 ft)
VC.22: Windows Fixed - LRT: NW (A321°, 8.75 ft², width 3.5 ft)
VC.22: Windows Fixed - LRT: NW (A321°, 6 ft², width 3 ft)
VC.22: Windows Fixed - LRT: South (A180°, 15 ft², width 3 ft)
VC.22: Windows Fixed - LRT: SE (A142.7°, 3 ft², width 3 ft)
VC.22: Windows Fixed - LRT: NE (A52.7°, 3 ft², width 3 ft)
VC.22: Windows Fixed - LRT: South (A180°, 3 ft², width 3 ft)
0
8333.33
16666.67
25000
33333.33
41666.67
50000
[kBtu/yr]

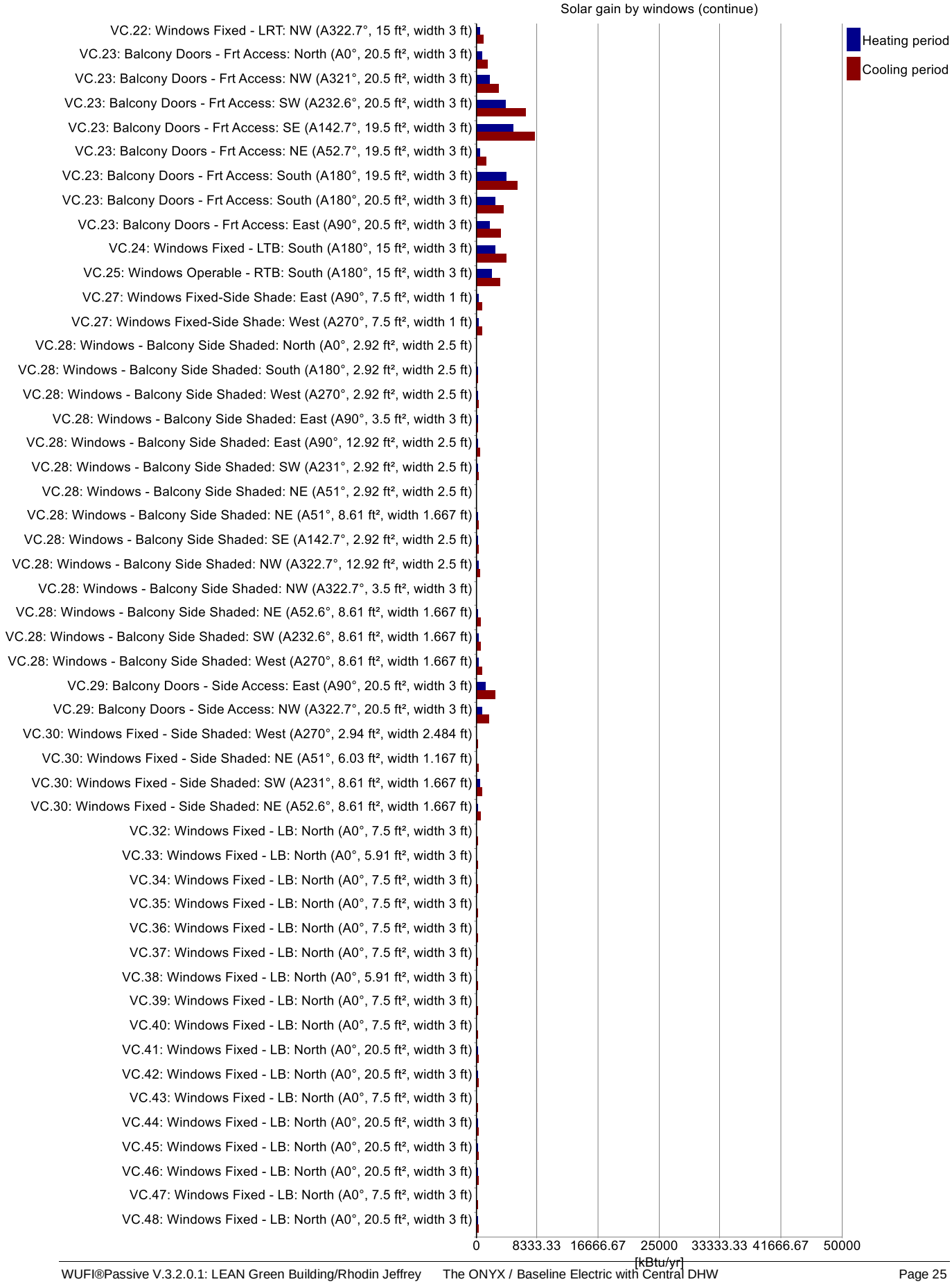

Transmission heat losses - windows (continue)
Heating period
Cooling period
VC.22: Windows Fixed - LRT: NW (A322.7°, 15 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: North (A0°, 20.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: NW (A321°, 20.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: SW (A232.6°, 20.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: SE (A142.7°, 19.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: NE (A52.7°, 19.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: South (A180°, 19.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: South (A180°, 20.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: East (A90°, 20.5 ft², width 3 ft)
VC.24: Windows Fixed - LTB: South (A180°, 15 ft², width 3 ft)
VC.25: Windows Operable - RTB: South (A180°, 15 ft², width 3 ft)
VC.27: Windows Fixed-Side Shade: East (A90°, 7.5 ft², width 1 ft)
VC.27: Windows Fixed-Side Shade: West (A270°, 7.5 ft², width 1 ft)
VC.28: Windows - Balcony Side Shaded: North (A0°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: South (A180°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: West (A270°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: East (A90°, 3.5 ft², width 3 ft)
VC.28: Windows - Balcony Side Shaded: East (A90°, 12.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: SW (A231°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: NE (A51°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: NE (A51°, 8.61 ft², width 1.667 ft)
VC.28: Windows - Balcony Side Shaded: SE (A142.7°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: NW (A322.7°, 12.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: NW (A322.7°, 3.5 ft², width 3 ft)
VC.28: Windows - Balcony Side Shaded: NE (A52.6°, 8.61 ft², width 1.667 ft)
VC.28: Windows - Balcony Side Shaded: SW (A232.6°, 8.61 ft², width 1.667 ft)
VC.28: Windows - Balcony Side Shaded: West (A270°, 8.61 ft², width 1.667 ft)
VC.29: Balcony Doors - Side Access: East (A90°, 20.5 ft², width 3 ft)
VC.29: Balcony Doors - Side Access: NW (A322.7°, 20.5 ft², width 3 ft)
VC.30: Windows Fixed - Side Shaded: West (A270°, 2.94 ft², width 2.484 ft)
VC.30: Windows Fixed - Side Shaded: NE (A51°, 6.03 ft², width 1.167 ft)
VC.30: Windows Fixed - Side Shaded: SW (A231°, 8.61 ft², width 1.667 ft)
VC.30: Windows Fixed - Side Shaded: NE (A52.6°, 8.61 ft², width 1.667 ft)
VC.32: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.33: Windows Fixed - LB: North (A0°, 5.91 ft², width 3 ft)
VC.34: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.35: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.36: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.37: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.38: Windows Fixed - LB: North (A0°, 5.91 ft², width 3 ft)
VC.39: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.40: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.41: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.42: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.43: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.44: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.45: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.46: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.47: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.48: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
0
8333.33
16666.67
25000
33333.33
41666.67
50000
[kBtu/yr]


Transmission heat losses - windows (continue)
Heating period
Cooling period
VC.49: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.50: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.51: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.52: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.53: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.54: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.55: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.56: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.57: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.58: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)
VC.59: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)
VC.60: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)
VC.61: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.62: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.63: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)
VC.64: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)
VC.65: Windows Fixed - LB: North (A341.3°, 7.5 ft², width 3 ft)
VC.66: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.67: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.68: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.69: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.70: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.71: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.72: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.73: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.74: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.75: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.76: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.77: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.78: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.79: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.80: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.81: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.82: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.83: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.84: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.85: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.86: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.87: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)
VC.88: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.89: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)
VC.90: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.91: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.92: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.93: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)
VC.94: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)
VC.95: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.96: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.97: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.98: Windows Fixed - LB: NE (A52.6°, 7.5 ft², width 3 ft)
0
8333.33
16666.67
25000
33333.33
41666.67
50000
[kBtu/yr]

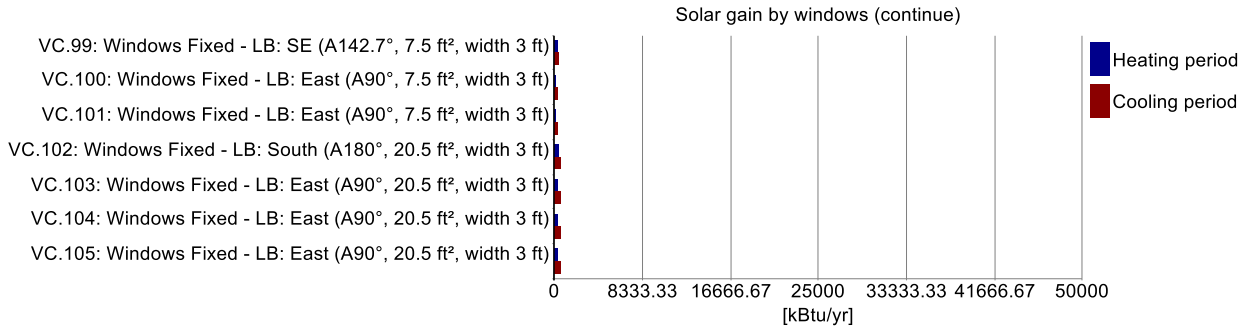

Transmission heat losses - windows (continue)
VC.99: Windows Fixed - LB: SE (A142.7°, 7.5 ft², width 3 ft)
VC.100: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)
VC.101: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)
VC.102: Windows Fixed - LB: South (A180°, 20.5 ft², width 3 ft)
VC.103: Windows Fixed - LB: East (A90°, 20.5 ft², width 3 ft)
VC.104: Windows Fixed - LB: East (A90°, 20.5 ft², width 3 ft)
VC.105: Windows Fixed - LB: East (A90°, 20.5 ft², width 3 ft)
Heating period
Cooling period
0
8333.33
16666.67
25000
33333.33
41666.67
50000
[kBtu/yr]


Solar gain by windows
Heating period
Cooling period
VC.4: Windows - LRTB: North (A0°, 1.5 ft², width 1.5 ft)
VC.4: Windows - LRTB: NW (A321°, 15 ft², width 3 ft)
VC.4: Windows - LRTB: South (A180°, 15 ft², width 3 ft)
VC.4: Windows - LRTB: SE (A142.7°, 15 ft², width 3 ft)
VC.4: Windows - LRTB: SE (A142.5°, 15 ft², width 3 ft)
VC.4: Windows - LRTB: East (A90°, 15 ft², width 3 ft)
VC.5: Main Entrance Doors: North (A341.3°, 20.5 ft², width 3 ft)
VC.6: Windows Fixed - T: North (A0°, 6 ft², width 3 ft)
VC.6: Windows Fixed - T: North (A0°, 15 ft², width 3 ft)
VC.6: Windows Fixed - T: North (A0°, 3 ft², width 3 ft)
VC.6: Windows Fixed - T: NW (A321°, 6 ft², width 3 ft)
VC.6: Windows Fixed - T: NW (A321°, 15 ft², width 3 ft)
VC.6: Windows Fixed - T: North (A341.3°, 9 ft², width 3 ft)
VC.6: Windows Fixed - T: NW (A321°, 3 ft², width 3 ft)
VC.6: Windows Fixed - T: SW (A232.7°, 15 ft², width 3 ft)
VC.6: Windows Fixed - T: SW (A232.6°, 3 ft², width 3 ft)
VC.6: Windows Fixed - T: East (A90°, 15 ft², width 3 ft)
VC.6: Windows Fixed - T: South (A180°, 3 ft², width 3 ft)
VC.6: Windows Fixed - T: East (A90°, 3 ft², width 3 ft)
VC.7: Windows Fixed - RT: North (A0°, 6 ft², width 3 ft)
VC.7: Windows Fixed - RT: North (A0°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: North (A0°, 3 ft², width 3 ft)
VC.7: Windows Fixed - RT: NW (A321°, 6 ft², width 3 ft)
VC.7: Windows Fixed - RT: NW (A321°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: North (A341.3°, 9 ft², width 3 ft)
VC.7: Windows Fixed - RT: NW (A321°, 3 ft², width 3 ft)
VC.7: Windows Fixed - RT: SW (A232.6°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: SW (A232.6°, 3 ft², width 3 ft)
VC.7: Windows Fixed - RT: South (A180°, 19.5 ft², width 3 ft)
VC.7: Windows Fixed - RT: NE (A52.7°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: SE (A142.6°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: South (A180°, 3 ft², width 3 ft)
VC.7: Windows Fixed - RT: East (A90°, 15 ft², width 3 ft)
VC.7: Windows Fixed - RT: East (A90°, 3 ft², width 3 ft)
VC.10: Windows Fixed - L: North (A0°, 6 ft², width 3 ft)
VC.10: Windows Fixed - L: NW (A321°, 5.91 ft², width 3 ft)
VC.10: Windows Fixed - L: North (A341.3°, 13 ft², width 3 ft)
VC.10: Windows Fixed - L: North (A341.3°, 9 ft², width 3 ft)
VC.11: Windows Fixed - R: North (A0°, 6 ft², width 3 ft)
VC.11: Windows Fixed - R: NW (A321°, 6 ft², width 3 ft)
VC.11: Windows Fixed - R: North (A341.3°, 9 ft², width 3 ft)
VC.11: Windows Fixed - R: North (A341.3°, 13 ft², width 3 ft)
VC.13: Windows Fixed - LT: North (A0°, 6 ft², width 3 ft)
VC.13: Windows Fixed - LT: North (A0°, 15 ft², width 3 ft)
VC.13: Windows Fixed - LT: North (A0°, 3 ft², width 3 ft)
VC.13: Windows Fixed - LT: NW (A321°, 6 ft², width 3 ft)
VC.13: Windows Fixed - LT: NW (A321°, 15 ft², width 3 ft)
VC.13: Windows Fixed - LT: North (A341.3°, 9 ft², width 3 ft)
VC.13: Windows Fixed - LT: NW (A321°, 3 ft², width 3 ft)
VC.13: Windows Fixed - LT: SW (A232.7°, 15 ft², width 3 ft)
0
8333.33
16666.67
25000
33333.33
41666.67
50000
[kBtu/yr]


Solar gain by windows (continue)
Heating period
Cooling period
VC.13: Windows Fixed - LT: SW (A232.7°, 3 ft², width 3 ft)
VC.13: Windows Fixed - LT: NE (A52.6°, 15 ft², width 3 ft)
VC.13: Windows Fixed - LT: SE (A142.7°, 15 ft², width 3 ft)
VC.13: Windows Fixed - LT: South (A180°, 3 ft², width 3 ft)
VC.13: Windows Fixed - LT: East (A90°, 15 ft², width 3 ft)
VC.13: Windows Fixed - LT: East (A90°, 3 ft², width 3 ft)
VC.14: Windows Fixed - Middle: North (A0°, 6 ft², width 3 ft)
VC.14: Windows Fixed - Middle: NW (A321°, 6 ft², width 3 ft)
VC.14: Windows Fixed - Middle: North (A341.3°, 9 ft², width 3 ft)
VC.18: Windows Fixed - LR: North (A0°, 5.91 ft², width 3 ft)
VC.18: Windows Fixed - LR: North (A0°, 12.25 ft², width 3.5 ft)
VC.18: Windows Fixed - LR: NW (A321°, 12.25 ft², width 3.5 ft)
VC.18: Windows Fixed - LR: NW (A321°, 6 ft², width 3 ft)
VC.19: Windows Fixed - LRB: North (A0°, 5.91 ft², width 3 ft)
VC.19: Windows Fixed - LRB: North (A0°, 7.5 ft², width 3 ft)
VC.19: Windows Fixed - LRB: North (A0°, 8.75 ft², width 3.5 ft)
VC.19: Windows Fixed - LRB: NW (A321°, 5.91 ft², width 3 ft)
VC.19: Windows Fixed - LRB: NW (A321°, 8.75 ft², width 3.5 ft)
VC.19: Windows Fixed - LRB: South (A180°, 7.5 ft², width 3 ft)
VC.19: Windows Fixed - LRB: NW (A322.7°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: North (A0°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: North (A0°, 5.91 ft², width 3 ft)
VC.20: Windows Fixed - RB: North (A0°, 20.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: NW (A321°, 5.91 ft², width 3 ft)
VC.20: Windows Fixed - RB: NW (A321°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: North (A341.3°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: SW (A232.6°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: SE (A142.6°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: NE (A52.7°, 7.5 ft², width 3 ft)
VC.20: Windows Fixed - RB: East (A90°, 7.5 ft², width 3 ft)
VC.21: Windows Fixed - B: North (A0°, 5.91 ft², width 3 ft)
VC.21: Windows Fixed - B: North (A0°, 7.5 ft², width 3 ft)
VC.21: Windows Fixed - B: North (A0°, 20.5 ft², width 3 ft)
VC.21: Windows Fixed - B: NW (A321°, 5.91 ft², width 3 ft)
VC.21: Windows Fixed - B: NW (A321°, 7.5 ft², width 3 ft)
VC.21: Windows Fixed - B: NW (A321°, 20.5 ft², width 3 ft)
VC.21: Windows Fixed - B: SW (A232.6°, 7.5 ft², width 3 ft)
VC.21: Windows Fixed - B: SW (A232.7°, 20.5 ft², width 3 ft)
VC.21: Windows Fixed - B: South (A180°, 20.5 ft², width 3 ft)
VC.21: Windows Fixed - B: East (A90°, 7.5 ft², width 3 ft)
VC.21: Windows Fixed - B: East (A90°, 20.5 ft², width 3 ft)
VC.22: Windows Fixed - LRT: North (A0°, 6 ft², width 3 ft)
VC.22: Windows Fixed - LRT: North (A0°, 15 ft², width 3 ft)
VC.22: Windows Fixed - LRT: North (A0°, 8.75 ft², width 3.5 ft)
VC.22: Windows Fixed - LRT: NW (A321°, 8.75 ft², width 3.5 ft)
VC.22: Windows Fixed - LRT: NW (A321°, 6 ft², width 3 ft)
VC.22: Windows Fixed - LRT: South (A180°, 15 ft², width 3 ft)
VC.22: Windows Fixed - LRT: SE (A142.7°, 3 ft², width 3 ft)
VC.22: Windows Fixed - LRT: NE (A52.7°, 3 ft², width 3 ft)
VC.22: Windows Fixed - LRT: South (A180°, 3 ft², width 3 ft)
0
8333.33
16666.67
25000
33333.33
41666.67
50000
[kBtu/yr]


Solar gain by windows (continue)
Heating period
Cooling period
VC.22: Windows Fixed - LRT: NW (A322.7°, 15 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: North (A0°, 20.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: NW (A321°, 20.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: SW (A232.6°, 20.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: SE (A142.7°, 19.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: NE (A52.7°, 19.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: South (A180°, 19.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: South (A180°, 20.5 ft², width 3 ft)
VC.23: Balcony Doors - Frt Access: East (A90°, 20.5 ft², width 3 ft)
VC.24: Windows Fixed - LTB: South (A180°, 15 ft², width 3 ft)
VC.25: Windows Operable - RTB: South (A180°, 15 ft², width 3 ft)
VC.27: Windows Fixed-Side Shade: East (A90°, 7.5 ft², width 1 ft)
VC.27: Windows Fixed-Side Shade: West (A270°, 7.5 ft², width 1 ft)
VC.28: Windows - Balcony Side Shaded: North (A0°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: South (A180°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: West (A270°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: East (A90°, 3.5 ft², width 3 ft)
VC.28: Windows - Balcony Side Shaded: East (A90°, 12.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: SW (A231°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: NE (A51°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: NE (A51°, 8.61 ft², width 1.667 ft)
VC.28: Windows - Balcony Side Shaded: SE (A142.7°, 2.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: NW (A322.7°, 12.92 ft², width 2.5 ft)
VC.28: Windows - Balcony Side Shaded: NW (A322.7°, 3.5 ft², width 3 ft)
VC.28: Windows - Balcony Side Shaded: NE (A52.6°, 8.61 ft², width 1.667 ft)
VC.28: Windows - Balcony Side Shaded: SW (A232.6°, 8.61 ft², width 1.667 ft)
VC.28: Windows - Balcony Side Shaded: West (A270°, 8.61 ft², width 1.667 ft)
VC.29: Balcony Doors - Side Access: East (A90°, 20.5 ft², width 3 ft)
VC.29: Balcony Doors - Side Access: NW (A322.7°, 20.5 ft², width 3 ft)
VC.30: Windows Fixed - Side Shaded: West (A270°, 2.94 ft², width 2.484 ft)
VC.30: Windows Fixed - Side Shaded: NE (A51°, 6.03 ft², width 1.167 ft)
VC.30: Windows Fixed - Side Shaded: SW (A231°, 8.61 ft², width 1.667 ft)
VC.30: Windows Fixed - Side Shaded: NE (A52.6°, 8.61 ft², width 1.667 ft)
VC.32: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.33: Windows Fixed - LB: North (A0°, 5.91 ft², width 3 ft)
VC.34: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.35: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.36: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.37: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.38: Windows Fixed - LB: North (A0°, 5.91 ft², width 3 ft)
VC.39: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.40: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.41: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.42: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.43: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.44: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.45: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.46: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.47: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.48: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
0
8333.33
16666.67
25000
33333.33
41666.67
50000
[kBtu/yr]


Solar gain by windows (continue)
Heating period
Cooling period
VC.49: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.50: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.51: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.52: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.53: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.54: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.55: Windows Fixed - LB: North (A0°, 20.5 ft², width 3 ft)
VC.56: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.57: Windows Fixed - LB: North (A0°, 7.5 ft², width 3 ft)
VC.58: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)
VC.59: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)
VC.60: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)
VC.61: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.62: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.63: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)
VC.64: Windows Fixed - LB: NW (A321°, 5.91 ft², width 3 ft)
VC.65: Windows Fixed - LB: North (A341.3°, 7.5 ft², width 3 ft)
VC.66: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.67: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.68: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.69: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.70: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.71: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.72: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.73: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.74: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.75: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.76: Windows Fixed - LB: NW (A321°, 7.5 ft², width 3 ft)
VC.77: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.78: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.79: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.80: Windows Fixed - LB: NW (A321°, 20.5 ft², width 3 ft)
VC.81: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.82: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.83: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.84: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.85: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.86: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.87: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)
VC.88: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.89: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)
VC.90: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.91: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.92: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.93: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)
VC.94: Windows Fixed - LB: East (A90°, 7.5 ft², width 3 ft)
VC.95: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.96: Windows Fixed - LB: SW (A232.7°, 20.5 ft², width 3 ft)
VC.97: Windows Fixed - LB: SW (A232.7°, 7.5 ft², width 3 ft)
VC.98: Windows Fixed - LB: NE (A52.6°, 7.5 ft², width 3 ft)
0
8333.33
16666.67
25000
33333.33
41666.67
50000
[kBtu/yr]



Summary building envelope

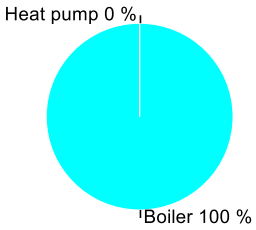
	Total area / length	Average U-value / Psi value	Transmission losses
Exterior wall ambient:	**20,433.7** ft²	**0.033** Btu/hr ft² °F	**106,598.9** kBtu/yr
Exterior wall ground:	**0** ft²	**0** Btu/hr ft² °F	**0** kBtu/yr
Basement:	**3,631.8** ft²	**0.051** Btu/hr ft² °F	**11,262.8** kBtu/yr
Roof:	**13,512** ft²	**0.019** Btu/hr ft² °F	**39,833.6** kBtu/yr
Windows:	**7,845.2** ft²	**0.168** Btu/hr ft² °F	**207,124** 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

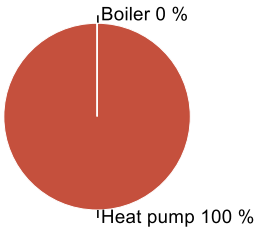
	Heating	Cooling
Reduction factor North:	**85.1** %	**84.8** %
Reduction factor East:	**69.4** %	**70.5** %
Reduction factor South:	**77.8** %	**73.8** %
Reduction factor West:	**78** %	**78.1** %
Reduction factor Horizontal:	**100** %	**100** %

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]
Boiler, Example Boiler	100	0	245,236.8	0	0	0	1.1	39,619,163	269,760.4
Heat pump, Mini-Split System	0	0	0	100	0	24,055.9	0	10,586,132.2	43,300.5
Σ	100	0	245,236.8	100	0	24,055.9		50,205,295.2	313,061

DHW - final energy



Heating - final energy



COOLING UNITS

	sensible	latent
Air cooling:	**0** kBtu/ft²yr	**0** kBtu/ft²yr
Recirculation cooling:	**5.9** kBtu/ft²yr	**4.3** kBtu/ft²yr
Additional dehumidification:		**0** kBtu/ft²yr
Panel cooling:	**0** kBtu/ft²yr	
Sum:	**5.9** kBtu/ft²yr	**4.3** kBtu/ft²yr

Boiler

Boiler type:	**Gas**
Condensing:	**yes**
In thermal envelope:	**yes**
Boiler output:	**145,260.9** Btu/hr
Efficiency at 30% load:	**98** %
Efficiency at normal output:	**94** %
Heatloss at 70°C standby:	**0.9** %

VENTILATION

Energy transportable by supply air

Heating energy

transportable: **1.4** W/ft²
load: **0.98** W/ft²

Cooling energy

transportable: **0.88** W/ft²
load: **0.88** W/ft²

Infiltration pressure test ACH50: **0.43** 1/hr
Total extract air demand: **5,620** cfm
Supply air per person: **18** cfm
Occupancy: **114**

Average air flow rate: **3,017.5** cfm
Average air change rate: **0.37** 1/hr
Effective ACH ambient: **0.08** 1/hr
Effective ACH ground: **0** 1/hr
Energetically effective air exchange: **0.08** 1/hr
Infiltration air change rate: **0.03** 1/hr
Infiltration air change rate (heating load): **0.08** 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: **100,031.99** kBtu/yr

Devices

Name	Sensible recovery efficiency [-]	Electric efficiency [W/cfm]	Heat recovery efficiency SHX [-]	Effective recovery efficiency [-]
Central Roof top System	0.9	0.04	0	0.9
Altogether	0.9	0.04	0	0.9

Ducts

Name	Length (total) [ft]	Clear cross-section [ft²]	U-value [Btu/hr ft² °F]	Assigned ventilation units
Main Supply	1	3.1416	0.49	Central Roof top System
Main Exhaust	1	3.1416	0.49	Central Roof top System
Σ	2			

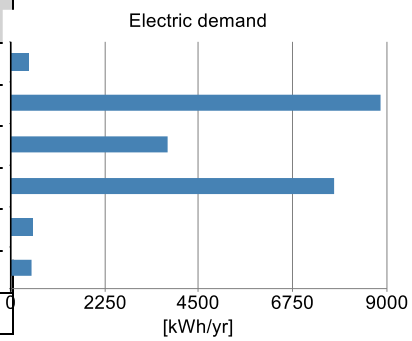
*length * quantity ** thermal conductivity / thickness

SUMMER VENTILATION

ACH night ventilation: **0** 1/hr
ACH natural summer: **0** 1/hr
Mechanical ventilation summer: **0.4** 1/hr
Mechanical ventilation summer with HR: **yes**

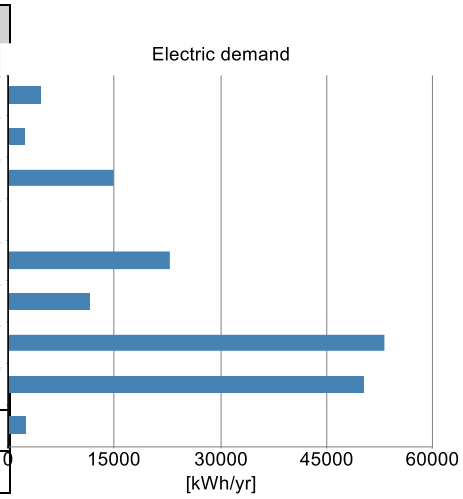
ELECTRICITY DEMAND - AUXILIARY ELECTRICITY

Type	Quantity	Indoor	Norm demand	Electric demand [kWh/yr]	Source energy [kBtu/yr]
Boiler DHW system auxiliary energy	1	yes	272.4 W	428.3	2630.4
Ventilation winter	1	no	0.6 W/cfm	8877.3	54517.5
Ventilation Defrost	1	no	16,069.5 W	3771.1	23159.4
Ventilation summer	1	no	0.6 W/cfm	7739.6	47530.8
DHW circulating pump	1	yes	64.6 W	528.1	3243.2
DHW storage load pump	1	yes	321.2 W	505.1	3101.8
Σ				21849.5	134183



ELECTRICITY DEMAND RESIDENTIAL BUILDING

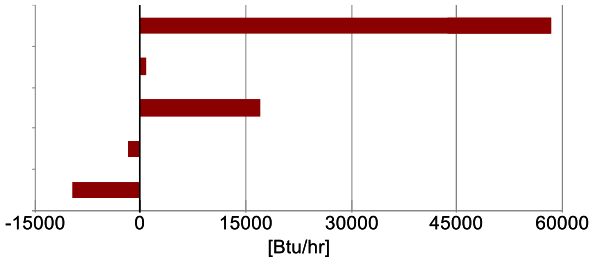
Type	Quantity	Indoor	Norm demand	Electric demand [kWh/yr]	Non-electric demand [kWh/yr]	Source energy [kBtu/yr]
Kitchen dishwasher	1	yes	1.2	4492.8	0	27591.5
Laundry - washer	1	yes	0.3	2135.8	0	13116.5
Laundry - dryer	1	yes	3.9	14786.1	0	90805.4
Energy consumed by evaporation	0	yes	3.1	0	507.5	2013.1
Kitchen fridge/freeze combo	1	yes	1.2	22899	0	140628.5
Kitchen cooking	1	yes	0.2	11400	0	70010.2
User defined MELs	1	yes	53,133	53133	0	326303
User defined lighting	1	yes	50,355	50355	0	309242.6
User defined lighting	1	no	2,366	2366	0	14530.2
Σ	8			161567.8	507.5	994240.9



INTERNAL HEAT GAINS

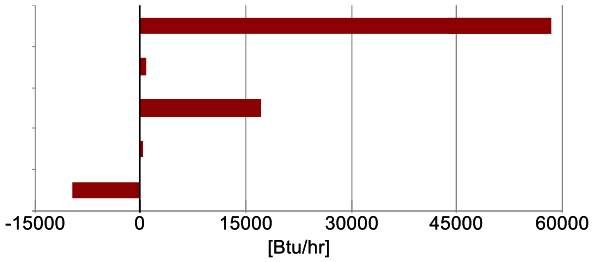
Heating season

Electricity total:	**58,508.7**	Btu/hr
Auxiliary electricity:	**790.4**	Btu/hr
People:	**17,115.3**	Btu/hr
Cold water:	**-1,585.7**	Btu/hr
Evaporation:	**-9,724.6**	Btu/hr
Σ:	**65,080.1**	Btu/hr
Specific internal heat gains:	**1.5**	Btu/hr ft²



Cooling season

Electricity total:	**58,508.7**	Btu/hr
Auxiliary electricity:	**790.4**	Btu/hr
People:	**17,115.3**	Btu/hr
Cold and hot water:	**359.3**	Btu/hr
Evaporation:	**-9,724.6**	Btu/hr
Σ:	**65,080.1**	Btu/hr
Specific internal heat gains:	**1.5**	Btu/hr ft²



DHW AND DISTRIBUTION

DHW consumption per person per day:	**6.6**	gal/Person/day
Average cold water temperature supply:	**52.8**	°F
Useful heat DHW:	**215,871.5**	kBtu/yr
Specific useful heat DHW:	**4,972.3**	Btu/ft²yr
Total heat losses of the DHW system:	**12,529.2**	kBtu/yr
Specific losses of the DHW system:	**288.6**	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:	**228,400.7**	kBtu/yr
Total specific heat demand of DHW system:	**5,260.9**	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	1425	10055.4
Σ	1425	10055.4
Individual pipes		
In conditioned space		0
Σ		0
Water storage		
Device 3 (Water storage: DHW)		1997.1
Σ		1997.1

National Rater Design Review Checklist [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

If pursuing Track A – HVAC Grading by Rater, complete this page. [3]

Project Name:_____ Number of Units: _____ Permit Date: _____

Project Address: _____ City: _____ State: _____

	Must Correct	Rater [4] Verified
1. Partnership Status		
1.1 Rater has verified and documented that builder or developer has an ENERGY STAR partnership agreement using www.energystar.gov/partnerlocator. Builder name: _____ Developer name: _____	☐	☐
1.2 ASHRAE Only: Rater has verified that modeler is listed in the online directory using www.energystar.gov/ASHRAEdirectory. Modeler name: _____ (Not required for projects in California)	☐	☐
2. High-Performance Fenestration		
2.1 Dwelling units:		
2.1.1 Prescriptive: Specified fenestration meets or exceeds ENERGY STAR MF Reference Design requirements. [5]	☐	☐
2.1.2 ERI and ASHRAE only: Specified fenestration meets or exceeds 2009 IECC residential requirements. [5]	☐	☐
2.2 Common space: [2]		
2.2.1 ERI and Prescriptive: Specified fenestration meets or exceeds ENERGY STAR MF Reference Design requirements. [5]	☐	☐
2.2.2 ASHRAE only: Specified fenestration meets or exceeds 2009 IECC commercial requirements. [5]	☐	☐
3. High-Performance Insulation		
3.1 Dwelling unit:		
3.1.1: Prescriptive: Specified ceiling [6], wall [7], floor, and slab-on-grade insulation levels meet or exceed ENERGY STAR MF Reference Design requirements. [8, 9, 10]	☐	☐
3.1.2: ERI and ASHRAE only: Specified ceiling [6], wall [7], floor, and slab-on-grade insulation levels meet or exceed values from the "Group R" column in the 2009 IECC Commercial chapter. [8, 9, 10]	☐	☐
3.2 Common space: [2]		
3.2.1 ERI and Prescriptive: Specified ceiling [6], wall [7], floor, and slab-on-grade insulation levels meet or exceed ENERGY STAR MF Reference Design requirements. [8, 9, 10]	☐	☐
3.2.2 ASHRAE only: Specified ceiling [6], wall [7], floor, and slab-on-grade insulation levels meet or exceed the values from the "All Other" column in the 2009 IECC Commercial chapter. [8, 9, 10]	☐	☐
4a. Review of ANSI / RESNET / ACCA Std. 310 HVAC Design Report with ENERGY STAR MFNC Supplement		
4a.1 HVAC design report(s) compliant with ANSI / RESNET / ACCA Std. 310 representing all applicable systems, with the ENERGY STAR MFNC supplement, collected for records, with no Items left blank.	☐	☐
4a.2 ANSI / RESNET / ACCA Std. 310 Rater Design Review Checklist completed for applicable housing type, with all items marked, "Rater Verified".	☐	☐
4a.3 Prescriptive Path: Dwelling Unit Mechanical Ventilation is <150% of ASHRAE 62.2-2013 requirements. [11]	☐	☐
4a.4 Total occupant gains do not exceed 645 Btuh per occupant. [12]	☐	☐
4a.5 Non-occupant internal gains are less than 3,600 Btuh.	☐	☐
4a.6 Cooling sizing % is within the cooling sizing limit selected by the HVAC designer.	☐	☐

Rater Name: _____ Date of Review: _____

Rater Signature: _____ Rater Company Name:_____

National Rater Design Review Checklist [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

If pursuing Track B – HVAC Testing by FT Agent, complete this page.

