betterbricks/

Very High Efficiency Dedicated Outside Air System:

Equipment and Design Best Practices for Optimal Energy Efficiency

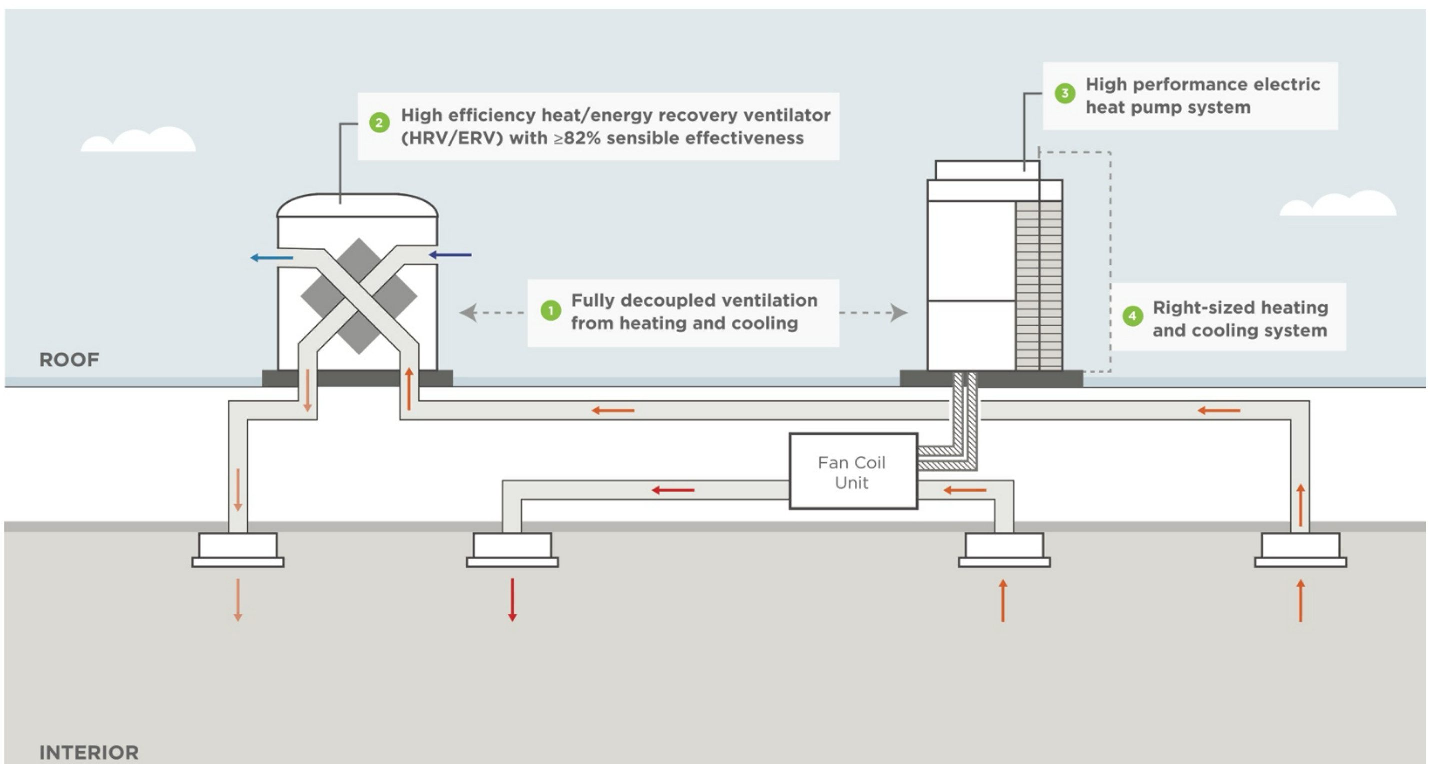
SYSTEM REQUIREMENTS | ADDITIONAL DESIGN RECOMMENDATIONS | HRV/ERV REQUIREMENTS & PRODUCTS | HEATING/COOLING EFFICIENCY REQUIREMENTS

Introduction

The following system definition and design recommendations provide guidance to manufacturers, designers and specifiers regarding the key components of a very high efficiency dedicated outside air system (or very high efficiency DOAS). Developed and refined over several years of research, market analysis, and demonstration project installations, this system approach improves indoor-air quality and occupant comfort, and decreases energy use, compared to a conventional rooftop packaged HVAC system.