Project Name:_____ Number of Units: _____ Permit Date: _____

Project Address: _____ City: _____ State: _____

1. Partnership Status	**Must Correct**	**Rater [4] Verified**
1.1 Rater has verified and documented that builder or developer has an ENERGY STAR partnership agreement using www.energystar.gov/partnerlocator. Builder name: _____ Developer name: _____	☐	☐
1.2 ASHRAE Only: Rater has verified that modeler is listed in the online directory using www.energystar.gov/ASHRAEdirectory. Modeler name: _____ (Not required for projects in California)	☐	☐
2. High-Performance Fenestration		
2.1 Dwelling units:		
2.1.1 Prescriptive: Specified fenestration meets or exceeds ENERGY STAR MF Reference Design requirements. [5]	☐	☐
2.1.2 ERI and ASHRAE only: Specified fenestration meets or exceeds 2009 IECC residential requirements. [5]	☐	☐
2.2 Common space: [2]		
2.2.1 ERI and Prescriptive: Specified fenestration meets or exceeds ENERGY STAR MF Reference Design requirements. [5]	☐	☐
2.2.2 ASHRAE only: Specified fenestration meets or exceeds 2009 IECC commercial requirements. [5]	☐	☐
3. High-Performance Insulation		
3.1 Dwelling unit:		
3.1.1: Prescriptive: Specified ceiling [6], wall [7], floor, and slab-on-grade insulation levels meet or exceed ENERGY STAR MF Reference Design requirements. [8, 9, 10]	☐	☐
3.1.2: ERI and ASHRAE only: Specified ceiling [6], wall [7], floor, and slab-on-grade insulation levels meet or exceed values from the "Group R" column in the 2009 IECC Commercial chapter. [8, 9, 10]	☐	☐
3.2 Common space: [2]		
3.2.1 ERI and Prescriptive: Specified ceiling [6], wall [7], floor, and slab-on-grade insulation levels meet or exceed ENERGY STAR MF Reference Design requirements. [8, 9, 10]	☐	☐
3.2.2 ASHRAE only: Specified ceiling [6], wall [7], floor, and slab-on-grade insulation levels meet or exceed the values from the "All Other" column in the 2009 IECC Commercial chapter. [8, 9, 10]	☐	☐
4b. Review of ENERGY STAR MFNC National HVAC Design Report (National HVAC Design Report Item # indicated in parenthesis) [13]		
4b.1 National HVAC Design Report(s) collected for records, with no Items left blank.	☐	☐
4b.2 National HVAC Design Report(s) reviewed by Rater for the following parameters (National MFNC HVAC Design Report Item # indicated in parenthesis):		
4b.2.1 Prescriptive Path: Dwelling Unit Mechanical Ventilation (2.7) is <150% of ASHRAE 62.2-2013 requirements. [11]	☐	☐
4b.2.2 Cooling season and heating season outdoor design temperatures used in loads (3.4) are within the limits defined for the State and County where the building will be built, or the designer has provided an allowance from EPA to use alternative values. All limits are published at www.energystar.gov/hvacdesigntemps. Note that revised (i.e., 2019 Edition) limits are required to be used for all HVAC Design Reports generated after 07/01/2020. [14]	☐	☐
4b.2.3 Number of occupants used in loads (3.6) is within ± 2 of the dwelling unit to be certified and total occupant gains (3.7) do not exceed 645 Btuh per occupant. [12]	☐	☐
4b.2.4 Conditioned floor area used in loads (3.8) is between 100 sq. ft. smaller and 300 sq. ft. larger than the dwelling unit to be certified. [15]	☐	☐
4b.2.5 Window area used in loads (3.9) is between 15 sq. ft. smaller and 60 sq. ft. larger than the dwelling unit to be certified, or for dwelling units to be certified with > 500 sq. ft. of window area, between 3% smaller and 12% larger.[16]	☐	☐
4b.2.6 Predominant window SHGC used in loads (3.10) is within 0.1 of predominant value in the dwelling unit to be certified. [17]	☐	☐
4b.2.7 Mechanical ventilation used in loads (3.12) is the same as the ventilation design (2.7) for the given unit plan.	☐	☐
4b.2.8 Non-occupant internal gains (3.13) are less than 3,600 Btuh.	☐	☐
4b.2.9 Sensible & total heat gain are documented (3.15, 3.17) for the orientation of the dwelling unit to be certified. [18]	☐	☐
4b.2.10 Cooling sizing % (4.18) is within the cooling sizing limit (4.19) selected by the HVAC designer.	☐	☐

Rater Name: _____ Date of Review: _____

Rater Signature: _____ Rater Company Name:_____

National Rater Design Review Checklist [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

5. Additional Construction Document Review – <u>Recommended, not required</u>	
5.1 Air Sealing: Review construction documents to verify that air-sealing details at assemblies adjacent to exterior and unconditioned spaces are represented which, at a minimum, demonstrate compliance with checklist items in Section 4 of the National Rater Field Checklist (noted with an asterisk below). Items 5.1.9 and 5.1.10 are not verified by the Rater in the field, but are recommended.	
5.1.1 Ducts, flues, shafts, plumbing, piping, wiring, exhaust fans, & other penetrations to unconditioned space sealed, with blocking / flashing as needed*.	☐
5.1.2 Recessed lighting fixtures adjacent to unconditioned space ICAT labeled and gasketed. Also, if in insulated ceiling without attic above, exterior surface of fixture insulated to ≥ R-10 in CZ 4-8*.	☐
5.1.3 Continuous top plate or blocking is at top of walls adjoining unconditioned space including at balloon-framed parapets, and sealed*.	☐
5.1.4 Drywall sealed to top plate at all unconditioned attic / wall interfaces using caulk, foam, drywall adhesive (but not other construction adhesives), or equivalent material. Either apply sealant directly between drywall and top plate or to the seam between the two from the attic above*.	☐
5.1.5 Rough opening around windows & exterior doors sealed*.[19]	☐
5.1.6 Assemblies that separate attached garages from occupiable space sealed and, also, an air barrier installed, sealed, and aligned with these assemblies*.[20]	☐
5.1.7 Attic access panels, roof hatches and drop-down stairs are gasketed (i.e., not caulked) or equipped with durable covers that are gasketed*.[21]	☐
5.1.8 Doors adjacent to unconditioned space (e.g., attics, garages, basements), ambient conditions, or a unit entrance to a corridor / stairwell, made substantially air-tight with doorsweep and weatherstripping or equivalent gasket*.	☐
5.1.9 Above-grade sill plates adjacent to conditioned space sealed to foundation or sub-floor. Gasket also placed beneath above-grade sill plate if resting atop concrete / masonry & adjacent to conditioned space. [22, 23]	☐
5.1.10 The gap between the common wall (e.g., the drywall shaft wall) and the structural framing between units sealed at all exterior boundaries.	☐
5.2 Dwelling Unit Compartmentalization	
5.2.1 Review construction documents to verify that air-sealing details [24] are represented such that air exchange between the dwelling unit and outside as well as the dwelling unit and other adjacent spaces is minimized and designed to achieve compartmentalization less than or equal to 0.30 CFM50 per square feet of dwelling unit enclosure area, following procedures in ANSI / RESNET / ICC Std. 380.	☐
5.2.2 Seal all spaces 5.1.1-5.1.10 on adiabatic unit enclosure assemblies.	☐
5.3 Prescriptive Path: Verify that Window-to-wall ratio ≤ 30%. [25]	☐
5.4 Verify that fully-aligned air barrier details are in compliance with checklist items in Section 2 of the National Rater Field Checklist.	☐
5.5 Verify that thermal bridging details are in compliance with checklist items in Section 3 of the National Rater Field Checklist.	☐
5.6 Verify that HVAC details are in compliance with checklist items in Sections 5 - 10 of the National Rater Field Checklist.	☐
5.6.1 Verify that HVAC design includes access and means to measure the dwelling-unit mechanical ventilation airflow rate.	☐
5.6.2 Verify that bedrooms with design airflow ≥ 150 CFM are specified with a combination of transfer grilles, jump ducts dedicated return ducts, and/or undercut doors to achieve a Rater-measured pressure differential ≥ -5 Pa and ≤ +5 Pa with respect to the main body of the dwelling unit when all air handlers are operating.	☐
5.6.3 Verify that Functional Testing Agent(s) hold(s) credential required to complete the applicable sections of the National HVAC Functional Testing Checklist for all HVAC equipment in the building. For Track A, a Functional Testing Agent is not needed to complete Sections 2 and 3 for HVAC systems that will be verified and graded by the Rater. [26]	☐
5.7 Verify that Domestic Hot Water, Lighting, Appliances, Plumbing Fixtures, and Whole Building Utility Data Acquisition Strategy details are in compliance with checklist items in Sections 11 – 14 of the National Rater Field Checklist.	☐

National Rater Design Checklist Footnotes

ENERGY STAR Multifamily New Construction Version 1 / 1.1 / 1.2 (Rev. 02)

Footnotes:

1. This Checklist applies to all dwelling units, sleeping units, common spaces [2], and garages (open or enclosed) in the building being certified, and where specified, parking lots. These requirements do not apply to parking garages or lots where the cost of the energy use of the parking garage or lot is not the responsibility of the Builder/Developer, Building Owner or Property Manager. This Checklist does not apply to commercial or retail spaces. This Checklist does not apply to common spaces that are located in buildings on the property without any dwelling or sleeping units. The term 'sleeping unit' refers to a room or space in which people sleep, which can also include permanent provisions for living, eating, and either sanitation or kitchen facilities but not both. Where the term 'dwelling unit' is used in this Checklist, the requirement is also required of 'sleeping' units. The term 'building' refers to a structure utilized or intended for supporting or sheltering occupancy for a residential purpose; a structure with no dwelling or sleeping units connected to a structure with dwelling or sleeping units by less than 10% of its exterior wall area is not to be included in the 'building'.
2. The term 'common space' refers to any spaces in the building being certified that serve a function in support of the residential part of the building that is not part of a dwelling or sleeping unit. This includes spaces used by residents, such as corridors, stairs, lobbies, laundry rooms, exercise rooms, residential recreation rooms, and dining halls, as well as offices and other spaces used by building management, administration or maintenance in support of the residents.
3. Track A –HVAC Grading by Rater shall not be used until an implementation schedule has been defined for ANSI / RESNET / ACCA Std. 310 by the Home Certification Organization (HCO) or Multifamily Review Organization (MRO) that the building is being certified under. Track A –HVAC Grading by Rater shall then use ANSI / RESNET / ACCA Std. 310 including all Addenda and Normative Appendices, with new versions and Addenda implemented according to the schedule defined by the HCO or MRO that the building is being certified under.
4. The term 'Rater' refers to the person(s) completing the third-party verification required for certification. The person(s) shall: a) be a Certified Rater, Approved Inspector, as defined by ANSI / RESNET / IECC Standard 301, or an equivalent designation as determined by a HCO or MRO; and, b) have attended and successfully completed an EPA-recognized training class. See www.energystar.gov/mftraining.
5. All windows, doors and skylights must meet or exceed the U-factor and SHGC requirements specified in the table below. If no NFRC rating is noted on the window or in product literature (e.g., for site-built fenestration), select the U-factor and SHGC value from Tables 4 and 10, respectively, in 2013 ASHRAE Handbook of Fundamentals, Chapter 15. Select the highest U-factor and SHGC value among the values listed for the known window characteristics (e.g., frame type, number of panes, glass color, and presence of low-e coating). Note that the U-factor requirement applies to all fenestration while the SHGC only applies to the glazed portion.

	Dwelling unit doors and windows that are not classified "Class AW"*	**Dwelling unit windows and doors that are classified as "Class AW"* and all skylights**	**Common Space †**
ERI	2009 IECC Table 402.1.1	2009 IECC Table 502.3	ENERGY STAR MF Reference Design – for Class AW
ASHRAE	2009 IECC Table 402.1.1	2009 IECC Table 502.3	2009 IECC Table 502.3
Prescriptive	ENERGY STAR MF Reference Design	Windows and Doors: ENERGY STAR MF Reference Design – for Class AW Skylights: 2012 IECC Table 402.3	ENERGY STAR MF Reference Design – for Class AW

* Classified as "Class AW" under the North American Fenestration Standard (AAMA / WDMA / CSA 101 / I.S.2 / A440).
† Opaque doors in common spaces in CZ1-6 shall not exceed U-0.70, and in CZ 7-8, shall not exceed U-0.5.

The following exemptions apply:

i. An area-weighted average of fenestration products shall be permitted to satisfy the U-factor requirements;
ii. An area-weighted average of fenestration products ≥ 50% glazed shall be permitted to satisfy the SHGC requirements; and
iii. 5% of all combined fenestration area (glazed and opaque) shall be exempt from the U-factor and SHGC requirements, and shall be excluded from area-weighted averages calculated using i) and ii), above.

In PHIUS+ or PHI certified buildings, where triple-glazed window assemblies with thermal breaks / spacers between the panes are used, such windows meet the intent of Items 2.1 and 2.2 and shall be excluded when assessing compliance of i) through iii), above.

6. All insulated ceiling surfaces, regardless of slope (e.g., cathedral ceilings, tray ceilings, conditioned attic roof decks, flat ceilings, sloped ceilings), must meet the requirements for ceilings, unless the ceiling is adiabatic, such as the insulated or uninsulated ceiling between two dwelling units in a multistory building. Where the term "ceiling" is used, the component insulation levels for "roofs" shall be used.
7. Items 3.1 and 3.2 are applicable to walls that are adjacent to other buildings, the exterior, or a garage. Where the wall assembly includes continuous insulation that is interrupted by fasteners or service openings, an assembly U-factor must be calculated. For the interrupted portions, the continuous insulation cannot contribute to the assembly U-factor and an overall U-factor shall be calculated based on an area weighted ratio. Thermally broken shelf-angles are exempt from de-rating.
8. The following exceptions apply:
   a. For ceilings with attic spaces, R-30 shall satisfy the requirement for R-38 and R-38 shall satisfy the requirement for R-49 wherever the full height of uncompressed insulation at the lower R-value extends over the wall top plate at the eaves. This exemption shall not apply if the alternative calculations in e) are used;
   b. For ceilings without attic spaces, that are not roofs with insulation above deck, R-30 shall satisfy the requirement for any required value above R-30 if the design of the roof / ceiling assembly does not provide sufficient space for the required insulation value. This exemption shall be limited to 20% of the total insulated ceiling area. This exemption shall not apply if the alternative calculations in e) are used;
   c. Common spaces following the ENERGY STAR Multifamily Reference Design should use the version of IECC specified and the "All Other" column of either the commercial R-value or U-factor tables. To identify the assembly insulation requirement, use the row of

the table that best corresponds to that assembly. Unlike Prescriptive Path dwelling units, the common spaces do not need to follow the row corresponding to a wood-framed building.

d. Where identifying insulation requirements from the commercial chapter of IECC, values from either the R-value or U-factor table may be used for compliance. When referencing the 2009 IECC, projects in Climate Zone 4 and Climate Zone 5/Marine 4 may use U-0.089 and U-0.064 respectively for Group R wood-framed walls instead of the printed U-0.064 and U-0.051.

e. An alternative total UA calculation may also be used to demonstrate compliance, as follows:

A total building thermal envelope UA that is less than or equal to the total UA resulting from meeting the individual assembly U-factors also complies. The performance of all components (i.e., roofs, walls, floors, slabs-on-grade, and fenestration) can be traded off using the UA approach. Note that Items 1.5, 1.6, and 3.1 through 3.7 of the National Rater Field Checklist shall be met regardless of the UA tradeoffs calculated. The UA calculation shall be done using a method consistent with the ASHRAE Handbook of Fundamentals and shall include the thermal bridging effects of framing materials. The calculation for a steel-frame envelope assembly shall use the ASHRAE zone method or a method providing equivalent results, and not a series-parallel path calculation method.

9. Consistent with the 2009 IECC, slab edge insulation is only required for slab-on-grade floors with a floor surface less than 24 inches below grade. Slab-on-grade perimeter insulation shall extend to the top of the slab to provide a complete thermal break. If the top edge of the insulation is installed between the exterior wall and the edge of the interior slab, it shall be permitted to be cut at a 45-degree angle away from the exterior wall. Alternatively, the thermal break is permitted to be created using ≥ R-3 rigid insulation on top of an existing slab (e.g., in a building undergoing a gut rehabilitation). In such cases, up to 10% of the slab surface is permitted to not be insulated (e.g., for sleepers, for sill plates). Insulation installed on top of slab shall be covered by a durable floor surface (e.g., hardwood, tile, carpet).

10. Where an insulated wall separates a garage, patio, porch, or other unconditioned space from the conditioned space of the building, slab perimeter insulation shall also be installed at this interface to provide a thermal break between the conditioned and unconditioned slab, if the slab is in contact with the ground at that interface. Where specific details cannot meet this requirement, partners shall provide the detail to EPA to request an exemption prior to the building's certification. EPA will compile exempted details and work with industry to develop feasible details for use in future revisions to the program. A list of currently exempted details is available at: www.energystar.gov/slabedge.

11. Raters may use this table to determine the maximum ventilation rate allowed.

	Number of Bedrooms				
Floor area	**1**	**2**	**3**	**4**	**5**
<500	45	57	67.5	79.5	90
501-1000	67.5	79.5	90	102	112.5
1001-1500	90	102	112.5	124.5	135
1501-2000	112.5	124.5	135	147	157.5
2001-2500	135	147	157.5	169.5	180
2501-3000	157.5	169.5	180	192	202.5
3001-3500	180	192	202.5	214.5	225
3501-4000	202.5	214.5	225	237	247.5
4001-4500	225	237	247.5	259.5	270
4501-5000	247.5	259.5	270	282	292.5

12. To determine the number of occupants among all HVAC systems in the dwelling unit, calculate the number of bedrooms, as defined below, and add one. The number of occupants used in loads must be within ± 2 of the dwelling unit to be certified.

A bedroom is defined by ANSI / RESNET / ICC Standard 301-2014 as a room or space 70 sq. ft. or greater size, with egress window and closet, used or intended to be used for sleeping. A "den", "library", or "home office" with a closet, egress window, and 70 sq. ft. or greater size or other similar rooms shall count as a bedroom, but living rooms and foyers shall not.

An egress window, as defined in 2009 IRC Section R310, shall refer to any operable window that provides for a means of escape and access for rescue in the event of an emergency. The egress window definition has been summarized for convenience. The egress window shall:

- have a sill height of not more than 44 inches above the floor; AND
- have a minimum net clear opening of 5.7 sq. ft.; AND
- have a minimum net clear opening height of 24 in.; AND
- have a minimum net clear opening width of 20 in.; AND
- be operational from the inside of the room without the use of keys, tools or special knowledge.

13. The Rater shall collect the National HVAC Design Report(s) per building / project. See Footnote 1 of the National HVAC Design Report for alternatives. Where using an ENERGY STAR Single-Family New Homes National HVAC Design Report, Rater must still review all Items under 4b.2. Regardless of whether the "unit-specific design", "group design", or "worst-case design" box has been checked in Item 3.2 of the National HVAC Design Report, the system design as documented on the National HVAC Design Report must fall within the tolerances in Item 4b.2 for the unit to be certified. The Rater is only responsible for verifying that the designer has not left any items blank on the National HVAC Design Report and for verifying the discrete objective parameters in Item 4b.2 of this Checklist, not for verifying the accuracy of every input on the National HVAC Design Report.

14. Visit www.energystar.gov/hvacdesigntemps for the maximum cooling season design temperature and minimum heating season design temperature permitted and the process for a designer to obtain an allowance from EPA. The same design report is permitted to be used in other counties, as long as the design temperature limits in those other counties meet or exceed the cooling and heating season temperature

limits for the county selected. For example, if Fauquier County, VA, is used for the load calculations, with a 1% cooling temperature limit of 93 °F, then the same report could be used in Fairfax County (which has a higher limit of 94 °F) but not in Arlington County (which has a lower limit of 92 °F).

15. Conditioned Floor Area for the dwelling unit to be certified shall be calculated in accordance with the definition in ANSI / RESNET / ICC Standard 301-2019.
16. Window area for the dwelling unit to be certified shall be calculated in accordance with the on-site inspection protocol provided in Normative Appendix B of ANSI / RESNET / ICC Standard 301-2019.
17. "Predominant" is defined as the SHGC value used in the greatest amount of window area in the dwelling unit.
18. Orientation represents the direction that the front door of the dwelling unit is facing. The designer is only required to document the loads for the orientation(s) that the dwelling unit might be built in. For example, if a unit plan will only be built in a specific orientation (e.g., facing South), then the designer only needs to document the loads for this one orientation.
19. In Climate Zones 1 through 3, a continuous stucco cladding system sealed to windows and doors is permitted to be used in lieu of sealing rough openings with caulk or foam.
20. For dwelling or sleeping units adjacent to garages, EPA recommends, but does not require, carbon monoxide (CO) alarms installed in a central location in the immediate vicinity of each separate sleeping zone and according to NFPA 720.
21. Examples of durable covers include, but are not limited to, pre-fabricated covers with integral insulation, rigid foam adhered to cover with adhesive, or batt insulation mechanically fastened to the cover (e.g., using bolts, metal wire, or metal strapping).
22. Existing sill plates (e.g., in a building undergoing a gut rehabilitation) on the interior side of structural masonry or monolithic walls may not be able to complete this Item. In addition, other existing sill plates resting atop concrete or masonry and adjacent to conditioned space can in lieu of using a gasket, be sealed with caulk, foam, or equivalent material at both the interior seam between the sill plate and the subfloor and the seam between the top of the sill plate and the sheathing.
23. In Climate Zones 1 through 3, a continuous stucco cladding system adjacent to sill and bottom plates is an alternate option of sealing plates to foundation or sub-floor with caulk, foam, or equivalent material.
24. Recommended air leakage paths to be sealed include, but are not limited to the following:
    a. Plumbing penetrations, including those from water piping, drain waste and vent piping, HVAC piping, and gas line piping.
    b. Electrical penetrations, including those for receptacle outlets, lighting outlets / fixtures, communications wiring, thermostats, and smoke alarms.
    c. HVAC penetrations, including those for fans and for exhaust, supply, transfer, and return air ducts.
    d. Envelope penetrations, including at the intersection of baseboard trim and floor, at the intersection of walls and ceilings, around window trim and dwelling unit doors, including the door latch hole.
25. Window-to-Wall ratio is taken as the sum of all window area divided by the total exterior above-grade wall area. All decorative glass and skylight window area contribute to the total window area to above-grade wall ratio (WWR). Spandrel sections of curtain wall systems contribute to the above-grade wall area.
26. Functional Testing Agents must hold an approved credential, as listed at www.energystar.gov/ftas, or must be a representative of the Original Equipment Manufacturer (OEM), or a contractor credentialed by an HVAC Quality Installation Training and Oversight Organization (H-QUITO), if not completing Sections 6 and higher. Functional Testing Agents may not be the installing contractor, nor employed by the same company as the installing contractor, unless they are a credentialed contractor. An explanation of the credentialing process and links to H-QUITOs, which maintain lists of credentialed contractors, can be found at www.energystar.gov/findhvac. A directory of other FT Agents can be found at www.energystar.gov/ftas.

National HVAC Design Report [1]

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HVAC Designer Responsibilities:

- Complete one National HVAC Design Report for each building which includes system design for all unique unit plans and common spaces. For projects with multiple buildings, one National HVAC Design Report per building or per project is permitted. [1]
- Obtain efficiency features (e.g., window performance, insulation levels, and infiltration rate) from the builder, architect, or Rater. [2]
- Provide the completed National HVAC Design Report to the Rater and the person / company completing the National HVAC Functional Testing Checklist. [2]

1. Design Overview

1.1 Designer name: _____ Designer company: _____ Date: _____

1.2 Select which party you are providing these design services to: ☐ Builder / Developer ☐ FT Agent ☐ MEP / Credentialed HVAC contractor

1.3 Name of company you are providing these design services to (if different than Item 1.1): _____

1.4 Project address: _____ City: _____ State: _____ Zip code: _____

2a. Dwelling Unit & Common Space Mechanical Ventilation Design ("Vent System") [3] & Inlets in Return Duct [4, 5, 6]						**Designer Verified**
Airflow:						
2.1 Dwelling unit ventilation airflow design rate & run-time meet the requirements of Section 4 of ASHRAE 62.2 [7] ☐ 2010 ☐ 2013.						☐
2.2 Common space outdoor airflow design rate meet the requirements of Section 6 of ASHRAE 62.1 [8] ☐ 2010 ☐ 2013, without exceeding 2013 rates by more than 50%.						☐
2.3 Access points to measure airflow rate and inspect outdoor air dampers are provided and accessible by the Rater. [2]						☐
List unique unit plan for which 62.2 ventilation rates were calculated in the spaces to the right: [9]						
2.4 # of bedrooms:						
2.5 Square footage:						
2.6 Ventilation airflow rate required by ASHRAE 62.2:						
2.7 Ventilation airflow rate designed:						
2.7.1 If applicable, run-time per cycle (minutes):						
2.7.2 If applicable, cycle time (minutes):						
List common space for which 62.1 ventilation rates were calculated in the spaces to the right: [9]						
2.8 Ventilation airflow rate required by ASHRAE 62.1:						
2.9 Ventilation airflow rate designed:						
System Type & Controls:						
List Ventilation System ID in the spaces to the right: [9]						
2.10 Specified system type: (e.g., supply, exhaust, balanced, ERV, HRV)						
2.11 Specified system type: (e.g., in-unit, central)						
2.12 Manufacturer:						
2.13 Model Number:						
2.14 Area / space(s) that system serves: (e.g., Unit A kitchens, corridor, community room)						
2.15 Specified control location: (e.g., Master bath, utility):						
2.16 Specified controls allow the systems to operate automatically, without occupant intervention. A ventilation override control is specified and also labeled if its function is not obvious (e.g., a label is required for a toggle wall switch, but not for a switch that's on the ventilation equipment). In townhouses only, this control must be readily accessible to the occupant. In all other multifamily dwelling units, the override control is not required to be readily accessible to the occupant. However, in such cases, EPA recommends but does not require that the control be readily accessible to others (e.g., building maintenance staff) in lieu of the occupant.						☐
2.17 For any outdoor air inlet designed to connect to the ducted return of the dwelling unit HVAC system, specified controls automatically restrict airflow using a motorized damper during ventilation off-cycle and occupant override. [6, 10,]						☐
Sound:						
2.18 If located in the dwelling unit, the fan of the specified system is rated ≤ 3 sones if intermittent and ≤ 2 sones if continuous, or exempted. [11]						☐
Efficiency:						
2.19 If dwelling-unit Vent System controller operates the dwelling unit HVAC fan, then HVAC fan operation is intermittent and either the fan type in Item 4.12 is ECM / ICM, or the controls will reduce the run-time by accounting for HVAC system is heating or cooling hours. [12]						☐
2.20 If in-unit bathroom fans or in-line fans are specified as part of the dwelling unit mechanical ventilation system, then they are ENERGY STAR certified. [13]						☐

National HVAC Design Report [1]

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2.21 If central exhaust fans, ≤ 1 HP, are specified as part of the dwelling unit mechanical ventilation system, then they are direct-drive, ECM, with variable speed controllers. If > 1 HP, they are specified with NEMA Premium™ Motors.	☐
Air Inlet Locations: (Complete this section if system has specified air inlet location(s); otherwise check "N/A".) [14]	**Designer Verified** ☐ N/A
2.22 Inlet(s) pull ventilation air directly from outdoors and not from attic, crawlspace, garage, or adjacent dwelling unit.	☐
2.23 Inlet(s) are ≥ 2 ft. above grade or roof deck; ≥ 10 ft. of stretched-string distance from known contamination sources (e.g., stack, vent, exhaust, vehicles) not exiting the roof, and ≥ 3 ft. from dryer exhausts and sources exiting the roof.	☐
2.24 Inlet(s) are provided with rodent / insect screen with ≤ 0.5 inch mesh.	☐
2b. Dwelling Unit Local Mechanical Exhaust Design – System(s) are designed that mechanically exhaust air from each dwelling unit kitchen and bathroom directly to the outdoors or to ventilation risers and meet the continuous and/or intermittent rates. [15]	☐

Location		**Continuous Rate**	**Intermittent Rate**[16]	**Exhaust Fan Type**
Kitchen	Airflow	≥ 5 ACH, based on kitchen volume[17, 18, 19]	≥ 100 CFM and, if not integrated with range, also ≥ 5 ACH based on kitchen volume [17, 18, 19, 20]	☐ Continuous ☐ Intermittent ☐ In-unit fan ☐ Central / shared fan
	Sound	Recommended if in-unit: ≤ 1 sone	Recommended if in-unit: ≤ 3 sones	
Bathroom	Airflow	≥ 20 CFM	≥ 50 CFM	☐ Continuous ☐ Intermittent ☐ In-unit fan ☐ Central / shared fan
	Sound	Required if in-unit: ≤ 2 sones	Recommended if in-unit: ≤ 3 sones	

2c. Common Space and Garage Minimum Exhaust Rates – System(s) are designed that mechanically exhaust air from each common space, as required by ASHRAE 62.1-2010 or 2013	☐

Location	**ASHRAE 62.1 Rate**	**Design Rate**	**Location**	**ASHRAE 62.1 Rate**	**Design Rate**
Janitor Room	1 cfm/ft²		Common space kitchen [21]	50 cfm / 100 cfm	
Trash / Recycling Room	1 cfm/ft²		Common space bathroom [22]	50 cfm per toilet / urinal	
Parking Garage	0.05 cfm/ft², standby 0.75 cfm/ft², full-on		☐ Shared garage exhaust fan controls include CO and NO2 sensors.		

3. Heating & Cooling Loads

Dwelling Unit Heating & Cooling Loads (only required for ducted split AC, unitary AC, ASHP, WSHP, GSHP, and furnaces.) [23] ☐ N/A

3.1 Loads calculated using: ☐ Unabridged ACCA Manual J v8 ☐ 2013 / 2017 ASHRAE Fundamentals ☐ Other per AHJ [24]
Townhouses only: Loads must be calculated room-by-room.

3.2 Check one box only to indicate whether the Dwelling Unit Loads is unit-specific or represents the design of more than one unit: [25]
☐ Unit-specific design ☐ Group design [26] ____ total groups for this project, representing ____ units.
☐ Worst-case design (If the top floor unit with the greatest CFA and window area results in total heat gain <18 kBtuh, it may represent all other units if cooling system selected for all is single-speed & <20 kBtuh or two-speed / variable-speed & <25 kBtuh.

3.3 Indoor design temperatures used in loads are 70°F for heating and 75°F for cooling. ☐

3.4 Outdoor design temperatures used in loads: (See Footnote 24 and www.energystar.gov/hvacdesigntemps.) [25,27]
County & State selected: _____ Cooling season: _____°F Heating season: _____°F

List the unit plan for which Loads were calculated: [9]								
3.5 Location of Unit: top, mid, bottom, corner, interior								
3.6 Number of occupants used in loads: [25, 28]								
3.7 Total occupant gains (Btuh): [25]								
3.8 Conditioned floor area used in loads: [25, 29]								
3.9 Window area used in loads: [25, 30]								
3.10 Predominant window SHGC used in loads: [25, 31]								
3.11 Infiltration (ACH / ACH50 / CFM) used in loads: [32]								
3.12 Mechanical ventilation (CFM) used in loads: [25]								
3.13 Non-occupant Internal gains (appliance, equipment and lighting) used in loads (Btuh): [25]								
3.14 Orientation (N, NE, E, SE, S, SW, W, NW): [26]								
3.15 Sensible Heat Gain At Design Conditions (kBtuh): [25]								
3.16 Latent Heat Gain At Design Conditions (kBtuh):								
3.17 Total Heat Gain at Design Conditions (kBtuh): [25]								
3.18 Total Heat Loss at Design Conditions (kBtuh):								

3.19 Common Space Heating & Cooling Loads [9]

Common Space Name: _____ Design Conditions: Total Heat Gain: _____(kBtuh) Total Heat Loss: _____(kBtuh)
Common Space Name: _____ Design Conditions: Total Heat Gain: _____(kBtuh) Total Heat Loss: _____(kBtuh)
Common Space Name: _____ Design Conditions: Total Heat Gain: _____(kBtuh) Total Heat Loss: _____(kBtuh)

National HVAC Design Report [1]

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3.20 Building Heating & Cooling Loads [9] (only required when shared systems such as central boilers or chillers are specified.)	**Designer Verified** ☐ N/A
System Name: _____Design Conditions: Total Heat Gain: _____(kBtuh) Total Heat Loss: _____(kBtuh)	
System Name: _____Design Conditions: Total Heat Gain: _____(kBtuh) Total Heat Loss: _____(kBtuh)	

4. Heating & Cooling Equipment Selection		
4.1 Equipment selected per ☐ ACCA Manual S, or where not applicable, ☐ Other: _____. (See Footnote 30) [33]	☐	
4.2 Prescriptive Path: Equipment serving dwelling units and common spaces meet the efficiency levels specified in the Exhibit X of the National Rater Field Checklist. Electric resistance space heating is not specified in dwelling units.	☐	☐ N/A
4.3 ERI Path: Equipment serving common spaces but not serving dwelling units meet the efficiency levels specified in the Exhibit X of the National Rater Field Checklist. Also see Exhibit X for restrictions on electric space resistance.	☐	☐ N/A

Cooling Equipment [9] (Complete all applicable items, noting "N/A" as needed; where the same Equipment ID is used in multiple spaces (columns), identical data is not required to be repeated and can be left blank; where cooling is not provided, check "N/A".) ☐ N/A							
List Cooling Equipment ID in the spaces to the right; duplicating as needed for each unique space served:							
4.4 Equipment type: (e.g., PTAC / AC, Chiller / CT, PTHP / WLHP / GSHP / ASHP / VRF)							
4.5 Area / Space(s) that system serves:							
4.6 Chiller / condenser / outdoor unit manufacturer:							
4.7 Chiller / condenser / outdoor unit model #:							
4.8 Evaporator / indoor unit manufacturer:							
4.9 Evaporator / indoor unit model #:							
4.10 AHRI reference #: [34]							
4.11 AHRI listed efficiency:							
4.12 Evaporator fan type: PSC, ECM / ICM, Other							
4.13 Compressor speed: Single, Two, Variable							
4.14 Turn down ratio (for variable speed equipment):							
4.15 Latent capacity at design conditions (kBtuh): [35]							
4.16 Sensible capacity at design conditions (kBtuh): [35]							
4.17 Total capacity at design conditions (kBtuh): [35]	0	0	0	0	0	0	0
4.18 Cooling sizing % = Total capacity (Item 4.17) divided by Total Heat Gain (Item 3.17) of space(s) in Item 4.5: [25]							
4.19 Meets cooling sizing limit: (see below for A, B, C, D or N/A) [23]							
4.20 If "B", list Load sensible heat ratio = Max. sensible heat gain (Item 3.15) / Max. total heat gain (Item 3.17): [36]							
4.21 If "B", calculate HDD / CDD ratio: [36]							

Equipment Type & Climate Condition	**Compressor Type (Per Item 4.13)**		
	Single-Speed	Two-Speed	Variable-Speed
A: For Cooling-Only Equipment or For Cooling Mode of Heat Pump in Condition A Climate [36]	Recommended: 90 – 115% Allowed: 90 – 130%	Recommended: 90 – 120% Allowed: 90 – 140%	Recommended: 90 – 130% Allowed: 90 – 160%
B: For Cooling Mode of Heat Pump in Condition B Climate [36]	90% - 100%, plus 15 kBtuh	90% - 100%, plus 15 kBtuh	90% - 100%, plus 15 kBtuh
C: For low-load spaces (≤15 kBtuh) [37]	≤ 20 kBtuh		
D: For low-load spaces (≤18 kBtuh) [37]		≤ 25 kBtuh	≤ 25 kBtuh

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Heating Equipment [9] (Complete all applicable items, noting "N/A" as needed; where the same Equipment ID is used in multiple spaces (columns), identical data is not required to be repeated and can be left blank; where heating is not provided, check "N/A".)							**Designer Verified** ☐ N/A
List Heating Equipment ID in the spaces to the right; duplicating as needed for each unique space served:							
4.22 Electric equipment type: PTHP, WLHP, GSHP, ASHP, VRF, Boiler, Furnace, Electric Resistance							
4.23 Gas Equipment type: HW PTAC / fan coil, Gas-Fired PTAC, Boiler, Furnace							
4.24 Area / Space(s) that system serves:							
4.25 Manufacturer:							
4.26 Model Number:							
4.27 Listed efficiency:							
4.28 Equipment output capacity (kBtuh):							
4.29 Air-source heat pump output capacity (17°F) (kBtuh):							
4.30 Type of Venting: Natural Draft, Mechanically Drafted, Direct Vent [38]							
4.31 Furnace heating sizing % = Total capacity (Item 4.28) divided by Total Heat Loss of space(s) in Item 4.24:							
4.32 Meets furnace sizing limit: (see below for A, B, C, or N/A) [23]							

A: For low-load spaces (≤ 10 kBtuh), furnace output capacity is ≤ 40 kBtuh	
B: When Used for Heating Only	C: When Paired With Cooling
100 – 400%	Recommended: 100 – 140% Allowed: 100 – 400%

Equipment Controls	
4.33 All equipment controls below have been included where applicable in the HVAC Design.	☐
4.34 All heating and cooling systems serving a dwelling unit shall have thermostatic controls within the dwelling unit which are not located on exterior walls. If more than one system provides heating or cooling to the same space, controls prevent simultaneous heating and cooling.	
4.34.1 Prescriptive Path: Dwelling unit thermostats are programmable.	
4.35 Stair and elevator shaft vents shall be equipped with motorized dampers that are capable of being automatically closed during normal building operation and are interlocked to open as required by fire and smoke detection systems.	
4.36 Freeze protection systems, such as heat tracing of piping and heat exchangers, including self-regulating heat tracing, and garage / plenum heaters shall include automatic controls capable of shutting off the systems when pipe wall or garage / plenum temperatures are above 40°F. Where heat tracing is specified for freeze protection, controls must be based on pipe wall temperature and a minimum of R-3 pipe insulation is also required.	
4.37 Snow- and ice-melting systems shall include automatic controls capable of shutting off the systems when the pavement temperature is above 50°F and no precipitation is falling, and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F so that the potential for snow or ice accumulation is negligible.	

Hydronic Distribution	☐ N/A
4.38 All hydronic distribution requirements below have been included where applicable in the HVAC Design.	☐
4.39 All terminal heating and cooling distribution equipment must be separated from the riser or distribution loop by a control valve or terminal distribution pump, so that heated or cooled fluid is not delivered to the dwelling unit distribution equipment when there is no call from the thermostat.	
4.40 Terminal units must be equipped with pressure independent balancing valves or pressure independent control valves.	
4.41 Piping of a heating or cooling system (e.g., steam, hot or chilled water, brine, refrigerant) shall be thermally insulated in accordance with ASHRAE 90.1-2007, Table 6.8.3. Construction documents must account for piping total thickness including required insulation when passing through planks or any other penetrations and shall specify that the piping must be inspected before access is covered up: Heating System: Pipe size:____ inches Insulation thickness:___ inches Pipe size:____ inches Insulation thickness:___ inches Cooling System: Pipe size:____ inches Insulation thickness:___ inches Pipe size:____ inches Insulation thickness:___ inches	
4.42 For circulating pumps serving hydronic heating or cooling systems with three-phase motors, 1 horse-power or larger, motors shall meet or exceed efficiency standards for NEMA Premium™ motors. If 5 horse-power or larger, must also be specified with variable frequency drives.	
4.43 If a variable speed pumping system is installed, system designed to prevent "dead-heading" and a method of water flow bypass is provided, such as a minimum flow bypass valve or 3-way valves on specific terminal units.	
4.44 For shared boilers, chillers, and cooling towers, temperature and pressure gauges, air eliminator, expansion tank, and check valves are clearly shown on the drawings. A complete sequence of operations for all systems indicating recommendations for all setpoints is provided.	

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5. Dwelling Unit Duct Design (Complete if heating or cooling equipment will be installed with ducts; otherwise check "N/A".)	**Designer Verified** ☐ N/A
5.1 Duct system designed for the equipment selected in Section 4, per ☐ ACCA Manual D ☐ Other: _____ Townhouses only: Duct system must be designed per ACCA Manual D.	☐

5.2 Room-by-room design airflows documented below (which should sum to the mode with the higher Design HVAC fan airflow). [9, 39, 40]

Name of the unit plan:	Name of the unit plan:
Design HVAC fan airflow: [41] Cooling mode _____ CFM Heating mode _____ CFM	Design HVAC fan airflow: [41] Cooling mode _____ CFM Heating mode _____ CFM
Design HVAC fan speed setting (e.g., low, medium, high): [42] Cooling mode _____ Heating mode _____	Design HVAC fan speed setting (e.g., low, medium, high): [42] Cooling mode _____ Heating mode _____
Design total external static pressure (corresponding to the mode with the higher airflow above): [43] _____ IWC	Design total external static pressure (corresponding to the mode with the higher airflow above): [43] _____ IWC

	Room Name	Design Airflow (CFM)		Room Name	Design Airflow (CFM)
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
	Total for all rooms	0		Total for all rooms	0

6. Duct Quality Installation - *Applies to Heating, Cooling, Ventilation, Exhaust, & Pressure Balancing Ducts, Unless Noted in Footnote*	
6.1 All duct quality installation requirements below have been included where applicable in the HVAC Design.	☐
6.2 Ductwork specified without kinks, sharp bends, compressions, or excessive coiled flexible ductwork. [44]	
6.3 All supply and return ducts not in conditioned space, including connections to trunk ducts, are insulated to ≥ R-6. [45]	
6.3.1 Prescriptive Path: Dwelling unit ductwork meets the location and insulation requirements specified in the ENERGY STAR MF Reference Design.	
Dwelling Unit	
6.4 MERV 6+ filter(s) specified for each ducted mech. system serving an individual dwelling unit and located to facilitate access & regular service by the occupant or building owner. Filter access panel specified with a gasket or comparable sealing mechanism. All return air and mechanically supplied outdoor air designed to pass through filter prior to conditioning.	
6.5 Ductwork air-sealing specified such that Rater-measured total duct leakage is ≤ 4 CFM25 per 100 ft^2 of CFA at rough-in or ≤ 8 CFM25 per 100 ft^2 at final, or if there are no ducted returns, ≤ 3 CFM25 per 100 ft^2 of CFA at rough-in or ≤ 6 CFM25 per 100 ft^2 at final. [46] Additionally, for Townhouses only, Rater-measured duct leakage to the outside is ≤ 4 CFM25 per 100 ft^2 of CFA or ≤ 40 CFM25. [47]	
6.6 Bedrooms with a design supply airflow ≥ 150 CFM (as reported in Item 5.2) are specified with any combination of transfer grilles, jump ducts, dedicated return ducts, and/or undercut doors to achieve a Rater-measured pressure differential ≥ - 5 Pa and ≤ 5 Pa with respect to the main body of the dwelling unit when all air handlers are operating.	
Common Space	
6.7 Duct design specifies that all supply, return, and exhaust ductwork and all plenums serving common spaces shall be sealed at all transverse joints, longitudinal seams, and duct wall penetrations.	
6.8 Central exhaust systems (that serve four or more dwelling units): Ductwork air-sealing specified such that measured duct leakage does not exceed 25% of exhaust fan flow at rough-in (e.g., including trunks, branches, and take-offs) or 30% of exhaust fan flow at final (e.g., inclusive of all ductwork between the fan and the grilles). [48]	

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Footnotes:

1. This report shall represent system design for all unique unit plans, common spaces, and where applicable, parking garages. The term 'common space' refers to any spaces in the building being certified that serve a function in support of the residential part of the building that is not part of a dwelling or sleeping unit. This includes spaces used by residents, such as corridors, stairs, lobbies, laundry rooms, exercise rooms, residential recreation rooms, and dining halls, as well as offices and other spaces used by building management, administration or maintenance in support of the residents. As an alternative, for dwelling units, project teams may instead choose to complete a Single-Family New Homes National HVAC Design Report for each unique unit plan. For those unit plans, Items 3.7 and 3.13 of this Report would still need to be completed. Sections 4 and 5 must be completed in either Design Report unless exempted by this Report. All other systems, including all systems serving common spaces, must be documented in this Design Report. This report is designed to meet ASHRAE 62.1-2010 / 2013, ASHRAE 62.2-2010 / 2013, and ANSI / ACCA's 5 QI-2015 protocol, thereby improving the performance of HVAC equipment in new multifamily buildings when compared to multifamily buildings built to minimum code. However, these features alone cannot prevent all ventilation, indoor air quality, and HVAC problems (e.g., those caused by a lack of maintenance or occupant behavior). Therefore, system designs documented through the use of this report are not a guarantee of proper ventilation, indoor air quality, or HVAC performance.
2. The term 'Rater' refers to the person(s) completing the third-party verification required for certification. The person(s) shall: a) be a Certified Rater, Approved Inspector, as defined by ANSI / RESNET / IECC Standard 301, or an equivalent designation as determined by a Home Certification Organization (HCO) or Multifamily Review Organization (MRO); and, b) have attended and successfully completed an EPA-recognized training class. See www.energystar.gov/mftraining.
3. As defined by ANSI / RESNET / ICC Std. 301-2019, a Dwelling Unit Mechanical Ventilation System is a ventilation system consisting of powered ventilation equipment such as motor-driven fans and blowers and related mechanical components such as ducts, inlets, dampers, filters and associated control devices that provides dwelling-unit ventilation at a known or measured airflow rate.
4. The dwelling-unit mechanical ventilation system shall have at least one supply or exhaust fan with associated ducts and controls. Local exhaust fans are allowed to be part of a dwelling-unit mechanical ventilation system. Designers may provide supplemental documentation as needed to document the system design.
5. In "Warm-Humid" climates as defined by 2009 IECC Figure 301.1 (i.e., CZ 1 and portions of CZ 2 and 3A below the white line), it is recommended, but not required, that equipment be specified with sufficient latent capacity to maintain indoor relative humidity at ≤ 60%.
6. Item 2.17 applies to any outdoor air inlet connected to a ducted return of the dwelling unit HVAC system, regardless of its intended purpose (e.g., for ventilation air, make-up air, combustion air). This Item does not apply to HVAC systems without a ducted return. For example, if an outdoor air inlet connected to a ducted return is used as a dedicated source of outdoor air for an exhaust ventilation system (e.g., bath fan), the outdoor airflow must be automatically restricted when the exhaust fan is not running and in the event of an override of the exhaust ventilation system.

   In dwelling / sleeping units in multifamily buildings, but not townhouses, automatic restriction of airflow is exempted if a manual shutoff damper is used with a continuous exhaust ventilation system and is readily-accessible, labeled as the override, and not used as a balancing damper.

   Note that a Rater will generally measure the ventilation rate at the highest HVAC fan speed applicable to ventilation mode (e.g., if the inlet only opens when the HVAC is in 'fan-only' mode, then test in this mode) to verify that it is ≤ 15 CFM or 15% above design value. If the inlet has a motorized damper that only opens when the local mechanical kitchen exhaust is turned on, then testing is not required. As an alternative, measurement of the outdoor airflow can be waived if a Constant Airflow Regulating (CAR) damper with a manufacturer-specified maximum flow rate no higher than 15 CFM or 15% above the ventilation design value is installed on the inlet.
7. Airflow design rates and run-times shall be determined using ASHRAE 62.2-2010 or later. Designers are permitted, but not required, to use published addenda and/or the 2013 version of the standard to assess compliance.
8. Airflow design rates shall be determined using ASHRAE 62.1-2010 or later. Designers are permitted, but not required, to use published addenda and/or the 2013 version of the standard to assess compliance.
9. If the tables provided cannot accommodate all the unit plans, spaces, or systems in the project, use the tables in Appendix A to supplement the Design Report.
10. In addition, consult manufacturer requirements to ensure return air temperature requirements are met.
11. Dwelling-unit mechanical ventilation fans shall be rated for sound at no less than the airflow rate in Item 2.7. Fans exempted from this requirement include HVAC air handler fans, remote-mounted fans, and intermittent fans rated ≥ 400 CFM. To be considered for this exemption, a remote-mounted fan must be mounted outside the habitable spaces, bathrooms, toilets, and hallways and there shall be ≥ 4 ft. ductwork between the fan and intake grill. Per ASHRAE 62.2-2010, habitable spaces are intended for continual human occupancy; such space generally includes areas used for living, sleeping, dining, and cooking but does not generally include bathrooms, toilets, hallways, storage areas, closets, or utility rooms.
12. Note that the 'fan-on' setting of a thermostat would not be an acceptable controller because it would continuously operate the HVAC fan.
13. Bathroom fans with a rated flow rate ≥ 500 CFM are exempted from the requirement to be ENERGY STAR certified.
14. Without proper maintenance, ventilation air inlet screens often become filled with debris. Therefore, EPA recommends, but does not require, that these ventilation air inlets be located so as to facilitate access and regular service by the building maintenance staff.
15. Continuous bathroom local mechanical exhaust fans shall be rated for sound at no less than the design airflow rate. Intermittent bathroom and both intermittent and continuous kitchen local mechanical exhaust fans are recommended, but not required, to be rated for sound at no less than the design airflow rate. Per ASHRAE 62.2-2010, an exhaust system is one or more fans that remove air from the building, causing outdoor air to enter by ventilation inlets or normal leakage paths through the building envelope (e.g., bath exhaust fans, range hoods, clothes dryers). Per ASHRAE 62.2-2010, a bathroom is any room containing a bathtub, shower, spa, or similar source of moisture.
16. An intermittent mechanical exhaust system, where provided, shall be designed to operate as needed by the occupant. Control devices shall not impede occupant control in intermittent systems.

17. Kitchen volume shall be determined by drawing the smallest possible rectangle on the floor plan that encompasses all cabinets, pantries, islands, peninsulas, ranges / ovens, and the kitchen exhaust fan, and multiplying by the average ceiling height for this area. In addition, the continuous kitchen exhaust rate shall be ≥ 25 CFM, per 2009 IRC Table M1507.3, regardless of the rate calculated using the kitchen volume. Cabinet volume shall be included in the kitchen volume.
18. While not required, the prescriptive duct sizing requirements in Table 5.3 of ASHRAE 62.2-2010 are recommended to be used for kitchen exhaust fans based upon the rated airflow of the fan at 0.25 IWC.
19. As an alternative, dwelling units are permitted to use a continuous kitchen exhaust rate of 25 CFM per 2009 IRC Table M1507.3, if they are either a) PHIUS+ or PHI certified, or b) provide both dwelling unit ventilation and local mechanical kitchen exhaust using a balanced system, and have a Rater-verified whole-building infiltration rate ≤ 1.0 ACH50 or ≤ 0.05 CFM50 per ft^2 of Enclosure Area. 'Enclosure Area' is defined as the area of the surfaces that bound the volume being pressurized / depressurized during the test.
20. All intermittent kitchen exhaust fans must be capable of exhausting at least 100 CFM. In addition, if the fan is not part of a vented range hood or appliance-range hood combination (i.e., if the fan is not integrated with the range), then it must also be capable of exhausting ≥ 5 ACH, based on the kitchen volume.
21. For continuous system operation, the lower rate may be used. Otherwise, use the higher rate. Commercial kitchens shall be designed to provide a minimum continuous rate of 0.70 cfm/ft^2.
22. As an alternative, for a toilet room intended to be occupied by one person at a time, a minimum continuous rate of 25 cfm is permitted.
23. This section / item applies to split air conditioners, unitary air conditioners, air-source heat pumps, and water-source (i.e., geothermal) heat pumps up to 65 kBtuh with forced-air distribution systems and to furnaces up to 225 kBtuh with forced-air distribution system serving individual dwelling units. Forced-air distribution systems are those that supply air through ductwork exceeding 0 ft. in length. This section / item is recommended, but not required for non-ducted systems, such as non-ducted mini-splits, multi-splits, PTHP's, or PTAC's.
24. Select "2013 / 2017 ASHRAE Fundamentals" if using Chapter 17 of the 2013 or 2017 ASHRAE Handbook of Fundamentals. Select "Other per AHJ" if the Authority Having Jurisdiction where the unit will be certified mandates the use of a load calculation methodology other than Unabridged ACCA Manual J v8 or 2013 or 2017 ASHRAE Handbook of Fundamentals.
25. Check the box for "unit-specific design" if the design was created for the specific plan configuration (i.e., elevation, option, orientation, and county) of the unit to be certified. Check the box for "group design" if designs were created for unit plans that are repeated throughout the project / building with potentially different configurations (i.e., different elevations and/or orientations). Check the box for "worst-case design" if loads for the unit with the largest heat gain in the project / building are less than 18 kBtuh and are being used to represent all other units. Only one box may be checked. Regardless of the box checked, the system design as documented on this HVAC Design Report must fall within the following tolerances for the unit to be certified:
    - Item 3.4: The outdoor design temperature used in loads are within the limits defined at www.energystar.gov/hvacdesigntemps.
    - Item 3.6: The number of occupants used in loads is within ± 2 of the dwelling unit to be certified.
    - Item 3.7: Total occupant gains used in loads shall not exceed 645 Btuh per occupant.
    - Item 3.8: The conditioned floor area used in loads is between 100 ft^2 smaller and 300 ft^2 larger than the dwelling unit to be certified.
    - Item 3.9: The window area used in loads is between 15 ft^2 smaller and 60 ft^2 larger than the dwelling unit to be certified, or for dwelling units with > 500 ft^2 of window area, between 3% smaller and 12% larger.
    - Item 3.10: The predominant window SHGC is within 0.1 of the predominant value in the dwelling unit to be certified.
    - Item 3.12: The mechanical ventilation rate used in loads is the same as the value in Section 2a for the given unit plan.
    - Item 3.13: The sum of the internal gains associated with lighting and appliances used in loads shall not exceed 3,600 Btuh.
    - Items 3.15 & 3.17: The sensible & total heat gain are documented for the orientation of the dwelling unit to be certified.
    - Item 4.18: The cooling sizing % is within the cooling sizing limit selected.

    Provide the National HVAC Design Report to the party you are providing these design services to (i.e., a builder / developer, Functional Testing Agent (FT Agent), and/or MEP / credentialed HVAC contractor) and to the Rater. The report is only required to be provided once per project / building. As long as a report has been provided that falls within these tolerances for the units to be certified, no additional work is required. However, if no report falls within these tolerances or if any aspect of the system design changes, then an additional report will need to be generated prior to certification.

    Visit www.energystar.gov/hvacdesigntools for a tool to assist with group designs and for more information.
26. For each unique unit floorplan, document the loads for the configuration (e.g., level, orientation) that the dwelling unit might be built in. For example, if a unit plan will only be built in a specific level and orientation (e.g., top-floor, facing South), then the designer only needs to document the loads for this one configuration. Orientation represents the direction that the front door of the dwelling unit is facing. In Section 4, to calculate Cooling sizing % for each configuration of each unique floorplan, the same system may need to be duplicated in multiple columns.
27. Visit www.energystar.gov/hvacdesigntemps for the maximum cooling season design temperature and minimum heating season design temperature permitted for ENERGY STAR. For "County & State, or US Territory, selected", select the County and State or US Territory (i.e., Guam, Northern Mariana Islands, Puerto Rico, or US Virgin Islands), where the unit is to be certified. The same design report is permitted to be used in other counties, as long as the design temperature limits in those other counties meet or exceed the cooling and heating season temperature limits for the county selected. For example, if Fauquier County, VA, is used for the load calculations, with a 1% cooling temperature limit of 93°F, then the same report could be used in Fairfax County (which has a higher limit of 94°F) but not in Arlington County (which has a lower limit of 92°F). If a jurisdiction-specified design temperature is used that exceeds the limit in the ENERGY STAR Single-Family New Homes Design Temperature Limit Reference Guide, designers must submit a Design Temperature Exception Request. Visit www.energystar.gov/hvacdesigntemps for a copy of this form.
28. To determine the number of occupants among all HVAC systems in the dwelling unit, calculate the number of bedrooms, as defined below, and add one. This number of occupants must be within ± 2 of the dwelling unit to be certified.

A bedroom is defined by ANSI / RESNET / ICC Standard 301-2014 as a room or space 70 ft^2 or greater size, with egress window and closet, used or intended to be used for sleeping. A "den", "library", or "home office" with a closet, egress window, and 70 ft^2 or greater size or other similar rooms shall count as a bedroom, but living rooms and foyers shall not.

An egress window, as defined in 2009 IRC section R310, shall refer to any operable window that provides for a means of escape and access for rescue in the event of an emergency. The egress window definition has been summarized for convenience. The egress window shall:

- have a sill height of not more than 44 inches above the floor; AND
- have a minimum net clear opening of 5.7 ft^2; AND
- have a minimum net clear opening height of 24 in.; AND
- have a minimum net clear opening width of 20 in.; AND
- be operational from the inside of the room without the use of keys, tools or special knowledge.

29. The difference between the Conditioned Floor Area (CFA) used in the design and the actual dwelling unit to be certified must fall within the tolerance specified in Footnote 22, as verified by a Rater. Be advised, the Rater will calculate CFA using the definition in ANSI / RESNET / ICC Standard 301-2019, which defines this value, in part, as the floor area of the Conditioned Space Volume within a building or Dwelling Unit, not including the floor area of attics, crawlspaces, and basements below air sealed and insulated floors. See www.codes.iccsafe.org/content/chapter/16185/ for the complete definition.
30. The difference between the window area used in the design and the actual dwelling unit to be certified must fall within the tolerance specified in Footnote 22, as verified by a Rater. Be advised, the Rater will calculate window area using the on-site inspection protocol provided in Normative Appendix B of ANSI / RESNET / ICC Standard 301-2019, which instructs the Rater to measure the width and height of the rough opening for the window and round to the nearest inch, and then to use these measurements to calculate window area, rounding to the nearest tenth of a square foot. See www.codes.iccsafe.org/content/chapter/16191/ for the complete protocol.
31. "Predominant" is defined as the SHGC value used in the greatest amount of window area in the dwelling unit.
32. Infiltration rate shall use "Tight" values for the cooling season infiltration rate and "Tight" values for the heating season infiltration rate, as defined by Table 5A or 5B of ACCA Manual J, Eighth Edition, Version Two. Alternatively, infiltration rate shall not exceed 0.24 air changes per hour.
33. Equipment shall be selected using the maximum total heat gain and the total heat loss in Section 3 per ACCA Manual S, Second Edition, except that cooling ranges above ACCA Manual S limits are temporarily allowed, per Item 4.19, and heating ranges above ACCA Manual S limits are allowed where heating and hot water are provided by the same equipment or where standby equipment is needed for redundancy, but only operate when the primary equipment is not operating. For equipment outside the scope of ACCA Manual S, "Other" may be indicated and the equipment sizing approach listed in the space provided.
34. If an AHRI Reference # is not available, OEM-provided documentation shall be attached with the rated efficiency of the specific combination of indoor and outdoor components of the air conditioner or heat pump, along with confirmation that the two components are designed to be used together.
35. Capacity will be listed as the capacity at design conditions, from OEM expanded performance data, and shall include the capacity of all systems providing space cooling to the dwelling unit.
36. Per ACCA Manual S, Second Edition, if the load sensible heat ratio is ≥ 95% and the HDD / CDD ratio is ≥ 2.0, then the Climate is Condition B, otherwise it is Condition A.
37. As an alternative for low-load dwelling units, a system match-up including a single-speed compressor with a total capacity ≤ 20 kBtuh is permitted to be used in spaces with a total cooling load ≤ 15 kBtuh. A system match-up including a two-speed or variable-speed compressor with a total capacity ≤ 25 kBtuh is permitted to be used in spaces with a total cooling load ≤ 18 kBtuh.
38. Per the 2009 International Mechanical Code, a direct-vent furnace or boiler is one that is constructed and installed so that all air for combustion is derived from the outdoor atmosphere and all flue gases are discharged to the outside atmosphere; a mechanical draft system is a venting system designed to remove flue or vent gases by mechanical means consisting of an induced draft portion under non-positive static pressure or a forced draft portion under positive static pressure; and a natural draft system is a venting system designed to remove flue or vent gases under non-positive static vent pressure entirely by natural draft. Naturally drafted equipment is only allowed if located in a space outside the pressure boundary, where the envelope assemblies separating it from conditioned space are insulated and air-sealed.
39. Designers may provide supplemental documentation with room-by-room and total design airflows in lieu of completing Item 5.5. Sample supplemental documentation can be found at www.energystar.gov/hvacdesigntools.
40. Orientation-specific room-by-room design airflows are recommended, but not required, to distribute airflow proportional to load, thereby improving comfort and efficiency. While air-balancing of supply registers and return grilles is not required to be completed as part of HVAC Functional Testing, it is recommended that ducted HVAC systems be designed such that they can be balanced in the field (i.e. provide proper access to any and all balancing dampers, provide ducting and grille layouts such that accurate air measurements can be taken).
41. Design HVAC fan airflow is the design airflow for the blower in CFM, as determined using the manufacturer's expanded performance data. The Functional Testing Agent is required to measure the HVAC fan airflow using the mode with the higher airflow, within ± 15% of design.
42. Design HVAC fan speed setting is the fan speed setting on the control board (e.g., low, medium, high) that corresponds with the Design HVAC fan airflow.
43. Design total external static pressure is the pressure corresponding to the Design HVAC fan airflow, inclusive of external components (e.g., evaporator coil, whole-house humidifier, or ≥ MERV 6 filter).
44. Kinks are to be avoided and are caused when ducts are bent across sharp corners such as framing members. Sharp bends are to be avoided and occur when the radius of the turn in the duct is less than one duct diameter. Compression is to be avoided and occurs when flexible ducts in unconditioned space are installed in cavities smaller than the outer duct diameter and ducts in conditioned space are installed in cavities smaller than inner duct diameter. Ducts shall not include coils or loops except to the extent needed for acoustical control.