For more information, including research findings and case studies, visit: betterbricks.com/solutions/very-high-efficiency-dedicated-outside-air-systems.

[Figure 1: Diagram featuring the key components of very high efficiency DOAS]



Disclaimer: This document, along with the equipment list and any guidance and recommendations included herein, are intended to assist the recipient in evaluating energy efficient HVAC system options; it should not be used in place of professional design or engineering services. Moreover, this document and its contents are provided "as is" without any warranty or representation regarding quality, accuracy, non-infringement, or usefulness. Under no circumstances are NEEA or NEEA's funders liable for any direct, indirect, special, incidental, consequential or other damages.

[REVISED SEPTEMBER 2024]

SYSTEM REQUIREMENTS

The following System Requirements detail the key components of systems that qualify as very high efficiency DOAS.

1) Decoupled Ventilation Design

Minimum Requirement: Ventilation and heating/cooling system fans must be controlled separately[1].

- Ventilation air from the HRV/ERV unit is supplied to each occupied space, either directly through a dedicated supply outlet or through heating/cooling ductwork when the ventilation supply air is delivered downstream of the terminal heating/cooling coils.

Best Practice: Fully decoupled system design

- Ventilation air is delivered directly to each occupied space. Separate ventilation supply outlets are provided for all spaces, as well as either a ducted return or a non-ducted return path with the free area sized so that air velocity does not exceed 300 FPM. Note that a plenum return is acceptable.
- Except where site conditions limit or restrict this approach, ventilation supply air outlet and exhaust/return grille should be at least half the length of the space to avoid short-circuiting.

2) High Efficiency Heat/Energy Recovery Ventilator (HRV/ERV)

- Prescriptive Requirements Path: Equipment listed on the Compliant Products List (CPL)*

OR

- Design Requirements Path: Demonstrate compliance with Design Requirements column of *HRV/ERV Minimum Requirements Table* in Appendix A with equipment selected at design conditions using AHRI 1060 certified software with HRV/ERV sensible effectiveness ≥ 82%*

*See *HRV/ERV Minimum Requirements Table* in Appendix A for detailed CPL requirements and current qualified equipment.

3) High-Performance Electric Heating/Cooling Equipment

Allowable Heating/Cooling Equipment Types
Multi-zone or single zone air-source split system heat pump (i.e., mini-split or ducted/ductless multi-zone), VRF air-source heat pump, air-to-water heat pump or heat pump chiller,[2] ground-source or ground-water source heat pumps.

Exception: Water-source heat pumps (WSHP) admissible only if new compliant HRV/ERV is installed. Any existing WSHP or central plant equipment may remain (including gas and electric boilers). Any new/replacement WSHP or central plant equipment must meet Table B1. New electric or fuel-fired boilers are not allowed.

Exception: Multi-family and lodging buildings may use the following alternate heating sources:

- Packaged terminal heat pumps that meet minimum efficiency requirements in Appendix B.
- Electric resistance heat in PHIUS certified buildings in spaces where no cooling is provided.

Exception for non-primary heating equipment:

- Semi-heated, unoccupied space: an enclosed space within a building that is heated by a heating system whose output capacity is less than 8 Btu/h-ft^2 of floor area and is not typically occupied (i.e. utility rooms, stairwells with fire risers, etc.) may be heated using an alternate equipment type (electric resistance, gas, etc.) controlled to a space temperature setpoint of 50°F or lower. All spaces heated by a heating system whose output capacity is greater than or equal to 8 Btu/h-ft^2 of floor area must meet the minimum system efficiency requirements of Appendix B.
- Secondary/backup heating equipment: heating equipment designed and controlled to come on only when outside air temperature falls below the ASHRAE 99.6% heating dry-bulb temperature for the location of the building may deviate from *allowable heating/cooling equipment types*.

Heating/Cooling System Efficiency
Heating/cooling equipment must meet minimum efficiency requirements as defined in the *Heating/Cooling Equipment Minimum Efficiency Requirements* detailed in Appendix B.

4) Right-Sized Heating/Cooling

Minimum Requirement: Right-sized heating/cooling system is supported by load calculations and uses no greater than 20% safety factors.

Best Practice: A right-sized heating/cooling system is supported by load calculations and uses no greater than 10% safety factors.