45. Item 6.3 does not apply to ducts that are a part of local mechanical exhaust or exhaust-only dwelling-unit ventilation systems. EPA recommends, but does not require, that all metal ductwork not encompassed by Section 6 (e.g., exhaust ducts, duct boots, ducts in conditioned space) also be insulated and that insulation be sealed to duct boots to prevent condensation.
46. Item 6.5 generally applies to the ducts of space heating, space cooling, and dwelling unit mechanical ventilation systems. However, visual inspection is permitted in lieu of testing for the following system types: 1) a dwelling unit mechanical ventilation system not connected to the space heating or space cooling system, regardless of the number of dwelling units it serves; 2) a space heating or space cooling system for which the ducts and air handler are in conditioned space and the total supply duct length of the system, including all supply trunks and branches, is ≤ 10 ft; and 3) a space heating or space cooling system that serves more than one dwelling unit. In such cases, a Rater shall visually verify that all seams and connections are sealed with mastic or metal tape and all duct boots are sealed to floor, wall, or ceiling using caulk, foam, or mastic tape.
47. Duct leakage shall be determined and documented by a Rater in accordance with ANSI / RESNET / ICC Std. 380. Leakage limits shall be assessed on a per-system, rather than per-dwelling unit, basis. For a duct system with one or two returns, the total Rater-measured duct leakage is permitted to be the greater of ≤ 4 CFM25 per 100 ft^2 of CFA or ≤ 40 CFM25 at 'rough-in' or the greater of ≤ 8 CFM25 per 100 ft^2 of CFA or ≤ 8 CFM25 at 'final'. For a duct system with three or more returns, the total Rater-measured duct leakage is permitted to be the greater of ≤ 6 CFM25 per 100 ft^2 of CFA or ≤ 60 CFM25 at 'rough-in' or the greater of ≤ 12 CFM25 per 100 ft^2 of CFA or ≤ 120 CFM25 at 'final'. For a duct system without any ducted returns, the total Rater-measured duct leakage is permitted to be the greater of ≤ 3 CFM25 per 100 ft^2 of CFA or ≤ 30 CFM25 at 'rough-in' or the greater of ≤ 6 CFM25 per 100 ft^2 of CFA or ≤ 60 CFM25 at 'final' and, the Rater-measured pressure difference between the space containing the air handler and the conditioned space, with the air handler running at high speed, is ≤ 5 Pa. For systems > 1 ton, increase by 1 Pa per half ton.
48. For the purpose of computing leakage allowance, exhaust fan flow shall be the lesser of the rated fan flow and at rough-in, 133% of the sum of the design exhaust airflow of the dwelling units that are exhausted by that central fan or at final, 143% of the sum of the design exhaust airflow of the dwelling units that are exhausted by that central fan. Measured fan flow (either at the fan itself or the total airflow measured from all exhaust grilles served by the fan) may be used in lieu of the rated fan flow to determine the leakage allowance. This test is not required of central exhaust systems serving clothes dryers.

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Appendix A – Supplementary tables for Section 2 and 3

2a. Dwelling Unit & Common Space Mechanical Ventilation Design [4, 5]						
List unique unit plan for which 62.2 ventilation rates were calculated in the spaces to the right:						
2.4 # of bedrooms:						
2.5 Square footage:						
2.6 Ventilation airflow rate required by ASHRAE 62.2:						
2.7 Ventilation airflow rate designed:						
2.7.1 If applicable, run-time per cycle (minutes):						
2.7.2 If applicable, cycle time (minutes):						

List common space for which 62.1 ventilation rates were calculated in the spaces to the right:						
2.8 Ventilation airflow rate required by ASHRAE 62.1:						
2.9 Ventilation airflow rate designed:						

System Type & Controls:						
List Ventilation System ID in the spaces to the right:						
2.10 Specified system type: (e.g., supply, exhaust, balanced, ERV, HRV)						
2.11 Specified system type: (e.g., in-unit, central)						
2.12 Manufacturer:						
2.13 Model Number:						
2.14 Area / space(s) that system serves: (e.g., Unit A kitchens, corridor, community room)						
2.15 Specified control location: (e.g., Master bath, utility):						

3. Heating & Cooling Loads								
Dwelling Unit Heating & Cooling Loads (only required for ducted split AC, unitary AC, ASHP, WSHP, GSHP, and furnaces) [22] ☐ N/A								
List the unit plan for which Loads were calculated:								
3.5 Location of Unit: top, mid, bottom, corner, interior								
3.6 Number of occupants used in loads: [25, 28]								
3.7 Total occupant gains (Btuh): [25]								
3.8 Conditioned floor area used in loads: [25, 29]								
3.9 Window area used in loads: [25, 30]								
3.10 Predominant window SHGC used in loads: [25, 31]								
3.11 Infiltration (ACH / ACH50) used in loads: [32]								
3.12 Mechanical ventilation (CFM) used in loads:								
3.13 Non-occupant Internal gains (appliance, equipment and lighting) used in loads (Btuh): [25]								
3.14 Orientation (N, NE, E, SE, S, SW, W, NW): [26]								
3.15 Sensible Heat Gain At Design Conditions (kBtuh): [25]								
3.16 Latent Heat Gain At Design Conditions (kBtuh):								
3.17 Total Heat Gain at Design Conditions (kBtuh): [25]								
3.18 Total Heat Loss at Design Conditions (kBtuh):								

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Appendix A – Supplementary tables for Section 3

3.19 Common Space Heating & Cooling Loads		
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)

3.20 Building Heating & Cooling Loads (only required when shared systems such as central boilers or chillers are specified)		
System Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
System Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
System Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
System Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)

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Appendix A – Supplementary tables for Section 4

4. Heating & Cooling Equipment Selection							
Cooling Equipment (Complete all applicable items, noting "N/A" as needed; where the same Equipment ID is used in multiple spaces (columns), identical data is not required to be repeated and can be left blank; where cooling is not provided, check "N/A".) ☐ N/A							
List Cooling Equipment ID in the spaces to the right; duplicating as needed for each unique space served:							
4.4 Equipment type: (PTAC / AC, Chiller / CT, PTHP / WLHP / GSHP / ASHP / VRF)							
4.5 Area / Space(s) that system serves:							
4.6 Chiller / condenser / outdoor unit manufacturer:							
4.7 Chiller / condenser / outdoor unit model #:							
4.8 Evaporator / indoor unit manufacturer:							
4.9 Evaporator / indoor unit model #:							
4.10 AHRI reference #: [34]							
4.11 AHRI listed efficiency:							
4.12 Evaporator fan type: PSC, ECM / ICM Other:							
4.13 Compressor speed: Single, Two, Variable							
4.14 Turn down ratio (for variable speed equipment):							
4.15 Latent capacity at design conditions (kBtuh): [35]							
4.16 Sensible capacity at design conditions (kBtuh): [35]							
4.17 Total capacity at design conditions (kBtuh): [35]	0	0	0	0	0	0	0
4.18 Cooling sizing % = Total capacity (Item 4.17) divided by Total Heat Gain (Item 3.17) of space(s) in Item 4.5: [25]							
4.19 Meets cooling sizing limit: (A, B, C, D or N/A) [23]							
4.20 If "B", list Load sensible heat ratio = Max. sensible heat gain (Item 3.15) / Max. total heat gain (Item 3.17): [33]							
4.21 If "B", calculate HDD / CDD ratio: [36]							

Equipment Type & Climate Condition	Compressor Type (Per Item 4.13)		
	Single-Speed	Two-Speed	Variable-Speed
A: For Cooling-Only Equipment or For Cooling Mode of Heat Pump in Condition A Climate [36]	Recommended: 90 – 115% Allowed: 90 – 130%	Recommended: 90 – 120% Allowed: 90 – 140%	Recommended: 90 – 130% Allowed: 90 – 160%
B: For Cooling Mode of Heat Pump in Condition B Climate [36]	90% - 100%, plus 15 kBtuh	90% - 100%, plus 15 kBtuh	90% - 100%, plus 15 kBtuh
C: For low-load spaces (≤15 kBtuh) [37]	≤ 20 kBtuh		
D: For low-load spaces (≤18 kBtuh) [37]		≤ 25 kBtuh	≤ 25 kBtuh

Heating Equipment (Complete all applicable items, noting "N/A" as needed; where the same Equipment ID is used in multiple spaces (columns), identical data is not required to be repeated and can be left blank; where heating is not provided, check "N/A".) ☐ N/A							
List Heating Equipment ID in the spaces to the right; duplicating as needed for each unique space served:							
4.22 Electric equipment type: PTHP, WLHP, GSHP, ASHP, VRF, Boiler, Furnace, Electric Resistance							
4.23 Gas Equipment type: HW PTAC / fan coil, Gas-Fired PTAC, Boiler, Furnace							
4.24 Area / Space(s) that system serves:							
4.25 Manufacturer:							
4.26 Model Number:							
4.27 Listed efficiency:							
4.28 Equipment output capacity (kBtuh):							
4.29 Air-source heat pump output capacity (kBtuh) (17°F):							
4.30 Type of Venting: Natural Draft, Mechanically Drafted, Direct Vent [38]							

4.31 Furnace heating sizing % = Total capacity (Item 4.28) divided by Total Heat Loss of space(s) in Item 4.24:							
4.32 Meets furnace sizing limit: (A, B, C, or N/A) [23]							
A: For low-load spaces (≤ 10 kBtuh), furnace output capacity is ≤ 40 kBtuh							
B: When Used for Heating Only	C: When Paired With Cooling						
100 – 400%	Recommended: 100 – 140% Allowed: 100 – 400%						

Appendix A – Supplementary tables for Section 5

5. Dwelling-Unit Duct Design

5.2 Room-by-room design airflows documented below (which should sum to the mode with the higher Design HVAC fan airflow). [9, 39, 40]

Name of the unit plan:			Name of the unit plan:		
Design HVAC fan airflow: [41] Cooling mode _____ CFM Heating mode _____ CFM			Design HVAC fan airflow: [41] Cooling mode _____ CFM Heating mode _____ CFM		
Design HVAC fan speed setting (e.g., low, medium, high): [42] Cooling mode _____ Heating mode _____			Design HVAC fan speed setting (e.g., low, medium, high): [42] Cooling mode _____ Heating mode _____		
Design total external static pressure (corresponding to the mode with the higher airflow above): [43] _____ IWC			Design total external static pressure (corresponding to the mode with the higher airflow above): [43] _____ IWC		
	Room Name	Design Airflow (CFM)		Room Name	Design Airflow (CFM)
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
	Total for all rooms	0		Total for all rooms	0

Name of the unit plan:			Name of the unit plan:		
Design HVAC fan airflow: [41] Cooling mode _____ CFM Heating mode _____ CFM			Design HVAC fan airflow: [41] Cooling mode _____ CFM Heating mode _____ CFM		
Design HVAC fan speed setting (e.g., low, medium, high): [42] Cooling mode _____ Heating mode _____			Design HVAC fan speed setting (e.g., low, medium, high): [42] Cooling mode _____ Heating mode _____		
Design total external static pressure (corresponding to the mode with the higher airflow above): [43] _____ IWC			Design total external static pressure (corresponding to the mode with the higher airflow above): [43] _____ IWC		
	Room Name	Design Airflow (CFM)		Room Name	Design Airflow (CFM)
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
	Total for all rooms	0		Total for all rooms	0

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1. Design Basis							
1.1 Design description (optional):							
1.2 Designer company:		Designer name:		Date:			

2. Dwelling Unit Mechanical Ventilation System Design ("Vent System") & Inlets in Return Duct [2, 3, 4]	Verified [5]	N/A
Airflow:		
2.1 Ventilation airflow design rate & run-time for each Vent System meets ASHRAE 62.2-2010 or later edition. [6]	☐	
2.2 Access point is specified for Rater to measure ventilation airflow rate and inspect any motorized / shutoff dampers. [4, 7]	☐	
System Controls:		
2.3 Specified controls for each Vent System allow it to operate automatically, without occupant intervention.	☐	
2.4 Specified controls for each Vent System include a readily-accessible override & a label has also been specified if its function is not obvious (e.g., a label is required for a toggle wall switch, but not for a switch that's on the vent. equip.). [8]	☐	
2.5 For any outdoor air inlet designed to connect to a ducted return of the HVAC system, specified controls automatically restrict airflow using a motorized damper during ventilation off-cycle and occupant override. [4, 9]	☐	☐
Sound: 2.6 Specified fan of each Vent System is rated ≤ 3 sones if intermittent and ≤ 1 sone if continuous, or exempted. [10]	☐	
Efficiency: (Complete if Vent System controller operates HVAC fan or Vent System uses bath fans; otherwise, check "N/A")		☐
2.7 If Vent System controller operates the HVAC fan, then HVAC fan operation is intermittent and either fan type in HVAC design report is ECM or controls will reduce the run-time by accounting for HVAC system heating or cooling hours. [11]	☐	☐
2.8 If bathroom fans are specified as part of any Vent System, then they are ENERGY STAR certified. [12]	☐	☐
2.9 MFNC Only:[13] If central exhaust fans are specified as part of the Vent System, then if ≤ 1 HP, they are direct-drive, ECM, with variable speed controllers; and if > 1 HP, they are specified with NEMA Premium™ Motors or equivalent.	☐	☐
Air Inlet Location: (Complete this section if system has a specified air inlet location; otherwise check "N/A") [14]		☐
2.10 Inlet(s) pull ventilation air directly from outdoors and not from attic, crawlspace, garage, or adjacent dwelling unit.	☐	
2.11 Inlet(s) are ≥ 2 ft. above grade or roof deck; ≥ 10 ft. of stretched-string distance from known contamination sources (e.g., stack, vent, exhaust, vehicles) not exiting the roof, and ≥ 3 ft. from known sources exiting the roof.	☐	
2.12 Inlet(s) are provided with rodent / insect screen with ≤ 0.5 inch mesh.	☐	

3. Dwelling Unit Local Mechanical Exhaust Design						
3.1 System(s) are designed that mechanically exhaust air from each dwelling unit kitchen and bathroom directly to the outdoors or to ventilation risers and meet the requirements in Table 1. [15]					☐	
Kitchens:	Runtime: [16]	☐ Continuous	☐ Intermittent [17]	Dwelling Units Served by Fan: [18]	☐ Single Unit	☐ Multiple Units
Bathrooms:	Runtime: [16]	☐ Continuous	☐ Intermittent [17]	Dwelling Units Served by Fan: [18]	☐ Single Unit	☐ Multiple Units

4. Heating Equipment, Cooling Equipment, & Equipment Controls Selection		
4.1 MFNC Only:[13] If using Prescriptive Path, equipment serving dwelling units meet the efficiency levels specified in Exhibit X of the National Rater Field Checklist, have programmable thermostatic controls, & do not use electric resistance heating.	☐	☐
4.2 MFNC Only:[13] Thermostatic controls for systems serving a dwelling unit are within the unit and not located on exterior walls. If more than one system provides heating or cooling to the same space, controls prevent simultaneous operation.	☐	☐

Air Conditioners & Heat Pumps If none will be installed, check N/A ☐	1	2	3
4.3 Unique name or ID for each system:			
4.4 Maximum sensible and total heat gain load of zone served (kBtuh):			
4.5 Sensible, latent, & total cooling capacity at design conditions (kBtuh): [19]			
4.6 If HP, heating capacity at 17°F and at 47°F (kBtuh):	N/A ☐	N/A ☐	N/A ☐
4.7 Compressor speed type:			
4.8 Cooling sizing % & applicable sizing limit key from Table 2: [20, 21]			
4.9 If C2 chosen in Item 4.8, load sensible heat ratio & HDD / CDD ratio: [22]	N/A ☐	N/A ☐	N/A ☐
4.10 Affirm that cooling sizing % is within cooling sizing limit (4.8):	☐	☐	☐

Furnaces If none will be installed, check N/A ☐	1	2	3
4.11 Unique name or ID for each system:			
4.12 Total heat loss load of zone served (kBtuh):			
4.13 Total heating capacity (kBtuh):			
4.14 Heating sizing % & applicable sizing limit key from Table 3: [23, 24]			
4.15 Affirm that heating sizing % is within heating sizing limit (4.14):	☐	☐	☐

5. Duct Design	5.1 All duct requirements in Table 4 have been included in the design, where applicable.	☐	☐

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National HVAC Design Supplement to Std. 310 for Dwellings & Units [1]

Table 1 – Local Mechanical Exhaust Airflow and Sound Limits

Location		Continuous Rate	Intermittent Rate
Kitchen	Airflow	≥ 5 ACH, based on kitchen volume [25, 26, 27]	≥ 100 CFM and, if not integrated with range, also ≥ 5 ACH based on kitchen volume [25, 26, 28]
	Sound [29]	Recommended: ≤ 1 sone	Recommended: ≤ 3 sones
Bathroom	Airflow	≥ 20 CFM	≥ 50 CFM
	Sound [29]	Required: ≤ 1 sone	Recommended: ≤ 3 sones

Table 2 – Air Conditioner and Heat Pump Cooling Sizing Limits

Limit Key	Criteria for Limit Type	Sizing Limits by Compressor Type		
		Single-Speed	Two-Speed	Variable-Speed
C1	Cooling-only equipment or Cooling mode of HP in Condition A Climate	Recommended: 90 – 115% Allowed: 90 – 130%	Recommended: 90 – 120% Allowed: 90 – 140%	Recommended: 90 – 130% Allowed: 90 – 160%
C2	Cooling mode of HP in Condition B Climate	90% - 100%, plus 15 kBtuh	90% - 100%, plus 15 kBtuh	90% - 100%, plus 15 kBtuh
C3	Low-load: Total heat gain load ≤ 15 kBtuh	≤ 20 kBtuh	N/A	N/A
C4	Low-load: Total heat gain load ≤ 18 kBtuh	N/A	≤ 25 kBtuh	≤ 25 kBtuh

Table 3 – Furnace Heating Sizing Limits

Limit Key	Criteria for Limit Type	Sizing Limits
H1	Furnaces used for heating only	100 - 140%
H2	Furnaces when paired with cooling	Recommended: 100 – 140% Allowed: 100 – 400%
H3	Low-load: Total heat loss load ≤ 10 kBtuh	≤ 40 kBtuh

Table 4 – Duct Quality Design & Installation Requirements

a) **Design:** SFNH and Townhouses Only: [31] Duct system designed per ACCA Manual D.

b) **Insulation**: All supply and return ducts that are not in conditioned space, including connections to trunk ducts, specified to be insulated ≥ R-6. MFNC Only: [13] In addition, if using Prescriptive Path, then if certifying under Version 1.0 of the program, any dwelling unit supply ducts located in unconditioned attics specified to be insulated ≥ R-8; if Version 1.1, all ducts and air handlers specified to be within conditioned space; if Version OR-WA 1.2, any dwelling unit supply ducts located in unconditioned space specified to be insulated ≥ R-8.

c) **Sealing**: Duct sealing specified to achieve Rater-measured total duct leakage that does not exceed ENERGY STAR limits:

# of Ducted Returns	**Total Duct Leakage Limit in CFM at 25 Pa (Select the Largest Applicable Value)**	
	If Tested at Rough-In:	If Tested at Final:
None [30]	≤ 3 per 100 ft^2 of Conditioned Floor Area or ≤ 30	≤ 6 per 100 ft^2 of Conditioned Floor Area or ≤ 60
1- 2	≤ 4 per 100 ft^2 of Conditioned Floor Area or ≤ 40	≤ 8 per 100 ft^2 of Conditioned Floor Area or ≤ 80
≥ 3	≤ 6 per 100 ft^2 of Conditioned Floor Area or ≤ 60	≤ 12 per 100 ft^2 of Conditioned Floor Area or ≤ 120

SFNH and Townhouses Only: [31] In addition, sealing specified to achieve Rater-measured duct leakage to outside, when tested at final, that is the greater of ≤ 4 CFM25 per 100 sq. ft. of conditioned floor area or ≤ 40 CFM25.

d) **Filtration**: MERV 6+ filter(s) specified for each ducted mechanical system serving an individual dwelling unit, designed so all return and mechanically supplied outdoor air passes through filter(s) prior to conditioning, and located to facilitate access & regular service by the occupant or building owner. Filter access panel specified with a gasket or comparable sealing mechanism.

e) **Pressure Balancing**: Bedrooms with a design supply airflow ≥ 150 CFM are specified with any combination of transfer grilles, jump ducts, dedicated return ducts, and/or undercut doors to achieve a Rater-measured pressure differential ≥ - 5 Pa and ≤ +5 Pa with respect to the main body of the dwelling unit when all air handlers are operating. SFNH and Townhouses Only: [31] In addition, bedrooms with a design supply airflow < 150 CFM are specified to achieve a Rater-measured pressure differential ≥ - 3 Pa and ≤ +3 Pa.

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National HVAC Design Supplement to Std. 310 for Dwellings & Units [1]

Footnotes

1. This report must be completed for dwellings (e.g., single-family homes, duplexes), townhouses, and dwelling / sleeping units pursuing ENERGY STAR certification using Track A – HVAC Grading. It provides supplemental design information not captured in the ANSI / RESNET / ACCA 310 HVAC Design Report, which must also be collected for such projects.
2. As defined by ANSI / RESNET / ICC 301-2019, a Dwelling Unit Mechanical Ventilation System is a ventilation system consisting of powered ventilation equipment such as motor-driven fans and blowers and related mechanical components such as ducts, inlets, dampers, filters and associated control devices that provides dwelling unit ventilation at a known or measured airflow rate. Each Vent System shall have at least one supply or exhaust fan with associated ducts and controls. Local exhaust fans are allowed to be part of a Vent System. Designers may provide supplemental documentation as needed to document the system design.
3. In “Warm-Humid” climates as defined by 2009 IECC Figure 301.1 (i.e., CZ 1 and portions of CZ 2 and 3A below the white line), it is recommended, but not required, that equipment be specified with sufficient latent capacity to maintain indoor relative humidity at ≤ 60%.
4. Item 2.5 applies to any outdoor air inlet connected to a ducted return of the dwelling unit HVAC system, regardless of its intended purpose (e.g., for ventilation air, make-up air, combustion air). This Item does not apply to HVAC systems without a ducted return.

   For example, if an outdoor air inlet connected to a ducted return is used as a dedicated source of outdoor air for an exhaust ventilation system (e.g., bath fan), the outdoor airflow must be automatically restricted when the exhaust fan is not running and in the event of an override of the exhaust ventilation system. In dwelling / sleeping units in multifamily buildings, but not townhouses, automatic restriction of airflow is exempted if a manual shutoff damper is used with a continuous exhaust ventilation system and is readily-accessible, labeled as the override, and not used as a balancing damper.

   Note that a Rater will generally measure the ventilation rate at the highest HVAC fan speed applicable to ventilation mode (e.g., if the inlet only opens when the HVAC is in ‘fan-only’ mode, it will be tested in this mode) to verify that it is ≤ 15 CFM or 15% above design value. As an alternative, measurement of the outdoor airflow can be waived if a Constant Airflow Regulating (CAR) damper with a manufacturer-specified maximum flow rate no higher than 15 CFM or 15% above the ventilation design value is installed on the inlet.
5. In Section 2 through 5, ‘Verified’ indicates designer has verified that all specified Vent Systems, inlets in return ducts, dwelling unit local mechanical exhaust systems, equipment controls, and duct systems in the dwelling, townhouse, or dwelling/sleeping unit, meet the applicable requirement.
6. Airflow design rates and run-times shall be determined using ASHRAE 62.2-2010 or later. Designers are permitted, but not required, to use published addenda and/or the 2013, 2016, or 2019 version of the standard to assess compliance.
7. The term ‘Rater’ refers to the person(s) completing the third-party verification required for certification. Examples of access points for measuring ventilation airflow rate include a section of smooth-walled duct with a hole and removable plug to facilitate an in-duct measurement; the grille of an exhaust fan for an exhaust-only ventilation system; or a tool that is integrated into the ventilation equipment.
8. In dwellings (e.g., single-family homes, duplexes) and townhouses, this control must be readily accessible to the occupant. In all other multifamily dwelling units, the override control is not required to be readily accessible to the occupant. However, in such cases, EPA recommends but does not require that the control be readily accessible to others (e.g., building maintenance staff) in lieu of the occupant.
9. In addition, consult manufacturer requirements to ensure return air temperature requirements are met.
10. Dwelling Unit Mechanical Ventilation System fans shall be rated for sound at no less than the airflow rate(s) specified in the ANSI / RESNET / ACCA 310 HVAC Design Report. Fans exempted from this requirement include HVAC air handler fans, remote-mounted fans, and intermittent fans rated ≥ 400 CFM. To be considered for this exemption, a remote-mounted fan must be mounted outside the habitable spaces, bathrooms, toilets, and hallways and there shall be ≥ 4 ft. ductwork between the fan and intake grill. Per ASHRAE 62.2-2010, habitable spaces are intended for continual human occupancy; such space generally includes areas used for living, sleeping, dining, and cooking but does not generally include bathrooms, toilets, hallways, storage areas, closets, or utility rooms.
11. Note that the ‘fan-on’ setting of a thermostat would not be an acceptable controller because it would continuously operate the HVAC fan.
12. Bathroom fans with a rated flow rate ≥ 500 CFM are exempted from the requirement to be ENERGY STAR certified.
13. Complete this Item only if the project is being certified using the ENERGY STAR Multifamily New Construction (MFNC) program.
14. Without proper maintenance, ventilation air inlet screens often become filled with debris. Therefore, EPA recommends, but does not require, that these ventilation air inlets be located so as to facilitate access and regular service by the occupant.
15. Per ASHRAE 62.2-2010, an exhaust system is one or more fans that remove air from the building, causing outdoor air to enter by ventilation inlets or normal leakage paths through the building envelope (e.g., bath exhaust fans, range hoods, clothes dryers). Per ASHRAE 62.2-2010, a bathroom is any room containing a bathtub, shower, spa, or similar source of moisture.
16. If both continuous and intermittent fans are present in the design for the kitchen(s) or bathroom(s), then select both boxes.
17. An intermittent mechanical exhaust system, where provided, shall be designed to operate as needed by the occupant. Control devices shall not impede occupant control in intermittent systems.
18. Select “Single Unit” if the kitchen or bathroom exhaust fan serves a single dwelling unit and select “Multiple Units” if the fan serves multiple dwelling units (e.g., a central or shared fan). If both types are present in the design, then select both boxes.
19. Use OEM expanded performance data to determine equipment capacity at design conditions.
20. Cooling sizing % = Total capacity (Item 4.5) divided by maximum total heat gain (Item 4.4).
21. Select the cooling sizing limit key from Table 2, either C1, C2, C3, or C4, based upon the equipment type and the compressor type. If selecting limit key C1 or C2, then also use the climate condition. If selecting limit key C3 or C4, then also use the total heat gain load of the zone.

22. Per ACCA Manual S, Second Edition, if the load sensible heat ratio is ≥ 95% and the HDD / CDD ratio is ≥ 2.0, then the Climate is Condition B, otherwise it is Condition A. The load sensible heat ratio = maximum sensible heat gain (Item 4.4) / maximum total heat gain (Item 4.4). For the HDD / CDD ratio, see Appendix A of ANSI / RESNET / ACCA 310 to determine this value for the design location.
23. Heating sizing % = total heating capacity (Item 4.13) divided by total heat loss (Item 4.12).
24. Select the heating sizing limit key from Table 3, either H1, H2, or H3, based upon whether the equipment is a furnace used for heating only or a furnace paired with cooling. If selecting limit key H3, then also use the total heat loss load of the zone.
25. Kitchen volume shall be determined by drawing the smallest possible rectangle on the floor plan that encompasses all cabinets, pantries, islands, peninsulas, ranges / ovens, and the kitchen exhaust fan, and multiplying by the average ceiling height for this area. In addition, the continuous kitchen exhaust rate shall be ≥ 25 CFM, per 2009 IRC Table M1507.3, regardless of the rate calculated using the kitchen volume. Cabinet volume shall be included in the kitchen volume.
26. While not required, the prescriptive duct sizing requirements in Table 5.3 of ASHRAE 62.2-2010 or later are recommended to be used for kitchen exhaust.
27. As an alternative, projects are permitted to use a continuous kitchen exhaust rate of 25 CFM per 2009 IRC Table M1507.3, if they are either a) PHIUS+ or PHI certified, or b) provide both dwelling unit ventilation and local mechanical kitchen exhaust using a balanced system, and have a Rater-verified whole-building infiltration rate ≤ 1.0 ACH50 or ≤ 0.05 CFM50 per sq. ft. of Enclosure Area, and a Rater-verified dwelling unit compartmentalization rate ≤ 0.30 CFM50 per sq. ft. of Enclosure Area if multiple dwelling units are present in the building. ‘Enclosure Area’ is defined as the area of the surfaces that bound the volume being pressurized / depressurized during the test.
28. All intermittent kitchen exhaust fans must be capable of exhausting at least 100 CFM. In addition, if the fan is not part of a vented range hood or appliance-range hood combination (i.e., if the fan is not integrated with the range), then it must also be capable of exhausting ≥ 5 ACH, based on the kitchen volume.
29. Continuous bathroom local mechanical exhaust fans shall be rated for sound at no less than the design airflow rate. Intermittent bathroom and both intermittent and continuous kitchen local mechanical exhaust fans are recommended, but not required, to be rated for sound at no less than the design airflow rate.
30. If project is certified using the ENERGY STAR Single-Family New Homes (SFNH) program and has no ducted return, then the leakage limit for 1-2 returns applies.
31. Complete this Item only if the project is a townhouse or is certified using the ENERGY STAR Single-Family New Homes (SFNH) program.

National HVAC Design Supplement to Std. 310 for Common Spaces & Central Systems [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

HVAC Designer Responsibilities:

- This Supplement shall be used for MFNC buildings where "Track A – HVAC Grading by Rater" is used for all dwelling unit HVAC systems.
- Complete one Supplement for Common Spaces and Central Systems for each building. This Supplement includes system design for all hydronic systems, common space heating and cooling systems that are not using HVAC Grading, and common space and central ventilation requirements not covered under ANSI / RESNET / ACCA 310 or the National HVAC Design Supplement to Std. 310 for Dwellings & Units. For projects with multiple buildings, one Supplement per building or per project is permitted. [1]
- Obtain efficiency features (e.g., window performance, insulation levels, and infiltration rate) from the builder, architect, or Rater. [2]
- Provide the completed Supplement to the Rater and the person / company completing the National HVAC Functional Testing Checklist. [2]

1. Design Overview

1.1 Designer name: _____ Designer company: _____ Date: _____

1.2 Select which party you are providing these design services to: ☐ Builder / Developer ☐ FT Agent ☐ MEP / Credentialed HVAC contractor

1.3 Name of company you are providing these design services to (if different than Item 1.1): _____

1.4 Project address: _____ City: _____ State: _____ Zip code: _____

2a. Common Space Mechanical Ventilation Design ("Vent System") [3] **& Inlets in Return Duct** [4, 5, 6]						**Designer Verified**
Airflow:						
2.1 Common space outdoor airflow design rate meet the requirements of Section 6 of ASHRAE 62.1 [5] ☐ 2010 ☐ 2013, without exceeding 2013 rates by more than 50%.						☐
List common space for which 62.1 ventilation rates were calculated in the spaces to the right: [6, 7]						
2.2 Ventilation airflow rate required by ASHRAE 62.1:						
2.3 Ventilation airflow rate designed:						
Common Space System Type & Controls: [7]						
List Ventilation System ID in the spaces to the right: [6]						
2.4 Specified system type: (e.g., supply, exhaust, balanced, ERV, HRV)						
2.5 Manufacturer:						
2.6 Model Number:						
2.7 # of Spaces Served (e.g., single, multiple)						
2.8 Area / space(s) that system serves: (e.g., common kitchens, corridor, community room)						
2.9 Specified control location: (e.g., restroom, utility):						
2.10 Specified controls allow the systems to operate automatically, without occupant intervention. A ventilation override control is specified and also labeled if its function is not obvious (e.g., a label is required for a toggle wall switch, but not for a switch that's on the ventilation equipment). [7]						☐

Common Space Air Inlet Locations: (Complete this section if system has specified air inlet location(s); otherwise check "N/A".) [7, 8]	**Designer Verified** ☐ N/A
2.11 Inlet(s) pull ventilation air directly from outdoors and not from attic, crawlspace, garage, or adjacent dwelling unit.	☐
2.12 Inlet(s) are ≥ 2 ft. above grade or roof deck; ≥ 10 ft. of stretched-string distance from known contamination sources (e.g., stack, vent, exhaust, vehicles) not exiting the roof, and ≥ 3 ft. from dryer exhausts and sources exiting the roof.	☐
2.13 Inlet(s) are provided with rodent / insect screen with ≤ 0.5 inch mesh.	☐
2b. Common Space and Garage Minimum Exhaust Rates – System(s) are designed that mechanically exhaust air from each common space, as required by ASHRAE 62.1-2010 or 2013	☐

Location	**ASHRAE 62.1 Rate**	**Design Rate**	**Location**	**ASHRAE 62.1 Rate**	**Design Rate**
Janitor Room	1 cfm/ft^2		Common space kitchen [9]	50 cfm / 100 cfm	
Trash / Recycling Room	1 cfm/ft^2		Common space bathroom [10]	50 cfm per toilet / urinal	
Parking Garage	0.05 cfm/ft^2, standby 0.75 cfm/ft^2, full-on		☐ Shared garage exhaust fan controls include CO and NO2 sensors.		

3. Heating & Cooling Loads

3.1 Common Space Heating & Cooling Loads [6, 7]

Common Space Name: _____ Design Conditions: Total Heat Gain: _____(kBtuh) Total Heat Loss: _____(kBtuh)

Common Space Name: _____ Design Conditions: Total Heat Gain: _____(kBtuh) Total Heat Loss: _____(kBtuh)

Common Space Name: _____ Design Conditions: Total Heat Gain: _____(kBtuh) Total Heat Loss: _____(kBtuh)

National HVAC Design Supplement to Std. 310 for Common Spaces & Central Systems [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

3.2 Building Heating & Cooling Loads [6] (only required when shared systems such as central boilers or chillers are specified.)	**Designer Verified** ☐ N/A
System Name: _____ Design Conditions: Total Heat Gain: _____(kBtuh) Total Heat Loss: _____(kBtuh)	
System Name: _____ Design Conditions: Total Heat Gain: _____(kBtuh) Total Heat Loss: _____(kBtuh)	
4. Heating & Cooling Equipment Selection	
4.1 Equipment selected per ☐ ACCA Manual S, or where not applicable, ☐ Other: _____. [7]	☐
4.2 Prescriptive and ERI Path: Equipment serving common spaces but not serving dwelling units meet the efficiency levels specified in the Exhibit X of the National Rater Field Checklist. Also see Exhibit X for restrictions on electric space resistance. [7]	☐ ☐ N/A

Common Space Cooling Equipment [6, 7] (Complete all applicable items, noting "N/A" as needed; where the same Equipment ID is used in multiple spaces (columns), identical data is not required to be repeated and can be left blank; where cooling is not provided, check "N/A".)							
List Cooling Equipment ID in the spaces to the right; duplicating as needed for each unique space served:							
4.3 Equipment type: (e.g., PTAC / AC, Chiller / CT, PTHP / WLHP / GSHP / ASHP / VRF)							
4.4 Area / Space(s) that system serves:							
4.5 Chiller / condenser / outdoor unit manufacturer:							
4.6 Chiller / condenser / outdoor unit model #:							
4.7 Evaporator / indoor unit manufacturer:							
4.8 Evaporator / indoor unit model #:							
4.9 AHRI reference #: [11]							
4.10 Listed efficiency:							
4.11 Evaporator fan type: PSC, ECM / ICM, Other							
4.12 Compressor speed: Single, Two, Variable							
4.13 Turn down ratio (for variable speed equipment):							
4.14 Latent capacity at design conditions (kBtuh): [12]							
4.15 Sensible capacity at design conditions (kBtuh): [12]							
4.16 Total capacity at design conditions (kBtuh): [12]							
4.17 Cooling sizing % = Total capacity (Item 4.16) divided by Total Heat Gain (Item 3.2) of space(s) in Item 4.4:							

Common Space Heating Equipment [6, 7] (Complete all applicable items, noting "N/A" as needed; where the same Equipment ID is used in multiple spaces (columns), identical data is not required to be repeated and can be left blank; where heating is not provided, check "N/A".)	**Designer Verified** ☐ N/A						
List Heating Equipment ID in the spaces to the right; duplicating as needed for each unique space served:							
4.18 Electric equipment type: PTHP, WLHP, GSHP, ASHP, VRF, Boiler, Furnace, Electric Resistance							
4.19 Gas Equipment type: HW PTAC / fan coil, Gas-Fired PTAC, Boiler, Furnace							
4.20 Area / Space(s) that system serves:							
4.21 Manufacturer:							
4.22 Model Number:							
4.23 Listed efficiency:							
4.24 Equipment output capacity (kBtuh):							
4.25 Air-source heat pump output capacity (17°F) (kBtuh):							
4.26 Type of Venting: Natural Draft, Mechanically Drafted, Direct Vent [13]							
4.27 Furnace heating sizing % = Total capacity (Item 4.24) divided by Total Heat Loss of space(s) in Item 4.20:							

Equipment Controls	
4.28 All equipment controls below have been included where applicable in the HVAC Design.	☐
4.29 Stair and elevator shaft vents shall be equipped with motorized dampers that are capable of being automatically closed during normal building operation and are interlocked to open as required by fire and smoke detection systems.	

National HVAC Design Supplement to Std. 310 for Common Spaces & Central Systems [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

4.30 Freeze protection systems, such as heat tracing of piping and heat exchangers, including self-regulating heat tracing, and garage / plenum heaters shall include automatic controls capable of shutting off the systems when pipe wall or garage / plenum temperatures are above 40°F. Where heat tracing is specified for freeze protection, controls must be based on pipe wall temperature and a minimum of R-3 pipe insulation is also required.	
4.31 Snow- and ice-melting systems shall include automatic controls capable of shutting off the systems when the pavement temperature is above 50°F and no precipitation is falling, and an automatic or manual control that will allow shutoff when the outdoor temperature is above 40°F so that the potential for snow or ice accumulation is negligible.	
Hydronic Distribution	☐ N/A
4.32 All hydronic distribution requirements below have been included where applicable in the HVAC Design.	☐
4.33 All terminal heating and cooling distribution equipment must be separated from the riser or distribution loop by a control valve or terminal distribution pump, so that heated or cooled fluid is not delivered to the dwelling unit distribution equipment when there is no call from the thermostat.	
4.34 Terminal units must be equipped with pressure independent balancing valves or pressure independent control valves.	
4.35 Piping of a heating or cooling system (e.g., steam, hot or chilled water, brine, refrigerant) shall be thermally insulated in accordance with ASHRAE 90.1-2007, Table 6.8.3. Construction documents must account for piping total thickness including required insulation when passing through planks or any other penetrations and shall specify that the piping must be inspected before access is covered up: Heating System: Pipe size:____ inches Insulation thickness:___ inches Pipe size:____ inches Insulation thickness:___ inches Cooling System: Pipe size:____ inches Insulation thickness:___ inches Pipe size:____ inches Insulation thickness:___ inches	
4.36 For circulating pumps serving hydronic heating or cooling systems with three-phase motors, 1 horse-power or larger, motors shall meet or exceed efficiency standards for NEMA Premium™ motors. If 5 horse-power or larger, must also be specified with variable frequency drives.	
4.37 If a variable speed pumping system is installed, system designed to prevent “dead-heading” and a method of water flow bypass is provided, such as a minimum flow bypass valve or 3-way valves on specific terminal units.	
4. For shared boilers, chillers, and cooling towers, temperature and pressure gauges, air eliminator, expansion tank, and check valves are clearly shown on the drawings. A complete sequence of operations for all systems indicating recommendations for all setpoints is provided.	
5. Duct Quality Installation - *Applies to Heating, Cooling, Ventilation, Exhaust, & Pressure Balancing Ducts, Unless Noted in Footnote*	
Common Spaces [7]	
5.1 All duct quality installation requirements below have been included where applicable in the HVAC Design.	☐
5.2 Ductwork specified without kinks, sharp bends, compressions, or excessive coiled flexible ductwork. [14]	
5.3 All supply and return ducts not in conditioned space, including connections to trunk ducts, are insulated to ≥ R-6. [15]	
5.3.1 Prescriptive Path: Dwelling unit ductwork meets the location and insulation requirements specified in the ENERGY STAR MF Reference Design.	
5.4 Duct design specifies that all supply, return, and exhaust ductwork and all plenums serving common spaces shall be sealed at all transverse joints, longitudinal seams, and duct wall penetrations.	
Duct Testing for Central Systems Serving Dwelling Units	
5.5 Central exhaust systems (that serve four or more dwelling units): Ductwork air-sealing specified such that measured duct leakage does not exceed 25% of exhaust fan flow at rough-in (e.g., including trunks, branches, and take-offs) or 30% of exhaust fan flow at final (e.g., inclusive of all ductwork between the fan and the grilles). [16]	

National HVAC Design Supplement to Std. 310 for Common Spaces & Central Systems [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

Footnotes:

1. This report shall represent system design for all unique common spaces, hydronic systems, central ventilation systems serving common spaces or dwelling units, and where applicable, parking garages. The term 'common space' refers to any spaces in the building being certified that serve a function in support of the residential part of the building that is not part of a dwelling or sleeping unit. This includes spaces used by residents, such as corridors, stairs, lobbies, laundry rooms, exercise rooms, residential recreation rooms, and dining halls, as well as offices and other spaces used by building management, administration or maintenance in support of the residents. As an alternative, for common spaces using Track A-HVAC grading by Rater, project teams may instead choose to complete an ANSI / RESNET / ACCA 310 HVAC Design Report and National HVAC Design Supplement to Std. 310 for Dwellings & Units for each unique common space. For those spaces, Items 2.2-2.13, 3.1, 4.1-4.27, and 5.1-5.4 of this Report are not required to be completed. All other systems serving common spaces, must be documented in this Design Report.
2. The term 'Rater' refers to the person(s) completing the third-party verification required for certification. The person(s) shall: a) be a Certified Rater, Approved Inspector, as defined by ANSI / RESNET / IECC Standard 301, or an equivalent designation as determined by a Home Certification Organization (HCO) or Multifamily Review Organization (MRO); and, b) have attended and successfully completed an EPA-recognized training class. See www.energystar.gov/mftraining.
3. A Mechanical Ventilation System is a ventilation system consisting of powered ventilation equipment such as motor-driven fans and blowers and related mechanical components such as ducts, inlets, dampers, filters and associated control devices that provides outdoor air at a known or measured airflow rate.
4. In "Warm-Humid" climates as defined by 2009 IECC Figure 301.1 (i.e., CZ 1 and portions of CZ 2 and 3A below the white line), it is recommended, but not required, that equipment be specified with sufficient latent capacity to maintain indoor relative humidity at ≤ 60%.
5. Airflow design rates shall be determined using ASHRAE 62.1-2010 or later. Designers are permitted, but not required, to use published addenda and/or the 2013 version of the standard to assess compliance.
6. If the tables provided cannot accommodate all the unit plans, spaces, or systems in the project, use the tables in Appendix A to supplement the Design Report.
7. Items 2.2-2.13, 3.1, 4.1-4.27, and 5.1-5.4 are N/A if all applicable systems are documented in a National HVAC Design Supplement to Std. 310 for Dwellings & Units.
8. Without proper maintenance, ventilation air inlet screens often become filled with debris. Therefore, EPA recommends, but does not require, that these ventilation air inlets be located so as to facilitate access and regular service by the building maintenance staff.
9. For continuous system operation, the lower rate may be used. Otherwise, use the higher rate. Commercial kitchens shall be designed to provide a minimum continuous rate of 0.70 cfm/ft^2.
10. As an alternative, for a toilet room intended to be occupied by one person at a time, a minimum continuous rate of 25 cfm is permitted.
11. If an AHRI Reference # is not available, OEM-provided documentation shall be attached with the rated efficiency. For split air conditioners and heat pumps, the rated efficiency shall be for the specific combination of indoor and outdoor components of the air conditioner or heat pump, along with confirmation that the two components are designed to be used together.
12. Capacity will be listed as the capacity at design conditions, from OEM expanded performance data, and shall include the capacity of all systems providing space cooling to the dwelling unit.
13. Per the 2009 International Mechanical Code, a direct-vent furnace or boiler is one that is constructed and installed so that all air for combustion is derived from the outdoor atmosphere and all flue gases are discharged to the outside atmosphere; a mechanical draft system is a venting system designed to remove flue or vent gases by mechanical means consisting of an induced draft portion under non-positive static pressure or a forced draft portion under positive static pressure; and a natural draft system is a venting system designed to remove flue or vent gases under non-positive static vent pressure entirely by natural draft. Naturally drafted equipment is only allowed if located in a space outside the pressure boundary, where the envelope assemblies separating it from conditioned space are insulated and air-sealed.
14. Kinks are to be avoided and are caused when ducts are bent across sharp corners such as framing members. Sharp bends are to be avoided and occur when the radius of the turn in the duct is less than one duct diameter. Compression is to be avoided and occurs when flexible ducts in unconditioned space are installed in cavities smaller than the outer duct diameter and ducts in conditioned space are installed in cavities smaller than inner duct diameter. Ducts shall not include coils or loops except to the extent needed for acoustical control.
15. Item 5.3 does not apply to ducts that are a part of local mechanical exhaust or exhaust-only dwelling-unit ventilation systems. EPA recommends, but does not require, that all metal ductwork not encompassed by Section 6 (e.g., exhaust ducts, duct boots, ducts in conditioned space) also be insulated and that insulation be sealed to duct boots to prevent condensation.
16. For the purpose of computing leakage allowance, exhaust fan flow shall be the lesser of the rated fan flow and at rough-in, 133% of the sum of the design exhaust airflow of the dwelling units that are exhausted by that central fan or at final, 143% of the sum of the design exhaust airflow of the dwelling units that are exhausted by that central fan. Measured fan flow (either at the fan itself or the total airflow measured from all exhaust grilles served by the fan) may be used in lieu of the rated fan flow to determine the leakage allowance. This test is not required of central exhaust systems serving clothes dryers.

National HVAC Design Supplement to Std. 310 for Common Spaces & Central Systems [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

Appendix A – Supplementary tables for Section 2 and 3

2a. Common Space Mechanical Ventilation Design [4]						
List common space for which 62.1 ventilation rates were calculated in the spaces to the right:						
2.2 Ventilation airflow rate required by ASHRAE 62.1:						
2.3 Ventilation airflow rate designed:						

System Type & Controls:						
List Ventilation System ID in the spaces to the right:						
2.4 Specified system type: (e.g., supply, exhaust, balanced, ERV, HRV)						
2.5 Manufacturer:						
2.6 Model Number:						
2.7 # of Spaces Served (e.g., single, multiple)						
2.8 Area / space(s) that system serves: (e.g., Unit A kitchens, corridor, community room)						
2.9 Specified control location: (e.g., Master bath, utility):						

3. Heating & Cooling Loads		
3.1 Common Space Heating & Cooling Loads		
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
Common Space Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)

3.2 Building Heating & Cooling Loads (only required when shared systems such as central boilers or chillers are specified)		
System Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
System Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
System Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)
System Name: _____	Design Conditions: Total Heat Gain: _____(kBtuh)	Total Heat Loss: _____(kBtuh)

National HVAC Design Supplement to Std. 310 for Common Spaces & Central Systems [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

Appendix A – Supplementary tables for Section 4

4. Heating & Cooling Equipment Selection							
Common Space Cooling Equipment (Complete all applicable items, noting "N/A" as needed; where the same Equipment ID is used in multiple spaces (columns), identical data is not required to be repeated and can be left blank; where cooling is not provided, check "N/A".) ☐ N/A							
List Cooling Equipment ID in the spaces to the right; duplicating as needed for each unique space served:							
4.3 Equipment type: (PTAC / AC, Chiller / CT, PTHP / WLHP / GSHP / ASHP / VRF)							
4.4 Area / Space(s) that system serves:							
4.5 Chiller / condenser / outdoor unit manufacturer:							
4.6 Chiller / condenser / outdoor unit model #:							
4.7 Evaporator / indoor unit manufacturer:							
4.8 Evaporator / indoor unit model #:							
4.9 AHRI reference #: [11]							
4.10 AHRI listed efficiency:							
4.11 Evaporator fan type: PSC, ECM / ICM Other:							
4.12 Compressor speed: Single, Two, Variable							
4.13 Turn down ratio (for variable speed equipment):							
4.14 Latent capacity at design conditions (kBtuh): [12]							
4.15 Sensible capacity at design conditions (kBtuh): [12]							
4.16 Total capacity at design conditions (kBtuh): [12]							
4.17 Cooling sizing % = Total capacity (Item 4.16) divided by Total Heat Gain (Item 3.2) of space(s) in Item 4.4:							

Common Space Heating Equipment (Complete all applicable items, noting "N/A" as needed; where the same Equipment ID is used in multiple spaces (columns), identical data is not required to be repeated and can be left blank; where heating is not provided, check "N/A".) ☐ N/A							
List Heating Equipment ID in the spaces to the right; duplicating as needed for each unique space served:							
4.18 Electric equipment type: PTHP, WLHP, GSHP, ASHP, VRF, Boiler, Furnace, Electric Resistance							
4.19 Gas Equipment type: HW PTAC / fan coil, Gas-Fired PTAC, Boiler, Furnace							
4.20 Area / Space(s) that system serves:							
4.21 Manufacturer:							
4.22 Model Number:							
4.23 Listed efficiency:							
4.24 Equipment output capacity (kBtuh):							
4.25 Air-source heat pump output capacity (kBtuh) (17°F):							
4.26 Type of Venting: Natural Draft, Mechanically Drafted, Direct Vent [13]							
4.27 Furnace heating sizing % = Total capacity (Item 4.24) divided by Total Heat Loss of space(s) in Item 4.20:							

Indoor airPLUS Version 1 (Rev. 04) Verification Checklist

Home Address:	City:	State:	Zip:
Climate Zone (1-6):	Radon Zone (1-3):		

Section		Requirements (Refer to full Indoor airPLUS Construction Specifications for details)	Must Correct	Builder Verified	Rater Verified	N/A
ENERGY STAR V3		***Note:*** **The Rev. 04 checklist reflects only the additional Indoor airPLUS requirements and their corresponding section numbers that must be met after completing the ENERGY STAR requirements. ENERGY STAR remains a prerequisite for Indoor airPLUS qualification.**				
		ENERGY STAR Version 3 (or 3.1, 3.2) Program Requirements must be followed and the home shall be ENERGY STAR certified in conjunction with Indoor airPLUS qualification.	☐		☐	
Moisture Control	1.1	Drain or sump pump installed in basements and crawlspaces. In EPA Radon Zone 1, check valve also installed.	☐	☐	☐	☐
		Exception Applied: ☐ Slab-on-grade foundation ☐ Free-draining soils				
	1.2	Layer of aggregate or sand (4 in.) with geotextile matting installed below slabs AND radon techniques used in EPA Radon Zone 1.	☐	☐	☐	☐
		Exception Applied: ☐ Slab-on-grade foundation ☐ Free-draining soils ☐ Dry climate				
	1.4	Basements/crawlspaces insulated, sealed and conditioned.	☐	☐	☐	☐
		Exception Applied: ☐ 100-year flood zone ☐ Marine climate ☐ Dry climate ☐ Crawlspace sealed with capillary break and active dehumidification ☐ Raised pier foundation with no walls				
	1.7	Protection from water splash damage if no gutters.	☐	☐	☐	☐
		Exception Applied: ☐ Rainwater harvesting system ☐ Dry climates				
	1.11	Supply piping in exterior walls insulated with pipe wrap.	☐	☐	☐	☐
		Exception Applied: ☐ Dry climate AND climate zone 1-3 ☐ Air barrier insulation in wall cavity				
	1.14	Hard-surface flooring in kitchens, baths, entry, laundry, and utility rooms.	☐	☐	☐	
Radon	2.1	Radon-resistant features installed in Radon Zone 1 homes in accordance with Construction Specification 2.1.	☐	☐	☐	☐
		Exception Applied: ☐ Perimeter pipe loop in lieu of full aggregate (dry climate) ☐ Manufactured home with raised pier foundation				
Pests	3.2	Corrosion-proof rodent/bird screens installed at all openings that cannot be fully sealed. (Not required for clothes dryer vents.)	☐	☐	☐	
HVAC Systems	4.1	Equipment selected to keep relative humidity < 60% in "Warm-Humid" climates.	☐		☐	☐
		Exception Applied: ☐ Climate zones 4-8, 3B, 3C and portions of 3A and 2B				
	4.2	Duct systems protected from construction debris AND no building cavities used as air supplies or returns.	☐	☐	☐	
	4.3	No air-handling equipment or ductwork installed in garage.	☐		☐	
	4.6	Clothes dryers vented to the outdoors or plumbed to a drain according to manufacturer's instructions.	☐		☐	
	4.7	Central forced-air HVAC system(s) have minimum MERV 8 filter AND no ozone generators in home. Temporary filter installed to protect unit from construction dust.	☐	☐	☐	☐
Combustion Pollutants	5.1	Emissions standards met for fuel-burning and space-heating appliances.	☐		☐	☐
		Identify appliance type: ☐ Masonry heater ☐ Factory-built wood-burning fireplace ☐ Wood stove ☐ Pellet stove ☐ Natural gas/propane fireplace Appliance model name/number:_____				
	5.2	CO alarms installed in each sleeping zone (e.g., common hallway) according to NFPA 720.	☐		☐	☐
	5.3	Multifamily buildings: Smoking restrictions implemented AND ETS transfer pathways minimized.	☐	☐	☐	☐
	5.4	Attached garages: Door closer installed on all connecting doors.	☐		☐	☐
		Attached garages: In homes with exhaust-only whole-house ventilation EITHER ☐ 70 cfm exhaust fan installed in garage OR ☐ Pressure test conducted to verify the effectiveness of the garage-to-house air barrier.	☐		☐	☐

Materials	6.1	All composite wood products certified low-emission. See spec.	☐	☐	☐	
	6.2	Interior paints and finishes certified low-emission. See spec.	☐	☐	☐	
	6.3	Carpet, carpet adhesives, and carpet cushion certified low-emission. See spec.	☐	☐	☐	☐
Final	7.1	HVAC system and ductwork verified to be dry and clean AND new filter installed.	☐	☐	☐	
	7.2	Home ventilated before occupancy.	☐	☐	☐	
	7.3	Equipment manuals, Indoor airPLUS label, and certificate provided for owner/occupant.	☐	☐	☐	

Rater Company: _____	**Builder Company:** _____
Rater Employee: _____	**Builder Employee:** _____
Rater Signature: _____ **Date:** _____	**Builder Signature:** _____ **Date:** _____

Guidance for Completing the Indoor airPLUS Verification Checklist:

1. Only ENERGY STAR certified homes verified to comply with these specifications can earn the Indoor airPLUS label. See Indoor airPLUS Construction Specifications for full descriptions of the requirements, terms, exceptions, abbreviations, references and climate map used in this checklist. Verification is not complete until this checklist is completed in full and signed.

   Note: ENERGY STAR footnotes and exceptions will always be utilized unless otherwise noted in the Indoor airPLUS Construction Specifications. In some cases, Indoor airPLUS modifies or excludes certain ENERGY STAR exceptions or alternate pathways.

2. Check one box per line. Check "N/A" for specifications that do not apply for specific conditions (e.g., climate) according to the exceptions described in the Indoor airPLUS Construction Specifications. Check either "Builder Verified" or "Rater Verified" for all other items to indicate who verified each item. Items may be verified visually on site during construction, by reviewing photographs taken during construction, by checking documentation, or through equivalent methods as appropriate.

3. The Rater who conducted the verification, or a responsible party from the Rater's company, must sign the completed verification checklist. The builder must also sign the checklist if any items in the "Builder Verified" column are checked, and by so doing accepts full responsibility for verifying that those items meet Indoor airPLUS requirements.

4. The Rater shall retain the rating documentation, all required ENERGY STAR Certified Homes documentation, and the Indoor airPLUS Verification Checklist for the home for a minimum of 2 years from final verification. The Rater shall coordinate with the Provider and/or builder to provide an Indoor airPLUS label and certificate for each qualified home.

5. Raters who operate under a Sampling Provider are permitted to use a RESNET-approved sampling protocol for Indoor airPLUS homes located outside California, and a sampling protocol approved by the California Energy Commission for homes located in California, to verify any item designated "Rater Verified." For example, if the approved sampling protocol requires rating one in seven homes, then the checklist will be completed for the one home that was rated. Only Raters are permitted to use sampling. All items verified by the builder shall be verified for each qualified home or unit within a multifamily building. For example, if a Rater verifies 10 items on the Indoor airPLUS Checklist and the builder verifies the remaining checklist items, then an approved sampling protocol is permitted to be used only on the 10 Rater-verified items.

   However, the builder may provide the Rater with a single signed copy of the checklist for an entire building or group of units with builder-verified items under the condition that all units within the building or group utilize: 1) the same HVAC system type (i.e. ductless mini-split, forced air, hydronic); 2) the same combustion appliances and combustion pollutant controls; and 3) the same low-emission materials certification/standard for all products (within their respective categories) verified in Section 6 of the Indoor airPLUS Construction Specifications. If there are no builder-verified items, the Rater may also utilize one checklist per group of units if the above criteria are met. Groups of units with any of the following conditions will require a separate and unique checklist to be completed and signed by the Rater and builder:

   - Any units with differing HVAC system type (i.e., ductless mini-split, forced air, hydronic);
   - Any units with differing combustion appliance types (e.g., masonry heater, pellet stove, wood-burning fireplace) stove, factory-built, etc.) or combustion pollutant controls; or Any units/groups with low-emission materials or finishes addressed in Section 6 that are compliant based on different certifications/standards within their product category.
   - Exception: Builders and Raters may use a single checklist for units utilizing low-emission materials certified to different labels or standards, provided that documentation of the certifications for those materials are retained by the builder and available for inspection upon request.

For further information on the Indoor airPLUS program, visit www.epa.gov/indoorairplus

ENERGY STAR

All Indoor airPLUS qualified homes meet strict guidelines for energy efficiency set by ENERGY STAR, the nationally-recognized symbol for energy efficiency.

National Water Management System Requirements [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

Builder / Developer Partner Responsibilities:

- It is the exclusive responsibility of the Partner to ensure that each multifamily building is constructed to meet these requirements.
- While Partners are not required to maintain documentation demonstrating compliance for each multifamily building, Partners are required to develop a process to ensure compliance for each building (e.g., incorporate these requirements into the Scope of Work for relevant sub-contractors, require the site supervisor to inspect each building for these requirements, and/or sub-contract the verification of these requirements to a Rater [2]).
- In the event that the EPA determines that a certified multifamily building was constructed without meeting these requirements, the building may be decertified.

1. Water-Managed Site and Foundation
1.1 Impermeable surfaces, such as patio, porch, or plaza slabs, sidewalks, ramps and driveways, sloped ≥ 0.25 in. per ft. away from building to edge of surface or 10 ft., whichever is less. [3]
1.2 Back-fill has been tamped, and permeable surfaces sloped ≥ 0.5 in. per ft. away from building for ≥ 10 ft. Alternatives in Footnote. [3]
1.3 Capillary break beneath all slabs (e.g., slab on grade, basement slab) except crawlspace slabs using either: ≥ 6 mil polyethylene sheeting, lapped 6-12 in., or ≥ 1 in. extruded polystyrene insulation with taped joints. See additional exemptions for garage slabs in Footnote 4. [4, 5, 6, 7]
1.4 Capillary break at all crawlspace floors using ≥ 6 mil polyethylene sheeting, lapped 6-12 in., & installed using one of the following: [5, 6, 7]
1.4.1 Placed beneath a concrete slab; OR,
1.4.2 Lapped up each wall or pier and fastened with furring strips or equivalent; OR,
1.4.3 Secured in the ground at the perimeter using stakes.
1.5 Exterior surface of below-grade walls of basements & unvented crawlspaces finished as follows: a) For poured concrete, masonry, & insulated concrete forms, finish with damp-proofing coating. [8] b) For wood framed walls, finish with polyethylene and adhesive or other equivalent waterproofing.
1.6 Class 1 vapor retarder not installed on interior side of air permeable insulation in exterior below-grade walls. [9]
1.7 Sump pit cover mechanically attached with full gasket seal or equivalent.
1.8 Drain tile installed at basement and crawlspace walls, with the top of the drain tile pipe below the bottom of the concrete slab or crawlspace floor. Drain tile surrounded with ≥ 6 in. of ½ to ¾ in. washed or clean gravel and with gravel layer fully wrapped with fabric cloth. Drain tile level or sloped to discharge to outside grade (daylight) or to a sump pit with a pump. If drain tile is on interior side of footing, then channel provided through footing to exterior side. [10]
2. Water-Managed Wall Assembly
2.1 Flashing at bottom of exterior walls with weep holes included for masonry veneer and weep screed for stucco cladding systems, or equivalent drainage system. [11]
2.2 Fully sealed continuous drainage plane behind exterior cladding that laps over flashing in Item 2.1 and fully sealed at all penetrations. Additional bond-break drainage plane layer provided behind all stucco and non-structural masonry cladding wall assemblies. [11, 12]
2.3 Window and door openings fully flashed. [13]
3. Water-Managed Roof Assembly
3.1 Step and kick-out flashing at all roof-wall intersections, extending ≥ 4” on wall surface above roof deck and integrated shingle-style with drainage plane above; boot / collar flashing at all roof penetrations. [14]
3.2 For buildings that don’t have a slab-on-grade foundation and do have expansive or collapsible soils, gutters & downspouts provided that empty to lateral piping that discharges water on sloping final grade ≥ 5 ft. from foundation, or to underground catchment system not connected to the foundation drain system that discharges water ≥ 10 ft. from foundation. Alternatives & exemptions in Footnote. [5, 15, 16]
3.3 Self-adhering polymer-modified bituminous membrane at all valleys & roof deck penetrations. [5, 17]
3.4 In 2009 IECC Climate Zones 5 & higher, self-adhering polymer-modified bituminous membrane over sheathing at eaves from the edge of the roof line to > 2 ft. up roof deck from the interior plane of the exterior wall. [5, 17]
4. Water-Managed Building Materials
4.1 Wall-to-wall carpet *not* installed within 2.5 ft. of toilets, tubs, and showers.
4.2 Cement board or equivalent moisture-resistant backing material installed on all walls behind tub and shower enclosures composed of tile or panel assemblies with caulked joints. Paper-faced backerboard shall not be used. [18]
4.3 In Warm-Humid climates, Class 1 vapor retarders not installed on the interior side of air permeable insulation in above-grade walls, except at shower and tub walls. [9]
4.4 Building materials with visible signs of water damage or mold *not* installed or allowed to remain. [19]
4.5 Framing members & insulation products having high moisture content *not* enclosed (e.g., with drywall). [20]
4.6 For each condensate-producing HVAC component, corrosion-resistant drain pan (e.g., galvanized steel, plastic) included that drains to a conspicuous point of disposal in case of blockage. Backflow prevention valve included if connected to a shared drainage system.

National Water Management System Requirements [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

Footnotes:

1. These requirements are designed to improve moisture control in buildings. However, these features alone cannot prevent all moisture problems. For example, leaky pipes or overflowing baths can lead to moisture issues and negatively impact the performance of the building. For the purpose of this document, the term 'Partner' represents either the builder or the developer.
2. The term 'Rater' refers to the person(s) completing the third-party verification required for certification. The person(s) shall: a) be a Certified Rater, Approved Inspector, or an equivalent designation as determined by a Verification Oversight Organization or Multifamily Review Organization and, b) have attended and successfully completed an EPA-recognized training class. See www.energystar.gov/mftraining.
3. Swales or drains designed to carry water from foundation are permitted to be provided as an alternative to the slope requirements for any building, and shall be provided for a building where setbacks limit space to less than 10 ft. Also, tamping of back-fill is not required if either: proper drainage can be achieved using non-settling compact soils, as determined by a certified hydrologist, soil scientist, or engineer; OR, the builder / developer has scheduled a site visit to provide in-fill and final grading after settling has occurred (e.g., after the first rainy season).
4. Not required for garage slabs that meet any of the following criteria:
    a. "Open" (i.e., 20% of wall area is openings for natural ventilation); OR
    b. Mechanically ventilated automatically by means of carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors at a standby airflow rate of not less than 0.05 cfm/ft^2 and full-on rate not less than 0.75 cfm/ft^2.
5. Not required in Dry (B) climates as shown in 2009 IECC Figure 301.1 and Table 301.1.
6. Not required for raised pier foundations with no walls. To earn the ENERGY STAR, EPA recommends, but does not require, that radon resistant features be included in buildings built in EPA Radon Zones 1, 2 & 3. For more information, see www.epa.gov/indoorairplus.
7. For an existing slab (e.g., in a building undergoing a gut rehabilitation), in lieu of a capillary break beneath the slab, a continuous and sealed Class I or Class II Vapor Retarder (per Footnote 8) is permitted to be installed on top of the entire slab. In such cases, up to 10% of the slab surface is permitted to be exempted from this requirement (e.g., for sill plates). In addition, for existing slabs in occupiable space, the Vapor Retarder shall be, or shall be protected by, a durable floor surface. If Class I Vapor Retarders are installed, they shall not be installed on the interior side of air permeable insulation or materials prone to moisture damage.
8. Interior surface of an existing below-grade wall (e.g., in a building undergoing a gut rehab.) listed in Item 1.5a is permitted to be finished by:
    - Installing a continuous and sealed drainage plane, capillary break, Class I Vapor Retarder (per Footnote 8) and air barrier that terminates into a foundation drainage system as specified in Item 1.8; OR
    - If a drain tile is not required as specified in Footnote 9, adhering a capillary break and Class I Vapor Retarder (per Footnote 8) directly to the wall with the edges taped / sealed to make it continuous.

    Note that no alternative compliance option is provided for existing below-grade wood-framed walls in Item 1.5b.
9. The 2009 IRC defines Class I vapor retarders as a material or assembly with a rating of ≤ 0.1 perm, using the desiccant method with Proc. A of ASTM E 96. The following materials are typically ≤ 0.1 perm and shall not be used on the interior side of air permeable insulation in above-grade exterior walls in warm-humid climates or below-grade exterior walls in any climate: rubber membranes, polyethylene film, glass, aluminum foil, sheet metal, and foil-faced insulating / non-insulating sheathings. These materials can be used on the interior side of walls if air permeable insulation is not present (e.g., foil-faced rigid foam board adjacent to a below-grade concrete foundation wall is permitted).

    Note that this list is not comprehensive and other materials with a perm rating ≤ 0.1 also shall not be used. Also, if mfr. spec.'s for a product indicate a perm rating ≥ 0.1, then it may be used, even if it is in this list. Also note that open-cell and closed-cell foam generally have ratings above this limit and may be used unless mfr. spec.'s indicate a perm rating ≤ 0.1. Several exemptions to these requirements apply:
    - Class I vapor retarders, such as ceramic tile, may be used at shower and tub walls;
    - Class I vapor retarders, such as mirrors, may be used if mounted with clips or other spacers that allow air to circulate behind them.
10. Alternatively, either a drain tile that is pre-wrapped with a fabric filter or a Composite Foundation Drainage System (CFDS) that has been evaluated by ICC-ES per AC 243 are permitted to be used. Note that the CFDS must include a soil strip drain or another ICC-ES evaluated perimeter drainage system to be eligible for use. In an existing building (e.g., in a building undergoing a gut rehab.) a drain tile installed only on the interior side of the footing without a channel is permitted. Additionally, a drain tile is not required when a certified hydrologist, soil scientist, or engineer has determined that a crawlspace foundation, or an existing basement foundation (e.g., in a building undergoing a gut rehab.), is installed in Group I Soils (i.e., well-drained ground or sand-gravel mixtures), as defined by 2009 IRC Table R405.1.
11. These Items not required for existing structural masonry walls (e.g., in a building undergoing a gut rehabilitation). Note this exemption does not extend to existing wall assemblies with masonry veneers.
12. Any of the following systems may be used: a monolithic weather-resistant barrier (i.e., house wrap) shingled at horizontal joints and sealed or taped at all joints; weather resistant sheathings (e.g., faced rigid insulation) fully taped at all "butt" joints; lapped shingle-style building paper or felts; or other water-resistive barrier recognized by ICC-ES or other accredited agency.
13. Apply pan flashing over the rough sill framing, inclusive of the corners of the sill framing; side flashing that extends over pan flashing; and top flashing that extends over side flashing or equivalent details for structural masonry walls or structural concrete walls.
14. Intersecting wall siding shall terminate 1 in. above the roof or higher, per manufacturer's recommendations. Continuous flashing shall be installed in place of step flashing for metal and rubber membrane roofs.
15. The assessment of whether the soil is expansive or collapsible shall be completed by a certified hydrologist, soil scientist, or engineer.
16. Any of the following are permitted to be used as alternatives to Item 3.2: a) a roof design that deposits rainwater to a grade-level rock bed with a waterproof liner and a lateral drain pipe that meets discharge requirements per Item 3.2; b) a rainwater harvesting system that drains overflow to meet discharge requirements per Item 3.2; or c) a continuous rubber membrane (e.g., EPDM) that is aligned with the foundation wall from final grade to ≥ 8 in. below grade and then slopes ≥ 0.5 in. per ft. away from the building for at least 5 ft., with Group I Soils (as defined in Footnote 9) covering the membrane to within 3 in. of final grade.

17. As an alternative, any applicable option in 2009 IRC Section R905.2.8.2 is permitted to be used to meet Item 3.3 and any option in 2009 IRC Section R905.2.7.1 is permitted to be used to meet Item 3.4. EPA recommends, but does not require, that products meet ASTM D1970. In addition, any option in 2009 IRC Section R905.13 is permitted to be used to meet either Item 3.3 or 3.4.
18. In addition to cement board, materials that have been evaluated by ICC-ES per AC 115 may also be used to meet this requirement. Monolithic tub and shower enclosures (e.g., fiberglass with no seams) are exempt from this backing material requirement unless required by the manufacturer. Paper-faced backerboard may only be used behind monolithic enclosures or waterproof membranes that have been evaluated by ICC-ES per AC 115, and then only if it meets ASTM mold-resistant standards ASTM D3273 or ASTM D6329.
19. If mold is present, effort should be made to remove all visible signs of mold (e.g., by damp wipe with water and detergent). If removal methods are not effective, then the material shall be replaced. However, stains that remain after damp wipe are acceptable. Lumber with "sap stain fungi" is exempt from this Item as long as the lumber is structurally intact.
20. For wet-applied insulation, follow manufacturer’s drying recommendations. EPA recommends that lumber moisture content be ≤ 18%.

National Rater Field Checklist [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

Project Name:_____ Number of Units: _____ Permit Date: _____

Project Address: _____ City: _____ State: _____

Thermal Enclosure System	Must Correct	Builder Verified [3]	Rater Verified [4]	N/A [5]
1. High-Performance Fenestration & Insulation				
1.1 Fenestration meets or exceeds specification in Items 2.1 & 2.2 of the Natl Rater Design Review Checklist.	☐	☐	☐	-
1.2 Insulation meets or exceeds specification in Items 3.1 & 3.2 of the Natl Rater Design Review Checklist.	☐	☐	☐	-
1.3 All insulation achieves Grade I install. per ANSI / RESNET / ICC Std. 301. Alternatives in Footnote 6. [6,7]	☐	☐	☐	-
1.4 Prescriptive Path: Window-to-wall ratio ≤ 30%. [8]	☐	☐	☐	☐
1.5 Heated plenums in unconditioned space or ambient conditions must meet the following requirements: [9]				
1.5.1 Sides of heated plenum are an air barrier and insulated to ≥ R-3ci in CZ 1-4; ≥ R-5ci in CZ 5-6; ≥ R-7.5ci in CZ 7; ≥ R-9.5ci in CZ 8, **AND;**	☐	☐	☐	☐
1.5.2 Insulation at top of heated plenum meets or exceeds the R-value for mass floors from the "All Other" column of Table 502.2(1) of 2009 IECC, **AND;**	☐	☐	☐	☐
1.5.3 Bottom of heated plenum must have at least R-13 insulation. [10]	☐	☐	☐	☐
1.6 Garages with space heating must meet the following requirements: [9]				
1.6.1 Insulation on above grade walls and walls on the first story below grade ≥ R-5ci in CZ 5-6; ≥ R-7.5ci in CZ 7; ≥ R-9.5ci in CZ 8, **AND;**	☐	☐	☐	☐
1.6.2 Ceiling insulation meets or exceeds the R-value for mass floors from the "All Other" column of Table 502.2(1) of 2009 IECC.	☐	☐	☐	☐
2. Fully-Aligned Air Barriers [11] At each insulated location below, a complete air barrier is provided that is fully aligned as follows:				
Ceilings: At interior or exterior horizontal surface of ceiling insulation in Climate Zones 1-3; at interior horizontal surface of ceiling insulation in Climate Zones 4-8. Also, at exterior vertical surface of ceiling insulation in all climate zones (e.g., using a wind baffle that extends to the full height of the insulation in every bay or a tabbed baffle in each bay with a soffit vent that prevents wind washing in adjacent bays). [12]				
2.1 Dropped ceilings / soffits below unconditioned attics, chase / dead space, and all other ceilings.	☐	☐	☐	☐
Walls: At exterior vertical surface of wall insulation in all climate zones; also at interior vertical surface of wall insulation in Climate Zones 4-8. [13]				
2.2 Walls behind showers, tubs, staircases, and fireplaces.	☐	☐	☐	☐
2.3 Architectural bump-outs, dead space, and all other exterior walls.	☐	☐	☐	-
Floors: At exterior vertical surface of floor insulation in all climate zones and, if over unconditioned space, also at interior horizontal surface including supports to ensure alignment. Alternatives in Footnotes 15 & 16. [14, 15, 16]				
2.4 Floors above garages, floors above unconditioned spaces, and cantilevered floors.	☐	☐	☐	☐
2.5 All other floors adjoining unconditioned space (e.g., rim / band joists at exterior wall or at porch roof).	☐	☐	☐	☐
3. Reduced Thermal Bridging				
3.1 For insulated ceilings with attic space above (i.e., non-cathedralized), Grade I insulation extends to the inside face of the exterior wall below and is ≥ R-21 in CZ 1-5; ≥ R-30 in CZ 6-8. [17]	☐	☐	☐	☐
3.2 For insulated ceilings with attic space above, attic access panels and drop-down stairs insulated ≥ R-10 or equipped with durable ≥ R-10 cover. [18]	☐	☐	☐	☐
3.3 Insulation beneath attic platforms (e.g., HVAC platforms, walkways) ≥ R-21 in CZ 1-5; ≥ R-30 in CZ 6-8.	☐	☐	☐	☐
3.4 For slabs on grade in CZ 4-8, 100% of slab edge insulated to ≥ R-5 at the depth specified by Table 502.2(1) of the 2009 IECC and aligned with the thermal boundary of the walls. [19, 20]	☐	☐	☐	☐
3.5 For elevated concrete slabs in CZ 4-8 (i.e., podiums and projected balconies, but not intermediate slab floor edges) 100% of the slab edge insulated to ≥ R-5. For podiums, this insulation must extend for a minimum of 8ft below the bottom of the slab edge. For columns, the insulation must surround the column, at a depth of 4ft. Alternatives in Footnote 21. [21]	☐	☐	☐	☐
3.6 For elevated concrete slabs in CZ 4-8 (i.e., podiums, but not intermediate floor slabs), floor insulation meets the U-factor specified in Table 502.1.2 of the 2009 IECC for Group R when dwelling units are above the slab, and for 'All Other' when common space is above the slab. [22]	☐	☐	☐	☐
3.7 At above-grade walls and rim / band joists separating conditioned space from the exterior, one of the following options used: [23, 26]				
3.7.1 Continuous rigid insulation, insulated siding, or combination of the two is: ≥ R-3 in CZ 1-4; ≥ R-5 in CZ 5-8 [24, 25, 26, 27], **OR**;	☐	☐	☐	☐
3.7.2 Structural Insulated Panels **OR**; Insulated Concrete Forms **OR**; Double-wall framing **OR**; [24, 26, 28]	☐	☐	☐	☐
3.7.3 Option only for wood-framed walls either in CZ 1-3 OR ≤ 3 stories: 'advanced framing' details including all of the Items below: [26, 29]				
3.7.3a Corners insulated ≥ R-6 to edge [30], **AND**;	☐	☐	☐	☐
3.7.3b Headers above windows & doors insulated ≥ R-3 for 2x4 framing or equivalent cavity width, and ≥ R-5 for all other assemblies (e.g., with 2x6 framing) [31], **AND**;	☐	☐	☐	☐
3.7.3c Interior / exterior wall intersections insulated to same R-value as rest of exterior wall. [32]	☐	☐	☐	☐

National Rater Field Checklist [1]

ENERGY STAR Multifamily New Construction, Version 1 / 1.1 / 1.2 (Rev. 02)

4. Air Sealing (Unless otherwise noted below, "sealed" indicates the use of caulk, foam, or equivalent material.)	**Must Correct**	**Builder Verified [3]**	**Rater Verified [4]**	**N/A [5]**
The following items must be verified in dwelling units and common spaces to reduce air leakage to exterior, adjacent buildings, or unconditioned spaces.				
4.1 Ducts, flues, shafts, plumbing, piping, wiring, exhaust fans, & other penetrations to unconditioned space sealed, with blocking / flashing as needed.	☐	☐	☐	-
4.2 Recessed lighting fixtures adjacent to unconditioned space ICAT labeled and gasketed. Also, if in insulated ceiling without attic above, exterior surface of fixture insulated to ≥ R-10 in CZ 4-8.	☐	☐	☐	☐
4.3 Continuous top plate or blocking is at top of walls adjoining unconditioned space including at balloon-framed parapets, and sealed.	☐	☐	☐	☐
4.4 Drywall sealed to top plate at all unconditioned attic / wall interfaces using caulk, foam, drywall adhesive (but not other construction adhesives), or equivalent material. Either apply sealant directly between drywall and top plate or to the seam between the two from the attic above.	☐	☐	☐	☐
4.5 Rough opening around windows & exterior doors sealed. [33]	☐	☐	☐	-
4.6 Assemblies that separate attached garages from occupiable space sealed and, also, an air barrier installed, sealed, and aligned with these assemblies. [34]	☐	☐	☐	☐
4.7 Doors adjacent to unconditioned space (e.g., attics, garages, basements) or ambient conditions made substantially air-tight with doorsweep and weatherstripping or equivalent gasket.	☐	☐	☐	☐
4.8 Attic access panels, roof hatches and drop-down stairs are gasketed (i.e., not caulked) or equipped with durable covers that are gasketed. [18]	☐	☐	☐	☐
The following items must be additionally verified in dwelling units, to reduce air leakage between conditioned spaces.				
4.9 Doors serving as a unit entrance from a corridor/stairwell made substantially air-tight with doorsweep and weatherstripping or equivalent gasket.	☐	☐	☐	☐
4.10 Rater-measured compartmentalization is no greater than 0.30 CFM50 per square feet of dwelling unit enclosure area, following procedures in ANSI / RESNET / ICC Std. 380. [35]	☐	-	☐	
4.10.1 For dwelling units with forced air distribution systems without ducted returns and located in a closet adjacent to unconditioned space, the Rater-measured pressure difference between the space containing the air handler and the conditioned space during the compartmentalization test is no greater than 5 Pa. [36]	☐	-	☐	☐

HVAC System [37]		**Must Correct**	**Rater Verified [4]**	**N/A [5]**
5. Heating & Cooling Eqpt. Complete Track A - HVAC Grading by Rater OR Track B – HVAC Testing by FT Agent [38]				
Track A [39]	5a.1 Blower fan volumetric airflow is Grade I or II per ANSI / RESNET / ACCA Std. 310	☐	☐	☐
	5a.2 Blower fan watt draw is Grade I or II per ANSI / RESNET / ACCA Std. 310	☐	☐	☐
	5a.3 Refrigerant charge is Grade I per ANSI / RESNET / ACCA Std. 310. See Footnote 40 for exemptions. [40]	☐	☐	☐
Track B	5b.1 HVAC manufacturer & model number on installed equipment matches either of the following (check box): [41] ☐ National HVAC Design Report (4.6-4.9 & 4.25-4.26) ☐ Written approval received from designer	☐	☐	-
	5b.2 External static pressure measured by Rater at contractor-provided test locations and documented below: [42] Return-Side External Static Pressure: _____ IWC Supply-Side External Static Pressure: _____ IWC	☐	☐	☐
5.4 Prescriptive Path: Heating and cooling equipment serving dwelling units and common spaces meet the efficiency levels specified in the Exhibit X. Electric resistance space heating is not installed in dwelling units.		☐	☐	☐
5.5 ERI Path: Heating and cooling equipment serving common spaces, but not serving dwelling units, meet the efficiency levels specified in the Exhibit X. See Exhibit X for restrictions on electric resistance space heating.		☐	☐	☐
5.6 National HVAC Functional Testing Checklist(s) collected prior to certification, with all HVAC systems in the building / project fully documented. Exception: Where credentialed HVAC Contractor(s) are completing the National HVAC Functional Testing Checklist, the checklist is not required to be collected for the systems they verify. [43]		☐	☐	☐
5.7 Rater has verified and documented that Functional Testing Agent(s) ("FT Agent(s)") completing the National HVAC Functional Testing Checklist(s) hold one of the required credentials and completed orientation, if applicable. [43] Credential(s): _____ FT Agent Name(s): _____		☐	☐	☐

Equipment Controls	**Must Correct**	**LP Verified [44]**	**Rater Verified [4]**	**N/A [5]**
5.8 All heating and cooling systems serving a dwelling unit have thermostatic controls within the dwelling unit which are not located on exterior walls.	☐	-	☐	☐
5.8.1 Prescriptive Path: Dwelling unit thermostats are programmable.	☐	-	☐	☐
5.9 Stair and elevator shaft vents equipped with motorized dampers that are capable of being automatically closed during normal building operation and are interlocked to open as required by fire and smoke detection systems. Dampers are verified to be closed at the time of inspection.	☐	☐	☐	☐

5.10 Freeze protection systems, such as heat tracing of piping and heat exchangers, including self-regulating heat tracing, and garage / plenum heaters include automatic controls that are verified to shut off the systems when pipe wall or garage / plenum temperatures are above 40°F.	☐	☐	☐	☐
5.10.1 Where heat tracing is installed for freeze-protection, controls must be based on pipe wall temperature and a minimum of R-3 pipe insulation is also required.	☐	☐	☐	☐
5.11 Snow- and ice-melting systems include automatic controls that are verified to shut off the systems when the pavement temperature is above 50°F and no precipitation is falling, and an automatic or manual control is installed that is verified to shut off system when the outdoor temperature is above 40°F, so that the potential for snow or ice accumulation is negligible.	☐	☐	☐	☐
Hydronic Distribution				
5.12 For hydronic distribution systems, all terminal heating and cooling distribution equipment are separated from the riser or distribution loop by a control valve or terminal distribution pump, so that heated or cooled fluid is not delivered to the dwelling unit distribution equipment when there is no call from the thermostat.	☐	☐	☐	☐
5.13 Terminal units in hydronic distribution systems are equipped with pressure independent balancing valves or pressure independent control valves.	☐	☐	☐	☐
5.14 Piping of a heating or cooling system is insulated in accordance with Item 4.41 on the National HVAC Design Report, including where passing through planks or any other penetrations.	☐	☐	☐	☐
5.15 For circulating pumps serving hydronic heating or cooling systems with three-phase motors, 1 horse-power or larger, motors meet or exceed efficiency standards for NEMA Premium™ motors. If 5 horse-power or larger, also installed with variable frequency drives.	☐	☐	☐	☐
6. Duct Quality Installation - *Applies to Heating, Cooling, Ventilation, Exhaust, & Pressure Balancing Ducts, Unless Noted in Footnote.*		**Must Correct**	**Rater Verified [4]**	**N/A [5]**
6.1 Ductwork installed without kinks, sharp bends, compressions, or excessive coiled flexible ductwork. [45]		☐	☐	☐
6.2 Bedrooms with a design supply airflow ≥ 150 CFM (per Item 5.2 on the National HVAC Design Report) pressure-balanced (e.g., using transfer grilles, jump ducts, dedicated return ducts, undercut doors) to achieve a Rater-measured pressure differential ≥ -5 Pa and ≤ +5 Pa with respect to the main body of the dwelling unit when all air handlers are operating. See Footnote 46 for test configuration. [46]		☐	☐	☐
6.3 All supply and return ducts in unconditioned space, including connections to trunk ducts, are insulated to ≥ R-6. [47]		☐	☐	☐
6.3.1 Prescriptive Path: Dwelling unit ductwork meets the location and insulation requirements specified in the ENERGY STAR Multifamily Reference Design.		☐	☐	☐
6.4 Rater-measured total duct leakage in dwelling units meets one of the following two options: [48, 49]				
6.4.1 Rough-in: Tested per allowances below, with air handler & all ducts, building cavities used as ducts, & duct boots installed. In addition, all duct boots sealed to finished surface, Rater-verified at final. [50] No ducted returns [36]: The greater of ≤ 3 CFM25 per 100 sq. ft. of CFA or ≤ 30 CFM. Additionally, the Rater-measured pressure difference between the space containing the air handler and the conditioned space, with the air handler running at high speed, is ≤ 5 Pa. For systems > 1 ton, increase by 1 Pa per half ton. One or two ducted returns [36]: The greater of ≤ 4 CFM25 per 100 sq. ft. of CFA or ≤ 40 CFM. Three or more ducted returns [36]: The greater of ≤ 6 CFM25 per 100 sq. ft. of CFA or ≤ 60 CFM.		☐	☐	☐
6.4.2 Final: Tested per allowances below, with the air handler & all ducts, building cavities used as ducts, duct boots, & register grilles atop the finished surface (e.g., drywall, floor) installed. [51] No ducted returns [36]: The greater of ≤ 6 CFM25 per 100 sq. ft. of CFA or ≤ 60 CFM. Additionally, the Rater-measured pressure difference between the space containing the air handler and the conditioned space, with the air handler running at high speed, is ≤ 5 Pa. For systems > 1 ton, increase by 1 Pa per half ton. One or two ducted returns [36]: The greater of ≤ 8 CFM25 per 100 sq. ft. of CFA or ≤ 80 CFM. Three or more ducted returns [36]: The greater of ≤ 12 CFM25 per 100 sq. ft. of CFA or ≤ 120 CFM.		☐	☐	☐
6.5 Townhouses only: Rater-measured duct leakage to the outside the greater of ≤ 4 CFM25 per 100 sq. ft. of CFA or ≤ 40 CFM25. [48, 52]		☐	☐	☐
6.6 Common Space: Supply, return, and exhaust ductwork and all plenums serving common spaces are sealed at all transverse joints, longitudinal seams, and duct wall penetrations with mastic, mastic tape, or internal aerosol-based sealant.		☐	☐	☐
6.7 Duct leakage of central exhaust systems that serve four or more dwelling units, meets one of the following two options:				
6.7.1 Rough-in: Tested including horizontal run outs, trunks, branches, and take-offs up to, but not including, the grilles, the leakage does not exceed 25% of exhaust fan flow. [53]		☐	☐	☐
6.7.2 Final: Tested inclusive of all ductwork between the fan and the grilles, the leakage does not exceed 30% of exhaust fan flow. [53]		☐	☐	☐

National Rater Field Checklist [1]

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7. Dwelling-Unit & Common Space Mechanical Vent. Systems ("Vent Systems") [54] & Inlets in Return Duct [55] (National HVAC Design Report Item # indicated in parenthesis)	**Must Correct**	**Rater Verified [4]**	**N/A [5]**
7.1 Ventilation manufacturer & model number on installed equipment matches either of the following (check box): [41] ☐ National HVAC Design Report ☐ Written approval received from designer	☐	☐	-
7.2 Rater-measured ventilation rate is within either ± 15 CFM or ±15% of dwelling unit design values (2.7), and meets or exceeds rates required by ASHRAE 62.2-2010. [56]	☐	☐	-
7.3 Measured ventilation rate is within either ± 15 CFM or ±15% of common space design values (2.9), and meets or exceeds rates required by ASHRAE 62.1-2010 (2.8). [57]	☐	☐	-
7.4 A ventilation override control installed and also labeled if its function is not obvious (e.g., a label is required for a toggle wall switch, but not for a switch that's on the ventilation equipment). Townhouses only: A readily-accessible ventilation override control installed and also labeled if its function is not obvious (e.g., a label is required for a toggle wall switch, but not for a switch that's on the ventilation equipment).	☐	☐	-
7.5 For any outdoor air inlet connected to a ducted return of the dwelling unit HVAC system (Complete if present; otherwise check "N/A"): [55]			☐
7.5.1 Controls automatically restrict airflow using a motorized damper during vent. off-cycle and occupant override. [58]	☐	☐	-
7.5.2 Rater-measured vent. rate is ≤ 15 CFM or 15% above design value at highest HVAC fan speed. Alt. in Fn. 59. [59]	☐	☐	-
7.6 If located in the dwelling unit, system fan rated ≤ 3 sones if intermittent, ≤ 2 sones if continuous, or exempted. [60]	☐	☐	-
7.7 If dwelling-unit Vent System controller operates the dwelling unit HVAC fan, then HVAC fan operation is intermittent and either the fan type is ECM / ICM (4.12), or the controls will reduce the run-time by accounting for HVAC system heating or cooling hours. [61]	☐	☐	☐
7.8 In-unit bathroom fans or in-line fans are ENERGY STAR certified if used as part of the dwelling-unit mechanical ventilation system. [62]	☐	☐	☐
7.9 If central exhaust fans, ≤ 1 HP, are installed as part of the dwelling-unit mechanical ventilation system, then they are direct-drive, ECM, with variable speed controllers. If > 1 HP, they are installed with NEMA™ Premium Motors.	☐	☐	☐
7.10 Air inlet locations (Complete if ventilation air inlet locations were installed (2.22, 2.23); otherwise check "N/A"): [63, 64]	-	-	☐
7.10.1 Inlet(s) pull ventilation air directly from outdoors and not from attic, crawlspace, garage, or adjacent dwelling unit.	☐	☐	-
7.10.2 Inlet(s) are ≥ 2 ft. above grade or roof deck; ≥ 10 ft. of stretched-string distance from known contamination sources not exiting the roof, and ≥ 3 ft. distance from dryer exhausts and sources exiting the roof. [65]	☐	☐	-
7.10.3 Inlet(s) are provided with rodent / insect screen with ≤ 0.5 inch mesh.	☐	☐	-

8. Local Mechanical Exhaust (National HVAC Design Report Item # indicated in parenthesis)

Dwelling Unit Mechanical exhaust - In each dwelling unit kitchen and bathroom, a system is installed that exhausts directly to the outdoors and meets one of the following Rater-measured airflow and manufacturer-rated sound level standards: [54, 66]

Location		**Continuous Rate**	**Intermittent Rate [67]**	**Must Correct**	**Rater Verified [4]**	**N/A [5]**
8.1 Kitchen	Airflow	≥ 5 ACH, based on kitchen volume [68, 69]	≥ 100 CFM and, if not integrated with range, also ≥ 5 ACH based on kitchen volume [68, 69, 70]	☐	☐	-
	Sound	Recommended: ≤ 1 sone	Recommended: ≤ 3 sones			
8.2 Bathroom	Airflow	≥ 20 CFM	≥ 50 CFM	☐	☐	-
	Sound	Required: ≤ 2 sones	Recommended: ≤ 3 sones			

Mechanical Exhaust for Common Spaces [2] and Shared Garages			
8.3 Measured exhaust rates are ≥ ASHRAE 62.1 rates (2c). [57]	☐	☐	☐
8.4 Where an exhaust system is installed in a shared garage, it is equipped with controls that sense CO and NO2.	☐	☐	☐
9. Filtration			
9.1 MERV 6+ filter(s) installed in each ducted mechanical system serving an individual dwelling unit and located to facilitate access & regular service by the occupant or building owner. [71]	☐	☐	☐
9.1.1 Filter access panel includes gasket and fits snugly against the exposed edge of filter when closed to prevent bypass. [72]	☐	☐	☐
9.1.2 All return air and mechanically supplied outdoor air passes through filter prior to conditioning.	☐	☐	☐
10. Combustion Appliances			
10.1 Furnaces, boilers, and water heaters located within the building's pressure boundary are mechanically drafted or direct-vented. If mechanically drafted, the minimum volume of combustion air required for safe operation by the manufacturer and/or code shall be met or exceeded and make-up air sources must be mechanically closed when the combustion appliance is not in operation. Alternatives in Footnote 75. [73, 74, 75]	☐	☐	☐
10.2 Fireplaces located within the building's pressure boundary are direct-vented. [73, 74]	☐	☐	☐
10.3 No unvented combustion appliances other than cooking ranges or ovens are located inside the building's pressure boundary. For cooking ranges and ovens, local mechanical exhaust per Checklist Item 8.1 requirements must be met. [73]	☐	☐	☐

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Other	Must Correct	LP Verified[44]	Rater Verified [4]	N/A [5]
11. Domestic Hot Water				
11.1 Prescriptive Path: Hot water equipment rated in EF or UEF meet the efficiency levels specified in the ENERGY STAR Multifamily Reference Design. Otherwise, meet or exceed 85% Et. [76]	☐	-	☐	☐
11.2 ERI: For hot water equipment serving common spaces but not dwelling units nor shared laundry: where rated in EF or UEF, meet the efficiency levels specified in the ENERGY STAR Multifamily Reference Design. Otherwise, meet or exceed 85% Et. [76]	☐	-	☐	☐
11.3 For in-unit storage water heaters, AHRI Certificate confirms the presence of a heat trap.	☐	-	☐	☐
11.4 DHW piping located in the dwelling unit is insulated with a minimum of R-3. [77]	☐	☐	☐	-
11.5 Rater-measured delivery temperatures at faucets and showerheads do not exceed 125°F. [78]	☐	-	☐	-
12. Lighting				
12.1 Common Space [2] Lighting Controls:				
12.1.1 ERI and Prescriptive Path: All common spaces [2] (including shared garages), except the building lobby and where automatic shutoff would endanger the safety of occupants, have occupancy sensors or automatic bi-level lighting controls installed and operation has been verified.	☐	☐	☐	☐
12.1.2 ASHRAE Path only: All common spaces [2] (including shared garages), except the building lobby, corridors, and stairwells and where automatic shutoff would endanger the safety of occupants, have occupancy sensors or automatic bi-level lighting controls installed and operation has been verified.	☐	☐	☐	☐
12.2 Common Space [2] Lighting Power Density Maximum (except garages): [79]				
12.2.1 ERI and Prescriptive Path: Total installed lighting power for the combined common spaces [2] must not exceed ASHRAE 90.1-2007 allowances for those combined spaces, using the Space-by-Space or Building Area Method. See Footnote 80 for allowances. [80]	☐	☐	☐	☐
12.2.2 ASHRAE Path only: Total installed lighting power for the combined common spaces [2] must not exceed ASHRAE 90.1-2007 allowances for those combined spaces, using the Space-by-Space or Building Area Method, by more than 20%. See Footnote 80 for allowances. [80]	☐	☐	☐	☐
12.3 Shared garages: Lighting power density does not exceed 0.24 W/ft^2.	☐	☐	☐	☐
12.4 Exterior lighting controls: Fixtures, including parking lot fixtures, must include automatic switching on timers or photocell controls except fixtures intended for 24-hour operation, required for security, or located on dwelling unit balconies.	☐	☐	☐	☐
12.5 ERI Path: All exterior and common space lighting fixtures meet the efficiency requirements in the ENERGY STAR Multifamily Reference Design, except fixtures located on dwelling unit balconies. [81, 82]	☐	-	☐	☐
12.6 Prescriptive Path: All lighting fixtures (i.e., dwelling units, common spaces, and exterior) meet the efficiency requirements in the ENERGY STAR Multifamily Reference Design. [81, 82]	☐	-	☐	☐
12.7 Prescriptive Path: Dwelling unit overall in-unit lighting power density ≤ 0.75 W/ft^2. When calculating overall lighting power density, use 1.1 W/ft^2 where lighting is not installed. [79]	☐	-	☐	☐

13. Appliances and Plumbing Fixtures	Must Correct	Rater Verified [4]	N/A [5]
13.1 Prescriptive Path: Installed appliances are ENERGY STAR certified. Installed bathroom faucets, bathroom aerators, and showerheads are WaterSense labeled. [83]	☐	☐	☐
13.2 ERI Path: Where installed in common spaces, refrigerators and dishwashers are ENERGY STAR certified and showerheads are WaterSense labeled.	☐	☐	☐
13.3 Prescriptive Path: Shower compartments with multiple fixtures cannot be operated simultaneously OR the total flow rate per shower compartment must not exceed 1.75 gallons per minute, as rated at 80 psi.	☐	☐	☐
14. Whole Building Energy Consumption Data Acquisition Strategy			
14.1 For buildings 50,000 ft^2 and larger, a strategy that enables the collection of monthly or annual building-level energy consumption data (electricity, natural gas, chilled water, steam, fuel oil, propane, etc.) has been confirmed. [84]	☐	☐	☐

Rater Name: _____ Rater Pre-Drywall Inspection Date(s): _____ Rater Initials: _____

Rater Company Name: _____

Rater Name: _____ Rater Final Inspection Date(s): _____ Rater Initials: _____

Rater Company Name: _____

Builder/Developer Employee: _____ Builder Inspection Date(s): _____ Builder Initials: _____

Builder/Developer Name: _____

Licensed Professional: _____ LP Inspection Date(s): _____ LP Initials: _____

National Rater Field Checklist Footnotes

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Footnotes:

1. This Checklist applies to all dwelling units, sleeping units, common spaces [2], and garages (open or enclosed) in the building being certified, and where specified, parking lots. These requirements do not apply to parking garages or lots where the cost of the energy use of the parking garage or lot is not the responsibility of the Builder/Developer, Building Owner or Property Manager. This Checklist does not apply to commercial or retail spaces. This Checklist does not apply to common spaces [2] that are located in buildings on the property without any dwelling or sleeping units. The term 'sleeping unit' refers to a room or space in which people sleep, which can also include permanent provisions for living, eating, and either sanitation or kitchen facilities but not both. Where the term 'dwelling unit' is used in this Checklist, the requirement is also required of 'sleeping' units. The term 'building' refers to a structure utilized or intended for supporting or sheltering occupancy for a residential purpose; a structure with no dwelling or sleeping units connected to a structure with dwelling or sleeping units by less than 10% of its exterior wall area is not to be included in the 'building'.
2. The term 'common space' refers to any spaces in the building being certified that serve a function in support of the residential part of the building that is not part of a dwelling or sleeping unit. This includes spaces used by residents, such as corridors, stairs, lobbies, laundry rooms, exercise rooms, residential recreation rooms, and dining halls, as well as offices and other spaces used by building management, administration or maintenance in support of the residents.
3. At the discretion of the Rater, the builder or developer may verify up to eight items in Sections 1-4 of this Checklist. For the purpose of this Checklist, "Builder" represents either the builder or the developer. When exercised, the builder's responsibility will be formally acknowledged by the builder, or their designated agent, signing off on the checklist for the item(s) that they verified. However, if a quality assurance review indicates that Items have not been successfully completed, the Rater will be responsible for facilitating corrective action.
4. The term 'Rater' refers to the person(s) completing the third-party verification required for certification. The person(s) shall: a) be a Certified Rater, Approved Inspector, as defined by ANSI / RESNET / IECC Standard 301, or an equivalent designation as determined by a Home Certification Organization (HCO) or Multifamily Review Organization (MRO); and, b) have attended and successfully completed an EPA-recognized training class. See www.energystar.gov/mftraining.
5. The column titled "N/A," which denotes items that are "not applicable," should be used when the checklist Item is not present in the project or conflicts with local requirements.
6. Two alternatives are provided: a) Grade II cavity insulation is permitted to be used for assemblies that contain a layer of continuous, air impermeable insulation ≥ R-3 in Climate Zones 1 to 4, ≥ R-5 in Climate Zones 5 to 8; b) Grade II batts are permitted to be used in floors if they fill the full width and depth of the floor cavity, even when compression occurs due to excess insulation, as long as the R-value of the batts has been appropriately assessed based on manufacturer guidance and the only defect preventing the insulation from achieving Grade I is the compression caused by the excess insulation.
7. Ensure compliance with this requirement using ANSI / RESNET / ICC Std. 301 including all Addenda and Normative Appendices, with new versions and Addenda implemented according to the schedule defined by the HCO or MRO that the building is certified under, with approved exceptions listed at www.energystar.gov/ERIExceptions.
8. Window-to-Wall ratio is taken as the sum of all window area divided by the total exterior above-grade wall area. All decorative glass and skylight window area contribute to the total window area to above-grade wall ratio (WWR). Spandrel sections of curtain wall systems contribute to the above-grade wall area.
9. Compliance with Items 1.5 and 1.6 is not required for ASHRAE projects, but the energy used by the heating systems must be modeled following the requirements in the Simulation Guidelines, available at www.energystar.gov/mfguidance.
10. The bottom of the heated plenum is permitted to be suspended ceiling tiles or other non-air barrier material. If fiberglass insulation is installed, it must be paper-faced. This insulation shall achieve a Grade I or Grade II install.
11. For purposes of this Checklist, an air barrier is defined as any durable solid material that blocks air flow between conditioned space and unconditioned space, including necessary sealing to block excessive air flow at edges and seams and adequate support to resist positive and negative pressures without displacement or damage. EPA recommends, but does not require, rigid air barriers.

    Open-cell or closed-cell foam shall have a finished thickness ≥ 5.5 in. or 1.5 in., respectively, to qualify as an air barrier unless the manufacturer indicates otherwise.

    If flexible air barriers such as house wrap are used, they shall be fully sealed at all seams and edges and supported using fasteners with caps or heads ≥ 1 in. diameter unless otherwise indicated by the manufacturer. Flexible air barriers shall not be made of kraft paper, paper-based products, or other materials that are easily torn. If polyethylene is used, its thickness shall be ≥ 6 mil.
12. All insulated ceiling surfaces, regardless of slope (e.g., cathedral ceilings, tray ceilings, conditioned attic roof decks, flat ceilings, sloped ceilings), must meet the requirements for ceilings, unless the ceiling is adiabatic.
13. All insulated vertical surfaces are considered walls (e.g., above and below grade exterior walls, knee walls) and must meet the air barrier requirements for walls. The following exceptions apply: air barriers recommended, but not required, in adiabatic walls; and, in Climate Zones 4 through 8, an air barrier at the interior vertical surface of insulation is recommended but not required in basement walls or crawlspace walls. For the purpose of these exceptions, a basement or crawlspace is a space for which ≥ 40% of the total gross wall area is below-grade.
14. EPA highly recommends, but does not require, an air barrier at the interior vertical surface of floor insulation in Climate Zones 4-8.
15. Examples of supports necessary for permanent contact include staves for batt insulation or netting for blown-in insulation. Alternatively, supports are not required if batts fill the full depth of the floor cavity, even when compression occurs due to excess insulation, as long as the R-value of the batts has been appropriately assessed based on manufacturer guidance and the only defect preventing the insulation from achieving the required installation grade is the compression caused by the excess insulation.
16. Alternatively, an air barrier is permitted to be installed at the exterior horizontal surface of the floor insulation if the insulation is installed in contact with this air barrier, the exterior vertical surfaces of the floor cavity are also insulated, and air barriers are included at the exterior vertical surfaces of this insulation.
17. The minimum designated R-values must be achieved regardless of the trade-offs determined using an equivalent U-factor or UA alternative calculation. Note that if the minimum designated values are used, then higher insulation values may be needed elsewhere to meet Item 1.2.

Also, note that these requirements can be met by using any available strategy, such as a raised-heel truss, alternate framing that provides adequate space, and / or high-density insulation.

18. Examples of durable covers include, but are not limited to, pre-fabricated covers with integral insulation, rigid foam adhered to cover with adhesive, or batt insulation mechanically fastened to the cover (e.g., using bolts, metal wire, or metal strapping. Low-slope roof hatch covers to be insulated to R-5 minimum.
19. Consistent with the 2009 IECC, slab edge insulation is only required for slab-on-grade floors with a floor surface less than 24 inches below grade. Slab-on-grade perimeter insulation shall extend to the top of the slab to provide a complete thermal break. If the top edge of the insulation is installed between the exterior wall and the edge of the interior slab, it shall be permitted to be cut at a 45-degree angle away from the exterior wall. Alternatively, the thermal break is permitted to be created using ≥ R-3 rigid insulation on top of an existing slab (e.g., in a building undergoing a gut rehabilitation). In such cases, up to 10% of the slab surface is permitted to not be insulated (e.g., for sleepers, for sill plates). Insulation installed on top of slab shall be covered by a durable floor surface (e.g., hardwood, tile, carpet).
20. Where an insulated wall separates a garage, patio, porch, or other unconditioned space from the conditioned space of the building, slab perimeter insulation shall also be installed at this interface to provide a thermal break between the conditioned and unconditioned slab, if the slab is in contact with the ground at that interface. Where specific details cannot meet this requirement, partners shall provide the detail to EPA to request an exemption prior to the building's certification. EPA will compile exempted details and work with industry to develop feasible details for use in future revisions to the program. A list of currently exempted details is available at: www.energystar.gov/slabedge.
21. For projected balconies, install a minimum of R-5 slab edge insulation to provide a thermal break between conditioned space and the unconditioned projected balcony slab. Alternatively, a UA calculation for the wall assembly that accounts for this projected slab must be performed to demonstrate compliance with Item 1.2. For the purpose of this UA calculation, the area of the wall that is uninsulated due to the projected balcony is required to be calculated as 400% of that actual area. For example, for a projected balcony without any thermal break that is 20 feet wide, and has a thickness of 1 foot, the area to be used in the UA calculation is 80 ft^2 instead of 20 ft^2. For thermal breaks R-2 and greater, the area is not required to be modified. The distance the balcony projects from the building is not used in this calculation.

    For podiums that are less than 8ft in height, insulation must be installed for the full height of the podium. For podiums that continue below-grade, insulate to a minimum of 8ft below the bottom of the slab edge, or to the depth below-grade specified for slab edge insulation by Table 502.2(1) of the 2009 IECC. For podiums, where insulation is installed on both interior and exterior surfaces of the wall, insulation depth may be reduced to 4ft.
22. Whether insulating from above or below the slab, thermal breaks must be accounted for when determining compliance with floor U-factors. Where structural columns cause a discontinuity in the installed floor insulation, the UA calculation for the floor assembly must account for this uninsulated area of the floor. For the purpose of this UA calculation, the area of the floor that is uninsulated due to the structural columns is required to be calculated as 400% of that actual area. For example, for a 4'x4' column, the area to be used in the UA calculation is 64 ft^2 instead of 16 ft^2. The height of the column is not used in this calculation. Alternatively, if the structural column is insulated for a minimum of 4 vertical feet, the modification to the UA calculation is not required, and the U-value of the column insulation shall be associated with the uninsulated area of the floor due to the column.
23. Item 3.7 is applicable to walls that are adjacent to other buildings. Mass walls utilized as the thermal mass component of a passive solar design (e.g., a Trombe wall) are exempt from this Item. To be eligible for this exemption, the passive solar design shall be comprised of the following five components: an aperture or collector, an absorber, thermal mass, a distribution system, and a control system. For more information, see: www.energy.gov/sites/prod/files/guide_to_passive_solar_home_design.pdf.

    Mass walls that are not part of a passive solar design (e.g., CMU block or log home enclosure) shall either utilize the strategies outlined in Item 3.7 or the pathway in the assembly with the least thermal resistance, as determined using a method consistent with the 2013 ASHRAE Handbook of Fundamentals, shall provide ≥ 50% of the applicable assembly resistance, defined as the reciprocal of the mass wall equivalent U-factor in the 2009 IECC Table 502.1.2. Documentation identifying the pathway with the least thermal resistance and its resistance value shall be collected by the Rater and any Builder Verified or Rater Verified box under Item 3.7 shall be checked.
24. Up to 10% of the total exterior wall surface area is exempted from the reduced thermal bridging requirements to accommodate intentional designed details (e.g., architectural details such as thermal fins, wing walls, brick returns, stone window sills, metal panels, or masonry fireplaces; structural details, such as fasteners (e.g., shelf angles, metal clips, z-girts, brick ties), projected balconies, and service openings (e.g., PTACs or PTHPs), but not steel columns or wall area occupied by intermediate floors). It shall be apparent to the Rater that the exempted areas are intentional designed details or the exempted area shall be documented in a plan provided by the builder, architect, or engineer. The entire area of the wall area that is bypassed by the fastener must be used in the calculation. The Rater need not evaluate the necessity of the designed detail to certify the project.
25. If used, insulated siding shall be attached directly over a water-resistive barrier and sheathing. In addition, it shall provide the required R-value as demonstrated through either testing in accordance with ASTM C 1363 or by attaining the required R-value at its minimum thickness. Insulated sheathing rated for water protection can be used as a water resistant barrier if all seams are taped and sealed. If non-insulated structural sheathing is used at corners, the advanced framing details listed in Item 3.7.3 shall be met for those wall sections.
26. Walls and rim / band joists using steel or other metal framing shall meet the reduced thermal bridging requirements by complying with Item 3.7.1 of the Checklist and may not demonstrate compliance using Item 3.7.2 or 3.7.3.
27. In a building undergoing a gut rehabilitation, continuous interior insulation may be used in lieu of continuous exterior rigid insulation or insulated siding. This alternative does not require continuous interior insulation where a floor intersects an exterior wall, it only requires it from floor to ceiling. Continuous interior insulation is required where the demising wall intersects the exterior wall; however, it may be exempted per Footnote 24.
28. Double-wall framing is defined as any framing method that ensures a continuous layer of insulation covering the studs to at least the R-value required in Item 3.7.1 of the Checklist, such as offset double-stud walls, aligned double-stud walls with continuous insulation between the adjacent stud faces, or single-stud walls with 2x2 or 2x3 cross-framing. In all cases, insulation shall fill the entire wall cavity from the interior to exterior sheathing except at windows, doors and other penetrations.
29. Rim / band joists are exempt from this requirement. For the purpose of this requirement, "≤ 3 stories" refers to any portion of the building elevation where the wood-framed walls do not exceed 3 stories in height. Partial floors that meet the definition of a mezzanine or loft, as defined by the 2012 IRC, do not count as a story. All 'advanced framing' details shall be met except where the builder, architect, or engineer

provides a framing plan that encompasses the details in question, indicating that structural members are required at these locations and including the rationale for these members (e.g., full-depth solid framing is required at wall corners or interior / exterior wall intersections for shear strength, a full-depth solid header is required above a window to transfer load to jacks studs, additional jack studs are required to support transferred loads, additional cripple studs are required to maintain on-center spacing, or stud spacing must be reduced to support multiple stories in a multifamily building). The Rater shall retain a copy of the detail and rationale for their records, but need not evaluate the rationale to certify the building.

30. All exterior corners shall be constructed to allow access for the installation of ≥ R-6 insulation that extends to the exterior wall sheathing. Examples of compliance options include standard-density insulation with alternative framing techniques, such as using three studs per corner, or high-density insulation (e.g., spray foam) with standard framing techniques.
31. Compliance options include continuous rigid insulation sheathing, SIP headers, other prefabricated insulated headers, single-member or two-member headers with insulation either in between or on one side, or an equivalent assembly. R-value requirement refers to manufacturer's nominal insulation value.
32. Insulation shall run behind interior / exterior wall intersections using ladder blocking, full length 2x6 or 1x6 furring behind the first partition stud, drywall clips, or other equivalent alternative.
33. In Climate Zones 1 through 3, a continuous stucco cladding system sealed to windows and doors is permitted to be used in lieu of sealing rough openings with caulk or foam.
34. For dwelling or sleeping units adjacent to garages, EPA recommends, but does not require, carbon monoxide (CO) alarms installed in a central location in the immediate vicinity of each separate sleeping zone and according to NFPA 720.
35. Where a sampling protocol is permitted in accordance with the National or California Program Requirements, at least 20% of the dwelling or sleeping units adjacent to a garage shall be selected for testing.
36. A 'ducted return' is defined as a continuous duct made of sheet metal, duct board, or flexible duct that connects one or more return grilles to the return-side inlet of the air handler. Any other approach to convey air from return or transfer grille(s) to the air handler, such as the use of building cavities, does not constitute a 'ducted return'.
37. This section of the Checklist is designed to meet the requirements of ASHRAE 62.1-2010 / 2013, ASHRAE 62.2-2010 / 2013, and ANSI / ACCA's 5 QI-2015 protocol, thereby improving the performance of HVAC equipment in new multifamily buildings when compared to multifamily buildings built to minimum code. However, these features alone cannot prevent all ventilation, indoor air quality, and HVAC problems, (e.g., those caused by a lack of maintenance or by occupant behavior). Therefore, this Checklist is not a guarantee of proper ventilation, indoor air quality, or HVAC performance.
38. Two tracks are provided for satisfying the mandatory requirements for all certified buildings, Exhibit 2. Track A – HVAC Grading by Rater allows a Rater to utilize ANSI / RESNET / ACCA Std. 310 [39], a standard for grading the installation of residential HVAC systems, for all applicable systems serving individual dwelling units or common spaces, and a Functional Testing Agent to verify commercial and central systems. Track B – HVAC Testing by FT Agent utilizes a Functional Testing Agent for all systems. Either path may be selected, but all requirements within that path must be satisfied for the building to be certified.
39. Track A – HVAC Grading by Rater shall not be used until an implementation schedule has been defined for ANSI / RESNET / ACCA Std. 310 by the HCO or MRO that the building is being certified under. Track A – HVAC Grading by Rater shall then use ANSI / RESNET / ACCA Std. 310 including all Addenda and Normative Appendices, with new versions and Addenda implemented according to the schedule defined by the HCO or MRO that the building is being certified under. For Track A, unitary HVAC Systems including air conditioners and heat pumps up to 65 kBtuh and furnaces up to 125 kBtuh serving individual dwelling or sleeping units or common spaces shall comply with 5a.1 through 5a.3 for the building to be certified.
40. If the non-invasive procedure in ANSI / RESNET / ACCA Std. 310 is not permitted to be used during the final inspection of a unit (i.e., due to the equipment type or to outdoor air temperatures that do not meet the requirements of the non-invasive method), then the unit is permitted to be certified with a default refrigerant charge designation of Grade III. Note that in these circumstances, the weigh-in method procedure in ANSI / RESNET / ACCA Std. 310 may still be used to pursue a Grade I designation.
41. If installed equipment does not match the National HVAC Design Report, then prior to certification the Rater shall obtain written approval from the designer (e.g., email, updated National HVAC Design Report) confirming that the installed equipment meets the requirements of the National HVAC Design Report. In addition, the Rater shall verify that all installed equipment are still exempted types per Footnote 20 of the National HVAC Design Report or, if no longer an exempted type, shall re-review Section 4b of the National Rater Design Review Checklist to ensure compliance with all requirements (e.g., full completion of HVAC Design Report, HVAC design tolerances). In cases where the condenser unit is installed after the time of inspection by the Rater, the HVAC manufacturer and model numbers on installed equipment can be documented through the use of photographs provided by the HVAC Contractor or Functional Testing Agent after installation is complete.
42. The Rater shall measure and record the external static pressure in the return-side and supply-side of the system using the contractor-provided test locations. However, at this time, the Rater need not assess whether these values are within a specific range to certify the dwelling unit. Ductless systems and systems with a total amount of supply ductwork or distribution building cavities ≤ 10 ft. in length are exempted from this requirement. The Rater is also not required to measure external static pressure for multi-split systems and may mark "N/A".
43. Functional Testing Agents must hold an approved credential, as listed at www.energystar.gov/ftas, or must be a representative of the Original Equipment Manufacturer (OEM), or a contractor credentialed by an HVAC Quality Installation Training and Oversight Organization (H-QUITO), if not completing Sections 6 and higher. Functional Testing Agents may not be the installing contractor, nor employed by the same company as the installing contractor, unless they are a credentialed contractor. An explanation of the credentialing process and links to H-QUITOs, which maintain lists of credentialed contractors, can be found at www.energystar.gov/findhvac. A directory of other FT Agents can be found at www.energystar.gov/ftas. Raters can confirm FT Agents have met the requirements by documenting they are listed in a directory. For Track A, a Functional Testing Agent is not needed to complete Sections 2 and 3 for residential HVAC systems serving dwelling units or common spaces that will be verified and graded by the Rater.
44. At the discretion of the Rater, a Licensed Professional (LP), (i.e., a Registered Architect or Professional Engineer in good standing and with a current license), may verify any of the items in Sections 5, 11, and 12 of this Checklist, where a checkbox is provided for "LP Verified". When exercised, the LP's responsibility will be formally acknowledged by the LP signing off on the checklist for the item(s) that they verified.

However, if a quality assurance review indicates that Items have not been successfully completed, the Rater will be responsible for facilitating corrective action.

45. Kinks are to be avoided and are caused when ducts are bent across sharp corners such as framing members. Sharp bends are to be avoided and occur when the radius of the turn in the duct is less than one duct diameter. Compression is to be avoided and occurs when flexible ducts in unconditioned space are installed in cavities smaller than the outer duct diameter and ducts in conditioned space are installed in cavities smaller than inner duct diameter. Ducts shall not include coils or loops except to the extent needed for acoustical control.
46. Item 6.2 does not apply to ventilation ducts, exhaust ducts, or non-ducted systems. For an HVAC system with a multi-speed fan, the highest design fan speed shall be used when verifying this requirement. When verifying this requirement, doors separating bedrooms from the main body of the dwelling unit (e.g., a door between a bedroom and a hallway) shall be closed and doors to rooms that can only be entered from the bedroom (e.g., a closet, a bathroom) shall be open. The Rater-measured pressure shall be rounded to the nearest whole number to assess compliance.
47. Item 6.3 does not apply to ducts that are a part of local mechanical exhaust or exhaust-only dwelling-unit mechanical ventilation systems. EPA recommends, but does not require, that all metal ductwork not encompassed by Section 6 (e.g., exhaust ducts, duct boots, ducts in conditioned space) also be insulated and that insulation be sealed to duct boots to prevent condensation.
48. Items 6.4 and 6.5 generally apply to the ducts of space heating, space cooling, and dwelling-unit mechanical ventilation systems.

    However, visual inspection is permitted in lieu of testing for the following system types: 1) a dwelling-unit mechanical ventilation system not connected to the space heating or space cooling system, regardless of the number of dwelling units it serves; 2) a space heating or space cooling system for which the ducts and air handler are in conditioned space and the total supply duct length of the system, including all supply trunks and branches, is ≤ 10 ft; and 3) a space heating or space cooling system that serves more than one dwelling unit. In such cases, a Rater shall visually verify that all seams and connections are sealed with mastic or metal tape and all duct boots are sealed to floor, wall, or ceiling using caulk, foam, or mastic tape.

    For duct systems requiring testing, duct leakage shall be determined and documented by a Rater using ANSI / RESNET / ICC Std. 380 including all Addenda and Normative Appendices, with new versions and Addenda implemented according to the schedule defined by the HCO or MRO that the building is being certified under. Leakage limits shall be assessed on a per-system, rather than per-dwelling unit, basis.
49. Note that compliance with Item 6.4.1 or 6.4.2 in conjunction with Section 4a of the National Rater Design Review Checklist automatically achieves Grade I total duct leakage per ANSI / RESNET / ACCA Std. 310.
50. Cabinets (e.g., kitchen, bath, multimedia) or ducts that connect duct boots to toe-kick registers are not required to be in place during the 'rough-in' test.
51. Registers atop carpets are permitted to be removed and the face of the duct boot temporarily sealed during testing. In such cases, the Rater shall visually verify that the boot has been durably sealed to the subfloor (e.g., using duct mastic or caulk) to prevent leakage during normal operation.
52. Testing of duct leakage to the outdoors can be waived in accordance with the 2nd or 3rd alternative of ANSI / RESNET / ICC Std. 301, Table 4.2.2 (1), footnote (w). Alternatively, testing of duct leakage to outdoors can be waived in accordance with Section 5.5.2 of ANSI / RESNET / ICC Std. 380 if total duct leakage, at rough-in or final, is ≤ 4 CFM25 per 100 sq. ft. of conditioned floor area or 40 CFM25, whichever is larger. Guidance to assist partners with these alternatives, including modeling inputs, is available at www.energystar.gov/newhomesguidance.
53. For the purpose of computing leakage allowance, exhaust fan flow shall be the lesser of the rated fan flow and at rough-in, 133% of the sum of the design exhaust airflow of the dwelling units that are exhausted by that central fan or at final, 143% of the sum of the design exhaust airflow of the dwelling units that are exhausted by that central fan. Measured fan flow (either at the fan itself or the total airflow measured from all exhaust grilles served by the fan) may be used in lieu of the rated fan flow to determine the leakage allowance. Duct leakage shall be tested at the design or average operating pressure and shall use the procedures in the *RESNET Guidelines for Multifamily Energy Ratings*, available at www.resnet.us/blog/resnet-adopts-guidelines-for-multifamily-energy-ratings/. Where testing at the design or average operating pressure is not feasible, testing at 50 Pa is permitted, however the following flow equation must be used to determine the leakage allowance at 50 Pa.

    $$CFM_{50} = CFM_{design} / [P_{design}^{(0.65)} / 50^{(0.65)}]$$

    No less than 50% of the ductwork, based on total linear feet, shall be tested and must include ductwork other than the main trunks. Where portions of ductwork are tested, rather than entire risers, the percentage of leakage allowed is based upon the design airflow of the dwelling units that are exhausted in that portion. Where failures occur, the percentage of total linear feet required to be tested increases by 10%. Where aerosol-based sealant is used on some but not all risers, the ductwork selected for testing must be representative of all sealing strategies used. This test is not required of central exhaust systems serving clothes dryers.
54. As defined by ANSI / RESNET / ICC Std. 301-2019, a Dwelling Unit Mechanical Ventilation System is a ventilation system consisting of powered ventilation equipment such as motor-driven fans and blowers and related mechanical components such as ducts, inlets, dampers, filters and associated control devices that provides dwelling-unit ventilation at a known or measured airflow rate.
55. Item 7.5 applies to any outdoor air inlet connected to a ducted return of the dwelling unit HVAC system, regardless of its intended purpose (e.g., for ventilation air, make-up air, combustion air). This Item does not apply to HVAC systems without a ducted return.
56. The dwelling-unit ventilation air flows and local exhaust air flows shall be determined and documented by a Rater using ANSI / RESNET / ICC Std. 380 including all Addenda and Normative Appendices, with new versions and Addenda implemented according to the schedule defined by the HCO or MRO that the building is being certified under. In Item 7.2, the dwelling-unit ventilation rates required by ASHRAE 62.2-2010 can be calculated using the Multifamily Workbook or the following equation: 0.01 x Conditioned Floor Area + 7.5 x (number of bedrooms + 1). Where local codes do not permit dwelling-unit ventilation to exceed ASHRAE 62.2-2010 rates, Rater-measured ventilation rate is permitted to be 0-15 CFM less than rates required by ASHRAE 62.2-2010.
57. While common spaces are not under the scope of ANSI / RESNET / ICC Std. 380, the ventilation air flow and exhaust air flows in common spaces shall be measured in accordance with the procedures in ANSI / RESNET / ICC Std. 380. The air flows may be measured by a Rater or a certified air-balancing contractor under the observation of a Rater. Where a system provides supply air that is a mix of return and outdoor air, and not 100% outdoor air, the outdoor air airflow shall be measured and compared to the total supply airflow to determine percentage of

outdoor air supplied. This percentage shall be applied to airflow measured at supply registers to determine outdoor air provided for comparison to design airflow rates.

58. For example, if an outdoor air inlet connected to a ducted return is used as a dedicated source of outdoor air for an exhaust ventilation system (e.g., bath fan), the outdoor airflow must be automatically restricted when the exhaust fan is not running and in the event of an override of the exhaust ventilation system.

    In dwelling / sleeping units in multifamily buildings, but not townhouses, automatic restriction of airflow is exempted if a manual shutoff damper is used with a continuous exhaust ventilation system and is readily-accessible, labeled as the override, and not used as a balancing damper.

59. When assessing the ventilation rate, the highest HVAC fan speed applicable to ventilation mode shall be used (e.g., if the inlet only opens when the HVAC is in 'fan-only' mode, then test in this mode). If the inlet has a motorized damper that only opens when the local mechanical kitchen exhaust is turned on, then testing is not required.

    When required, the ventilation airflow through the inlet shall be measured and documented by a Rater using ANSI / RESNET / ICC Std. 380 including all Addenda and Normative Appendices, with new versions and Addenda implemented according to the schedule defined by the HCO or MRO that the building is being certified under. As an alternative, measurement of the outdoor airflow can be waived if a Constant Airflow Regulating (CAR) damper with a manufacturer-specified maximum flow rate no higher than 15 CFM or 15% above the ventilation design value is installed on the inlet.

60. Dwelling-unit mechanical ventilation fans shall be rated for sound at no less than the airflow rate in Item 2.7 of the National HVAC Design Report. Fans exempted from this requirement include HVAC air handler fans, remote-mounted fans, and intermittent fans rated ≥ 400 CFM. To be considered for this exemption, a remote-mounted fan must be mounted outside the habitable spaces, bathrooms, toilets, and hallways and there shall be ≥ 4 ft. ductwork between the fan and intake grille. Per ASHRAE 62.2-2010, habitable spaces are intended for continual human occupancy; such space generally includes areas used for living, sleeping, dining, and cooking but does not generally include bathrooms, toilets, hallways, storage areas, closets, or utility rooms.

61. Note that the 'fan-on' setting of a thermostat would not be an acceptable controller because it would continuously operate the HVAC fan.

62. Bathroom fans with a rated flow rate ≥ 500 CFM are exempted from the requirement to be ENERGY STAR certified.

63. Ventilation air inlets that are only visible via rooftop access are exempted from Item 7.10 and the Rater shall mark "N/A". The outlet and inlet of balanced ventilation systems shall meet these spacing requirements unless manufacturer instructions indicate that a smaller distance may be used. However, if this occurs the manufacturer's instructions shall be collected for documentation purposes.

64. Without proper maintenance, ventilation air inlet screens often become filled with debris. Therefore, EPA recommends, but does not require, that these ventilation air inlets be located so as to facilitate access and regular service by the building owner.

65. Known contamination sources include, but are not limited to, stacks, vents, exhausts, and vehicles.

66. Continuous bathroom local mechanical exhaust fans shall be rated for sound at no less than the airflow rate in Item 8.2. Intermittent bathroom and both intermittent and continuous kitchen local mechanical exhaust fans are recommended, but not required, to be rated for sound at no less than the airflow rate in Items 8.1 and 8.2. Per ASHRAE 62.2-2010, an exhaust system is one or more fans that remove air from the building, causing outdoor air to enter by ventilation inlets or normal leakage paths through the building envelope (e.g., bath exhaust fans, range hoods, clothes dryers). Per ASHRAE 62.2-2010, a bathroom is any room containing a bathtub, shower, spa, or similar source of moisture.

67. An intermittent mechanical exhaust system, where provided, shall be designed to operate as needed by the occupant. Control devices shall not impede occupant control in intermittent systems.

68. Kitchen volume shall be determined by drawing the smallest possible rectangle on the floor plan that encompasses all cabinets, pantries, islands, peninsulas, ranges / ovens, and the kitchen exhaust fan, and multiplying by the average ceiling height for this area. In addition, the continuous kitchen exhaust rate shall be ≥ 25 CFM, per 2009 IRC Table M1507.3, regardless of the rate calculated using the kitchen volume. Cabinet volume shall be included in the kitchen volume.

69. Alternatively, the prescriptive duct sizing requirements in Table 5.3 of ASHRAE 62.2-2010 are permitted to be used for kitchen exhaust fans based upon the rated airflow of the fan at 0.25 IWC. If the rated airflow is unknown, ≥ 6 in. smooth duct shall be used, with a rectangular to round duct transition as needed. Guidance to assist partners with these alternatives is available at www.energystar.gov/newhomesguidance. As an alternative to Item 8.1, dwelling units are permitted to use a continuous kitchen exhaust rate of 25 CFM per 2009 IRC Table M1507.3, if they are either a) PHIUS+ or PHI certified, or b) provide both dwelling-unit ventilation and local mechanical kitchen exhaust using a balanced system, and have a Rater-verified whole-building infiltration rate ≤ 1.0 ACH50 or ≤ 0.05 CFM50 per sq. ft. of Enclosure Area. 'Enclosure Area' is defined as the area of the surfaces that bound the volume being pressurized / depressurized during the test.

70. All intermittent kitchen exhaust fans must be capable of exhausting at least 100 CFM. In addition, if the fan is not part of a vented range hood or appliance-range hood combination (i.e., if the fan is not integrated with the range), then it must also be capable of exhausting ≥ 5 ACH, based on the kitchen volume.

71. Based upon, ASHRAE 62.2-2010, ducted mechanical systems are those that supply air to an occupiable space with a total amount of supply ductwork exceeding 10 ft. in length and through a thermal conditioning component, except for evaporative coolers. Systems that do not meet this definition are exempt from this requirement. While filters are recommended for mini-split systems, HRV's, and ERV's, these systems, ducted or not, typically do not have MERV-rated filters available for use and are, therefore, also exempted under this version of the requirements. HVAC filters located in the attic shall be considered accessible to the occupant or building owner if either 1) drop-down stairs, a pull-down ladder, or door provide access to attic and a permanently installed walkway has been provided between the attic access location and the filter or 2) the filter location enables arm-length access from a portable ladder without the need to step into the attic and the height of the ceiling access panel or the bottom of the wall access panel where access is provided is ≤ 12 ft.

72. Sealing mechanisms comparable to a gasket are also permitted to be used. The filter media box (i.e., the component in the HVAC system that houses the filter) may be either site-fabricated by the installer or pre-fabricated by the manufacturer to meet this requirement. These requirements only apply when the filter is installed in a filter media box located in the HVAC system, not when the filter is installed flush with the return grille.

73. The pressure boundary is the primary enclosure boundary separating indoor and outdoor air. For example, a volume that has more leakage to outside than to conditioned space would be outside the pressure boundary.

74. Per the 2009 International Mechanical Code, a direct-vent appliance is one that is constructed and installed so that all air for combustion is derived from the outdoor atmosphere and all flue gases are discharged to the outside atmosphere; a mechanical draft system is a venting system designed to remove flue or vent gases by mechanical means consisting of an induced draft portion under non-positive static pressure or a forced draft portion under positive static pressure; and a natural draft system is a venting system designed to remove flue or vent gases under nonpositive static vent pressure entirely by natural draft.
75. Naturally drafted equipment is only allowed if located in a space outside the pressure boundary, where the envelope assemblies separating it from conditioned space are insulated and air-sealed.
76. Where water heater efficiency is rated in Uniform Energy Factor (UEF) rather than Energy Factor (EF), the EF may be calculated from the Uniform Energy Factor (UEF) using the RESNET EF Calculator 2017. The calculated EF must meet the efficiency levels specified in the ENERGY STAR Multifamily Reference Design.
77. In accordance with Section 7.4.3 of ASHRAE 90.1-2016, the following in-unit DHW piping requires insulation:
    a. Recirculating system piping, including the supply and return piping of a circulating tank type water heater.
    b. The first 8 feet of outlet piping of a constant-temperature nonrecirculating storage system.
    c. The first 8 feet of branch piping connecting to recirculated, heat-traced, or impedance heated piping.
    d. The inlet piping between the storage tank and a heat trap in a nonrecirculating storage system.
    e. Piping that is externally heated (such as heat trace or impedance heating).
78. To measure the delivery temperature, turn the hot water at a fixture completely on and place a digital thermometer in the stream of water. Observe the thermometer and when no additional rise in temperature occurs after 10 seconds, confirm this temperature does not exceed 125°F.
79. Senior housing projects can use the space-by-space allowances for 'facilities for the visually impaired' in ASHRAE 90.1-2016 Appendix G Table G3.7 for spaces used primarily by building residents. For example, 1.15 W/SF lighting power allowance may be used for the corridors in the baseline. To qualify for the increased allowance, the project must be designed to comply with the light levels in ANSI / IES RP-28 and must provide housing for seniors and/or people with special visual needs. Prescriptive Path dwelling unit overall in-unit lighting power density is permitted to be ≤ 1.3 W/SF, using 1.65 W/SF where lighting is not installed.
80. Lighting power density values from ASHRAE 90.1-2007 Section 9 for Space-by-Space Method for typical common spaces in multifamily properties are shown in the table below. Projects following the Building Area method, the lighting power density is 0.7 W/ft^2. For spaces not shown, refer to ASHRAE 90.1-2007 Section 9.

ASHRAE Space Type	Lighting Power Densities (W/ft^2)	ASHRAE Space Type	Lighting Power Densities (W/ft^2)	ASHRAE Space Type	Lighting Power Densities (W/ft^2)
Lobby / Elevator	1.3	Corridor / Transition	0.5	Office	1.1
Active Storage (e.g., trash chute / room, janitor closet)	0.8	Stairs - Active	0.6	Lounge / Recreation / Community Room / Computer Room	1.2
Inactive Storage (e.g., tenant storage)	0.3	Restroom	0.9	Electrical / Mechanical	1.5
Exercise Area / Room	0.9	Laundry Room	1.3	Workshop	1.9

81. This requirement applies to exterior lighting fixtures that are attached to the building, but does not apply to landscape or parking lot lighting fixtures.
82. For Prescriptive Path dwelling units, ENERGY STAR certified fixtures or light bulbs are required; however, the Rater is only responsible for verifying that the installed lighting meets the Tier I or Tier II definition specified in ANSI / RESNET / ICC Std. 301. For locations outside the dwelling unit, as an alternative to ENERGY STAR certified fixtures or light bulbs, lighting that meets the Tier I or Tier II definition specified in ANSI / RESNET / ICC Std.301 is permitted.
83. Appliances include refrigerators, dishwashers, clothes washers, and clothes dryers. Where an appliance type is not eligible for ENERGY STAR certification, (e.g., commercial dryers) the appliance is exempt from this requirement. Where a bathroom faucet or aerator is not eligible for WaterSense certification, (e.g., public use lavatory faucets) the fixture is exempt from this requirement.
84. Strategies include: an agreement with the utility companies to provide the aggregated building-level data, in a spreadsheet format or directly through Portfolio Manager; OR evidence that securing signed utility data release forms will be a mandatory component of all lease agreements; OR installation of a building-level energy monitor, data acquisition system, or utility-owned energy meter. If an energy monitor is installed, the builder shall provide the building operator with the manufacturer's documentation and operations manual. EPA recommends, but does not require, that one of these strategies also be implemented in buildings 25,000-49,999 ft^2.

Exhibit X – Prescriptive Minimum Heating and Cooling Equipment Efficiencies †

Equipment Type	Minimum Efficiency
Room AC (window, through-wall, ductless mini-splits)	ENERGY STAR certified
Air conditioners, air cooled (<13 KBtu/h)	13 SEER
Air conditioners, air cooled (≥13 and <65 KBtu/h)	See Reference Design
Air conditioners, air cooled (≥65 and <240 KBtu/h)	11.5 EER/12.0 IEER
Air conditioners, air cooled (≥240 and < 760 KBtu/h)	10.0 EER/10.5 IEER
Electric resistance space heating	• Not permitted in any dwelling unit using the Prescriptive Path • Electric resistance heating specified in common spaces has a total heating capacity ≤ 12 kBtu/h (3.5 kW) per enclosed space and has automatic thermostatic controls
Warm-Air Furnace (<225 KBtu/h, common spaces)	78% AFUE or 80% Et
Warm-Air Furnace (<225 KBtu/h, dwelling units)	See Reference Design. For PTAC, use 80% Et
Warm-Air Furnace (≥225 KBtu/h)	80% Et (gas) or 81% Et (oil)
Packaged Terminal Air Conditioner (PTAC < 7 kBtu/h)	11.9 EER
Packaged Terminal Air Conditioner (PTAC > 15 kBtu/h)	9.5 EER
Packaged Terminal Air Conditioner (≥7 and ≤15 KBtu/h)	14.0 – (0.300 X Cap/1000) EER
Packaged Terminal Heat Pump (PTHP)	Cooling: 14.0– (0.3 X Cap/1000) EER Heating: 3.7– (0.052 X Cap/1000) COP
Air cooled heat pump (≥13 and <65 KBtu/h)	See Reference Design
Air cooled heat pump (≥65 and <240 KBtu/h)	Cooling: 11.1 EER/11.6 IEER Heating: 3.3 COP (@47°F DB)
Air cooled heat pump (≥240 KBtu/h)	Cooling: 9.6 EER/9.6 IEER Heating: 3.2 COP (@47°F DB)
Water-source heat pump (<135 KBtu/h)	Cooling: 14.0 EER(86°F entering water) Heating: 4.2 COP(68°F entering water)
Boilers, hot water (<300,000 Btu/h)	See Reference Design
Boilers, hot water (≥300,000 Btu/h)	86% E_t (89% E_t if using heat pumps)
VRF Air Conditioners and Heat Pumps	See Tables 6.8.1I and 6.8.1J of ASHRAE 90.1-2010
Air-cooled chillers with or without condenser	10.0 EER / 12.5 IPLV
Water-cooled chiller, positive displacement (<75 tons)	0.780 kW/ton (Full load) / 0.630 kW/ton (IPLV)
Water-cooled chiller, positive displacement (75-150 tons)	0.775 kW/ton (Full load) / 0.615 kW/ton (IPLV)
Water-cooled chiller, positive displacement (150-300tons)	0.680 kW/ton (Full load) / 0.580 kW/ton (IPLV)
Water-cooled chiller, positive displacement (>300 tons)	0.620 kW/ton (Full load) / 0.540 kW/ton (IPLV)
Water-cooled, centrifugal (<300 tons)	0.634 kW/ton (Full load) / 0.596 kW/ton (IPLV)
Water-cooled, centrifugal (≥300 and <600 tons)	0.576 kW/ton (Full load) / 0.549 kW/ton (IPLV)
Water-cooled, centrifugal (≥600 tons)	0.570 kW/ton (Full load) / 0.539 kW/ton (IPLV)
Air-cooled absorption single effect chiller	0.6 COP
Water-cooled absorption single effect chiller	0.7 COP
Absorption double effect indirect-fired chiller	1.0 COP (Full load) / 1.05 COP (IPLV)
Absorption double effect direct-fired chiller	1.0 COP (Full load) / 1.00 COP (IPLV)
Open-loop propeller or axial fan cooling towers*	>40 gpm/hp (@95°F entering water, 85°F leaving water, 75°F wb entering air)
Closed-loop propeller or axial fan cooling towers*	>15 gpm/hp (@102°F entering water, 90°F leaving water, 75°F wb entering air)
Open-loop centrifugal fan cooling towers*	>22 gpm/hp (@95°F entering water, 85°F leaving water, 75°F wb entering air)
Closed-loop centrifugal fan cooling towers*	>8 gpm/hp (@102°F entering water, 90°F leaving water, 75°F wb entering air)

Cap means the rated capacity of the product in Btu/h. If < 7,000 Btu/h, use 7,000; if > 15,000, use 15,000 in calculation.

*Cooling tower fan motors must be equipped with VFD controlled by a temperature sensor on the condenser water supply pipe.

† For Equipment Types not listed here, minimum efficiencies shall be based on those listed in ASHRAE 90.1-2010.

National HVAC Functional Testing Checklist [1]

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HVAC Functional Testing Agent Responsibilities:

- The entity verifying Functional Testing, the Functional Testing Agent ("FT Agent"), must be a contractor credentialed by an HVAC Quality Installation Training and Oversight organization (H-QUITO), or must hold an approved credential, as listed at www.energystar.gov/ftas, or must be a representative of the Original Equipment Manufacturer (OEM) to complete this checklist. A contractor credentialed by an H-QUITO is only permitted to complete Sections 1-5 of this checklist. [2]
- Functional Testing checklists must be completed and signed by an FT Agent. [1] An FT Agent is permitted to complete just the specific sections of this checklist that pertain to their area of expertise. However, all applicable sections must be completed by an FT Agent, which may result in multiple checklists signed by multiple FT Agents. FT Agents shall only sign checklists that contain items that they have verified. An FT Agent may mark an item as 'verified' by conducting the test or inspection themselves, or witness the test or inspection being conducted by the installing contractor or other HVAC professional. Where a checkbox for "FT Agent Verified" is not provided, FT Agents should fill in all applicable data fields.
- Functional Testing checklists must include all HVAC systems in the building / project that serve the dwelling units, common spaces, and where applicable, parking garages, but may exclude systems solely serving commercial / retail spaces. Multiple checklists will be needed to document all HVAC systems in the building / project. Except where items are verified by the installing contractor, items on the Functional Testing Checklist are permitted to be verified using MFNC HVAC Functional Testing Checklist Sampling Protocols.
- The completed checklists, along with the corresponding National HVAC Design Report, shall be retained by the FT Agent for quality assurance purposes. Furthermore, if the FT Agent is not a credentialed contractor, they shall provide the completed and signed checklists to the builder / developer and the Rater [3] responsible for certifying the units / building, prior to the project's certification. Credentialed contractors shall provide the checklist upon request.

1. Functional Testing Overview

1.1 Company performing Functional Testing: _____ FT Agent name: _____ Date: _____

1.2 Functional Testing Agent Credential: _____
If a credentialed contractor, fill out applicable H-QUITO and ID Number: ☐ ACCA ☐ Advanced Energy ID Number: _____

1.3 Builder / developer client name: _____

1.4 Project address: _____ City: _____ State: _____ Zip code: _____

1.5 National HVAC Design Report corresponding to this project has been collected from designer or builder. ☐

1.6 Checklist applies to the following equipment (include unit # as applicable): _____

2. Refrigerant Charge - Run system for 15 minutes before testing. If outdoor ambient temperature at the condenser is ≤ 55°F or, if known, below the manufacturer-recommended minimum operating temperature for the cooling cycle, then the system shall include a TXV, the outdoor temperature shall be recorded in Item 2.1, and the contractor shall check "N/A" in this Section. [4] This section must be completed for refrigerant-based systems with field-installed refrigerant piping or components (i.e., split air conditioners, air-source heat pumps, and water-source heat pumps), up to 65 kBtu/h, whether serving dwelling units or common spaces in the building. Ducted or non-ducted single-packaged systems (i.e., PTAC), mini-splits, or multi-splits are exempt from this section. When using the alternative OEM test procedure in Item 2.16, check "NA" for Items 2.1-2.15. [5]		**FT Agent Verified**	**N/A ☐**
2.1 Outdoor ambient temperature at condenser:	_____ °F DB	-	-
2.2 Return-side air temperature inside duct near evaporator, during cooling mode:	_____ °F WB	-	☐
2.3 Liquid line pressure:	_____ psig	-	☐
2.4 Liquid line temperature:	_____ °F DB	-	☐
2.5 Suction line pressure:	_____ psig	-	☐
2.6 Suction line temperature:	_____ °F DB	-	☐
For System with Thermal Expansion Valve (TXV):			
2.7 Condenser saturation temperature: _____	°F DB (Using Item 2.3)	-	☐
2.8 Subcooling value: _____	°F DB (Item 2.7 – Item 2.4)	-	☐
2.9 OEM subcooling goal: _____	°F DB	-	☐
2.10 Subcooling deviation: _____	°F DB (Item 2.8 – Item 2.9)	-	☐
For System with Fixed Orifice:			
2.11 Evaporator saturation temperature: _____	°F DB (Using Item 2.5)	-	☐
2.12 Superheat value: _____	°F DB (Item 2.6 – Item 2.11)	-	☐
2.13 OEM superheat goal: _____	°F DB (Using superheat tables and Items 2.1 & 2.2)	-	☐
2.14 Superheat deviation: _____	°F DB (Item 2.12 – Item 2.13)	-	☐
2.15 Item 2.10 is ± 3°F or Item 2.14 is ± 5°F.		☐	☐
2.16 An OEM test procedure (e.g., as defined for a ground-source heat pump) has been used in place of the sub-cooling or super-heat process and documentation has been attached that defines this procedure.		☐	☐

National HVAC Functional Testing Checklist [1]

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3. Indoor HVAC Fan Airflow - This section must be completed for split air conditioners, unitary air conditioners, air-source heat pumps (including multi-splits), and water-source (i.e., geothermal or water-loop) heat pumps up to 65 kBtuh with forced-air distribution systems (i.e., ducts) and to furnaces up to 225 kBtuh with forced-air distribution systems (i.e., ducts), whether serving dwelling units or other common spaces in the building. Mini-splits, ducted or non-ducted, are exempt; however, multi-split systems such as shared VRF systems, where indoor HVAC fans with forced-air distribution are connected to a shared outdoor unit that exceeds 65 kBtuh, are not exempt. [5]	**FT Agent Verified**	**N/A** ☐
3.1 The mode with the higher design HVAC fan airflow used, per Item 5.2 of National HVAC Design Report: ☐ Heating ☐ Cooling	☐	-
3.2 Static pressure test holes have been created, and test hole locations are well-marked and accessible.	☐	-
Test hole location for **return** external static pressure: ☐ Plenum ☐ Cabinet ☐ Transition ☐ Other: _____	-	-
Test hole location for **supply** external static pressure: ☐ Plenum ☐ Cabinet ☐ Transition ☐ Other: _____	-	-
3.3 Measured **return** external static pressure (Enter value only, without negative sign): _____ IWC	-	-
3.4 Measured **supply** external static pressure (Enter value only, without positive sign): _____ IWC	-	-
3.5 Measured **total** external static pressure = Value-only from Item 3.3 + Value-only from Item 3.4 = _____ IWC	-	-
3.6 **Measured** (Item 3.5) - **Design** (Item 5.2 on National HVAC Design Report) total external static pressure = ____ IWC	-	-
3.7 Measured HVAC fan airflow, using Item 3.5 and fan speed setting: _____ CFM	-	-
3.8 Measured HVAC fan airflow (Item 3.7) is ± 15% of design HVAC fan airflow (Item 5.2 on National HVAC Design Report).	☐	-

4. Air Balancing of Supply Registers & Return Grilles (Recommended, but not Required) [6]	**Rater Verified**	**FT Agent Verified**	**N/A**
4.1 Balancing report attached with room-by-room design airflows from Item 5.2 on National HVAC Design Report, and contractor-measured airflow using ANSI / ACCA 5 QI-2015 protocol.	☐	☐	☐
4.2 Room-by-room airflows verified to be within the greater of ± 20% or 25 CFM of design airflow.	☐	☐	☐
5. Functional Testing: Indoor / Terminal Units - This section must be completed for all heating and cooling equipment located within dwelling units or common spaces, including systems identified in Sections 2 and 3, except where specifically noted. Indoor / terminal units include, but are not limited to, mini-splits, multi-splits, PTAC's, PTHP's, WLHP's, fan coils, and hydronic distribution systems. [5]	**Rater Verified**	**FT Agent Verified**	**N/A**
5.1 Installation Checks			
5.1.1 Zone thermostat (or remote zone temperature sensor) in dwelling units installed in design location, within the zone being served, and not on an exterior wall.	☐	☐	☐
5.2 Functional Testing			
5.2.1 Measured zone temperature is within 5°F of zone temperature displayed on thermostat or sensor.	☐	☐	☐
5.2.2 System turns on when there is a call for heat and heating is provided. System turns off when the heating setpoint has been met. [7] N/A due to ambient temperature ___ °F or equipment lock-out ☐ For forced air systems: Measured discharge air temperature ____ °F	☐	☐	☐
5.2.3 System turns on when there is a call for cooling and cooling is provided. System turns off when the cooling setpoint has been met. [7] N/A due to ambient temperature ___ °F or equipment lock-out ☐ For forced air systems: Measured discharge air temperature _____ °F	☐	☐	☐
5.2.4 Where OA dampers are installed, the damper closes when there is no call for ventilation or when fan is off.	☐	☐	☐
5.2.5 If more than one system provides heating or cooling to the same space, controls prevent simultaneous heating and cooling.	☐	☐	☐

6. Shared VRF Outdoor Units - This section must be completed for commercial-grade VRF outdoor units serving multiple dwelling units or common spaces.	**FT Agent Verified**	**N/A**
6.1 Installation Checks		
6.1.1 Pressure testing on refrigerant piping has been completed for this system. (indicate exact test in / test out pressure (psig) / time (hours)): _____/_____/_____	-	☐
6.1.2 Vacuum testing has been completed. (indicate exact test in / test out pressure (psig) / time (hours)): _____/_____/_____	-	☐
6.1.3 Refrigerant line lengths and height differences have been recorded from as-built shop drawings or field measured, and documentation of the measurement is available, if requested.	☐	☐
6.1.4 Indicate required additional charge amount (lbs): _____	-	☐

National HVAC Functional Testing Checklist [1]

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6.2 Functional Testing		
6.2.1 In cooling mode, the outdoor unit fan is ON and heat is being rejected. [7, 9] Measure and verify that outdoor unit fan discharge air temperature is warmer than the ambient air temperature. N/A due to ambient temperature ___ °F or equipment lock-out ☐	☐	☐
6.2.2 In heating mode, the outdoor unit fan is ON and heat is being absorbed. [7, 9] Measure and verify that outdoor unit fan discharge air temperature is colder than the ambient air temperature. N/A due to ambient temperature ___ °F or equipment lock-out ☐	☐	☐
6.2.3 Using the central maintenance tool or controller, none of the outdoor units or connected indoor units are showing an alarm.	☐	☐
6.2.4 Using the central maintenance tool, the manufacturer's representative confirmed refrigerant charge test per manufacturer's guidelines.	☐	☐
7. Boilers - This section must be completed for all commercial-grade space heating boilers serving multiple dwelling units.	**FT Agent Verified**	**N/A**
7.1 Installation Checks		
7.1.1 Piping pressure testing is completed, and all accessible boiler piping, fittings, and accessories are free from leaks.	☐	☐
7.1.2 Boiler relief valves and discharge piping do not show signs of weeping or leakage.	☐	☐
7.1.3 No signs of blockage, leakage, or deterioration in the fresh air intake or flue gas vent piping.	☐	☐
7.1.4 Temperature, pressure gauges, air eliminator, expansion tank, check valves and all other piping components installed as specified by HVAC Designer.	☐	☐
7.1.5 Boiler supply / header temperature sensor and, where applicable, outdoor air temperature sensor, are located as specified by HVAC Designer.	☐	☐
7.1.6 Indicate boiler header / supply setpoint type: ☐ Fixed ☐ Seasonal ☐ Outdoor temperature reset ☐ Indoor temperature reset ☐ Other: _____	-	☐
7.1.7 Where outdoor air temperature reset schedule is applicable, indicate reset schedule. (e.g., 180°F Supply @ 10°F outdoor, 120°F supply @ 55°F outdoor.) _____ @ _____ , _____ @ _____	-	☐
7.1.8 Where Warm Weather Shut Down (WWSD) is applicable, list temperature. (NA if boilers and system pumps also serve DHW.)	_____°F	☐
7.2 Functional Testing: Boilers [7] - N/A due to ambient temperature ___ °F or equipment lock-out ☐		☐
7.2.1 Measure the combustion gas efficiency at high fire and low fire for one of the boilers. Note which one and record information. [7] _____% ☐ high fire _____% ☐ low fire	-	☐
7.2.2 Where not direct-vented, boiler combustion air intake dampers open / close with boiler operation. [7]	☐	☐
7.2.3 If each boiler has its own dedicated boiler circulator pump, it operates only when the respective boiler is firing. [7] (Circulator pump may run for a short period of time before or after the boiler fires, as recommended by the equipment manufacturer.)	☐	☐
7.2.4 When there is a call for heating, the boiler(s) are enabled according to their design sequence of operation. [7]	☐	☐
7.2.5 When multiple boilers are supposed to operate at the same time, they operate according to the Engineer of Record's sequence of operation and the on / off sequencing is observed. [7]	☐	☐
7.2.6 Cycle the boilers on and off 1 time. Boiler(s) modulate / step down to the minimum firing rate before shutting off. [7]	☐	☐
7.2.7 Boiler(s) do not short cycle (i.e., the minimum on time is 5 minutes and the minimum off time is 5 minutes, or as recommended by the boiler manufacturer to prevent short cycling). [7]	☐	☐
7.2.8 Condensing Boiler: Return temperature enables condensing. [7] Design / OEM temp: _____°F Measured temp: _____°F	☐	☐
7.2.9 Boiler supply / header temperature sensor is reading within 3°F of measured boiler supply / header temperature. [7]	☐	☐
7.2.10 Boiler minimum flow rate and change in flow rate are maintained within the manufacturer's stated limits throughout the sequence of operation. [7, 8]	☐	☐
7.3 Functional Testing: Heating System Pumps		
7.3.1 Where heating system pumps (i.e., the pumps which are responsible for moving the water through the terminal units) are equipped with a VFD which is responding to a pressure sensor within the system or a sensorless pumping system, indicate which one: ☐ VFD+Sensor ☐ Sensorless	-	☐
7.3.2 If a variable speed pumping system is installed, the VFD increases and decreases pump speed in response to changes in the system.	☐	☐
7.3.3 If a variable speed pumping system is installed, system prevents "dead-heading". (May be tested under real or simulated low flow conditions.) Select the method of water flow bypass: ☐Minimum Flow Bypass Valve ☐ 3 way valves on specific terminal units ☐Other: _____	☐	☐
7.3.4 Pumps are off when outside air temperature is above WWSD. (N/A if pumps serve DHW as well as heating.)	☐	☐

National HVAC Functional Testing Checklist [1]

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8. Cooling Towers - This section must be completed for all cooling towers serving dwelling units or common spaces.	**FT Agent Verified**	**N/A**
8.1 Installation Checks		
8.1.1 Cooling Tower piping and all components are free from leaks.	☐	☐
8.1.2 Temperature gauges, check valves, tower bypass valve and all other piping components installed as specified by HVAC Designer.	☐	☐
8.1.3 Condenser Water Supply setpoint type: ☐ Fixed ☐Outdoor temperature reset ☐Seasonal / based on free cooling	-	☐
8.1.4 All control sensors (condenser water supply temperature, outdoor air humidity, etc.) are located as specified by HVAC Designer.	☐	☐
8.2 Functional Testing: Tower Fans [7] - N/A due to ambient temperature ___ °F or equipment lock-out ☐		☐
8.2.1 Tower fan(s) do not short cycle (i.e., the minimum on time is 5 minutes and the minimum off time is 5 minutes, or as recommended by the manufacturer to prevent short cycling). [7]	☐	☐
8.2.2 Cooling Tower fan(s) do not run unless associated cooling tower pump(s) are running. [7]	☐	☐
8.2.3 If installed, basin heater is not enabled when the basin water temperature is above the setpoint. [7]	☐	☐
8.2.4 Condenser Water Supply Sensor is reading within 3°F of measured temperature. [7]	☐	☐
8.3 Functional Testing: Cooling Tower Pumps		
8.3.1 Cycle the cooling tower pumps on and off 1 time. Cooling tower pumps only operate when controls call for operation. (N/A if tower pumps are set to run year round.) [7]	☐	☐
9. Chillers - This section must be completed for all chillers serving dwelling units or common spaces.	**FT Agent Verified**	**N/A**
9.1 Installation Checks		
9.1.1 Chiller piping and all components are free from leaks.	☐	☐
9.1.2 If multiple chillers, water flow is balanced across chillers using (indicate which one): ☐ Balancing valves ☐ Reverse return piping ☐ Individual chiller pumps ☐ Other: _____	-	☐
9.1.3 Temperature, pressure gauges, air eliminator, expansion tank, check valves and all other piping components installed as specified by HVAC Designer.	☐	☐
9.1.4 Chilled Water Supply temperature sensor (and outdoor air temperature sensor where applicable) are located as specified by HVAC Designer.	☐	☐
9.2 Functional Testing: Chillers [7] - N/A due to ambient temperature ___ °F or equipment lock-out ☐		☐
9.2.1 When there is a call for cooling, chillers are operating and maintaining chilled water setpoint. [7]	☐	☐
9.2.2 When multiple chillers are supposed to operate at the same time, they operate according to the Engineer of Record's sequence of operations and the on / off sequencing is observed. [7]	☐	☐
9.2.3 Chiller(s) do not short cycle (i.e., the minimum on time is 5 minutes and the minimum off time is 5 minutes, or as recommended by the chiller manufacturer to prevent short cycling). [7]	☐	☐
9.2.4 Chilled Water Supply Sensor is reading within 3°F of measured chiller temperature. [7]	☐	☐
9.2.5 Chiller minimum flow rate and change in flow rate are maintained within the manufacturer's stated limits throughout the sequence of operation. [7, 8]	☐	☐
9.3 Functional Testing: Chilled Water System Pumps		
9.3.1 Where Chilled Water System pumps (i.e., the pumps which are responsible for moving the chilled water through the terminal units) are equipped with a VFD, which is responding to a pressure sensor within the system or a sensorless VFD system, indicate which one: ☐ VFD+Sensor ☐ Sensorless	-	☐
9.3.2 If a variable speed pumping system is installed, confirm that the VFD increases and decreases pump speed in response to changes in the system.	☐	☐
9.3.3 If a variable speed pumping system is installed, system prevents "dead-heading". (May be tested under real or simulated low flow conditions.) Select the method of water flow bypass: ☐Minimum Flow Bypass Valve ☐ 3 way valves on specific terminal units ☐Other: _____	☐	☐
9.3.4 Pumps are off when cooling is not required. (N/A if chilled water is required year round.)	☐	☐

FT Agent Name: _____ Date: _____

FT Agent Signature: _____ Company Name: _____

Rater Name (if applicable): _____ Date: _____

Rater Signature: _____ Company Name: _____

National HVAC Functional Testing Checklist [1]

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Footnotes:

1. This Checklist is designed to align with the requirements of ANSI / ACCA's 5 QI-2015 protocol, thereby improving the performance of HVAC equipment in new multifamily buildings when compared to new multifamily buildings built to minimum code. However, these features alone cannot prevent all ventilation, indoor air quality, and HVAC problems (e.g., those caused by a lack of maintenance or occupant behavior). Therefore, this Checklist is not a guarantee of proper ventilation, indoor air quality, or HVAC performance.

   The checklist may be completed and signed by a Rater, rather than a Functional Testing Agent, if only Sections 1, 4 and 5 are applicable. A Rater completing Section 5 or Item 4.2 for a system that is also being verified by a Functional Testing Agent, may sign the same checklist as the FT Agent. For units following Track A, a Functional Testing Agent is not needed to complete Sections 2 and 3 for unitary HVAC systems serving dwelling units that will be verified and graded by the Rater. Track A – Dwelling Unit HVAC Grading shall not be used until an implementation schedule has been defined for ANSI / RESNET / ACCA Std. 310 by the Home Certification Organization (HCO) or Multifamily Review Organization (MRO) that the building is being certified under. Track A – Dwelling Unit HVAC Grading shall then use ANSI / RESNET / ACCA Std. 310 including all Addenda and Normative Appendices, with new versions and Addenda implemented according to the schedule defined by the HCO or MRO that the building is being certified under.

   Sections 2, 3, and 4 of this Checklist generally apply to split air conditioners, unitary air conditioners, air-source heat pumps, and water-source (i.e., geothermal or water-loop) heat pumps up to 65 kBtuh with forced-air distribution systems (i.e., ducts) and to furnaces up to 225 kBtuh with forced-air distribution systems (i.e., ducts). See specific sections for exemptions. If exempted, a Rater may complete those sections as N/A.

   Where the term 'dwelling unit' is used in this Checklist, the requirement is also required of 'sleeping' units. The term 'sleeping unit' refers to a room or space in which people sleep, which can also include permanent provisions for living, eating, and either sanitation or kitchen facilities but not both.

   The term 'common space' refers to any spaces in the building being certified that serve a function in support of the residential part of the building that is not part of a dwelling or sleeping unit. This includes spaces used by residents, such as corridors, stairs, lobbies, laundry rooms, exercise rooms, residential recreation rooms, and dining halls, as well as offices or other spaces used by building management, administration or maintenance in support of the residents.

2. An explanation of the credentialing process and links to H-QUITOs, which maintain lists of credentialed contractors, can be found at www.energystar.gov/findhvac. FT Agents may not be the installing contractor, nor employed by the same company as the installing contractor, unless they are a credentialed contractor. All FT Agents that are not credentialed contractors must sign up online in EPA's online database as an FT Agent and watch the online FT Agent orientation. See www.energystar.gov/ftas.

3. The term 'Rater' refers to the person(s) completing the third-party verification required for certification. The person(s) shall: a) be a Certified Rater, Approved Inspector, as defined by ANSI / RESNET / IECC Standard 301, or an equivalent designation as determined by an HCO or MRO; and, b) have attended and successfully completed an EPA-recognized training class. See www.energystar.gov/mftraining.

4. Either factory-installed or field-installed TXV's may be used. For field-installed TXV's, ensure that sensing bulbs are insulated and tightly clamped to the vapor line with good linear thermal contact at the recommended orientation, usually 4 or 8 o'clock.

5. The term "mini-split" refers to air conditioners and heat pumps that have variable refrigerant flow and distributed refrigerant technology with a single outdoor section serving a single indoor section. The indoor section is typically, but not exclusively, mounted on room walls and/or ceilings and designed to heat or cool air within the conditioned space either directly or through limited duct runs. The term "multi-split" refers to air conditioners and heat pumps that have variable refrigerant flow and distributed refrigerant technology with the capability of serving multiple indoor sections with a single outdoor section. The indoor sections are typically, but not exclusively, mounted on room walls and/or ceilings and designed to heat or cool air within the conditioned space either directly or through a ducted system. A single outdoor section can serve one or more dwelling units. The length of the duct system is not a determinant for meeting either of these definitions. Systems where total supply duct length of the entire system, including the sum of all supply trunks and branches, is 10 ft or less, may complete Item 4.2 in lieu of Section 3.

6. Air balancing of supply registers and return grilles is highly recommended to improve the performance of the HVAC system and comfort of the occupants, but is not required at this time for certification. When air balancing is completed, balancing dampers or proper duct sizing shall be used instead of looped or coiled ductwork to limit flow to diffusers. When balancing dampers are used, they shall be located at the trunk to limit noise unless the trunk will not be accessible when the balancing process is conducted. In such cases, Opposable Blade Dampers (OBD) or dampers located in the duct boot are permitted to be used.

7. For seasonally dependent testing: Where temperature lock-outs or equipment safety lock-outs prevent systems from operating in the specified mode during functional testing, "N/A" may be checked. The builder or developer must then provide signed documentation acknowledging that components of the Functional Testing were not completed due to temperature lock-outs or equipment safety lock-outs.

8. This test can be marked "Verified" if the boiler or chiller does not shut off on low water or high temperature during sequence testing. Direct water flow measurements can be taken throughout testing but are not required.

9. When manually testing outdoor unit heating or cooling mode of operation, at least 25% of associated indoor / terminal units connected to the outdoor unit(s) shall be controlled to the same heating or cooling mode being tested. The FT Agent shall increase the number of indoor / terminal units as needed in order to verify the discharge temperature is warmer / colder than ambient.