---

[1] *Exception: Systems using active chilled beams.*

[2] *Air-to-water heat pump may be used with various downstream terminal units. Terminal unit options may include chilled beams, 4-pipe fan coil units with ECM fan motors, or radiant heating/cooling systems.*

[BACK TO TOP]

[REVISED SEPTEMBER 2024]

ADDITIONAL DESIGN RECOMMENDATIONS

When fully implemented, the following additional design recommendations yield a best-in-class HVAC system. Designers are encouraged to consider whether each design recommendation below is beneficial to a given project and implement as appropriate.

HRV/ERV Design

HRV/ERV Ductwork Design	Added Value
Consider slightly oversizing ventilation supply and return ductwork. Doing so allows for periodic increases in ventilation supply air. Increasing ventilation air allows for more effective free cooling during night purges, and can be beneficial in a variety of circumstance, including temporary spikes in occupancy or in planning for future expansion. Larger ductwork also results in lower system static pressure to reduce the system's overall fan power. Best practices for minimizing DOAS fan power include incorporating localized ventilation units and sizing ventilation ductwork to no more than 0.08 inches water gauge pressure loss per 100 feet of straight duct.	As demonstrated by a recent study,[3] increased ventilation flexibility is a very effective way of mitigating the risk of viral transmission in buildings, which can be achieved with a relatively small upfront cost of increased ductwork sizing. Additionally, energy modeling shows that reducing system fan power by 54% can yield up to 17% annual HVAC energy savings in climate zone 4C.

Variable Speed HRV/ERV Fan Controls	Added Value
HRV/ERV should include variable speed fans, with inputs capable of controlling fan speed based on time-of-day scheduling, and inputs for CO_2 and duct static pressure at a minimum.[4]	Variable fans allow for more efficient fan operation, easier startup and commissioning, and allows for varying ventilation levels when appropriate.

Defrost Control Method	Added Value
Electric resistance pre-heat with modulating (SCR) control or wheel modulation are recommended defrost control methods. Other methods, such as Timed Exhaust, are not recommended as a best practice because desired ventilation is interrupted.	Defrost methods that provide uninterrupted ventilation ensure adequate ventilation without sacrificing thermal comfort or indoor air quality, even in cold conditions.

Heat Recovery Bypass Control Capabilities	Added Value
Include through use of variable damper control or wheel speed control.[5]	Heat recovery bypass allows for free cooling or night purges to offset mechanical cooling when outside air temperature is suitable.

Filters	Added Value
MERV 13 filters on outside air intake and MERV 8 filters on exhaust/return airstreams prior to the heat exchange medium.	Improved filtering capabilities can help to optimize indoor air quality by reducing infiltration of outdoor air contaminates such as pollen, smoke, and other pollutants.

HRV/ERV Supplemental Heating/Cooling	Added Value
In marine climates, consider excluding supplemental heating/cooling in the ventilation unit. Case studies have shown that this system design's required sensible effectiveness allows for comfortable ventilation supply air temperatures without additional tempering.	Eliminating supplemental heating/cooling reduces the upfront cost and control complexity of the HRV/ERV unit. This increases the cost-effectiveness of the entire system.

[3] *COVID-19 Risk Reduction Strategies and HVAC System Energy Impact,* Northwest Energy Efficiency Alliance, et. al., https://betterbricks.com/resources/covid-19-hvac-risk-reduction-strategies.

[4] Input for CO_2 and duct static pressure may be accomplished with integral sensors, auxiliary third-party sensors, or capability to receive 0-10 mV (or similar) signal from BMS, and respond accordingly.

[5] Heat recovery bypass control allows for variable operation that avoids heat exchange when desirable.

HRV/ERV Sizing	Added Value
Consider selecting HRV/ERV units at 30% below peak airflow capacity to allow for increased airflow during high-occupancy periods and future increased occupancy.	Allows for increasing ventilation levels when deemed appropriate, such as during pandemic operation, for night purge cycles, or during periods of high occupancy. Oversizing the HRV/ERV also increases energy recovery effectiveness and improves fan efficacy.

Outdoor Installation	Added Value
Outdoor HRV/ERV units should include casing insulation ≥ R-8 and gasketed seams and doors.	Minimizes casing heat loss in DOAS equipment installed outdoors.

Heating/Cooling System Design

Heating/Cooling System Fan Operation	Added Value
Cycle heating/cooling system fans off when there is no call for heating or cooling.[6]	Cycling fans reduces energy consumption when the space is not being heated or cooled.

Integral Refrigerant System Heat Recovery	Added Value
Analysis of past projects show that integral refrigerant heat recovery is often not cost-effective. Designers are encouraged to be aware of this tendency when selecting a variable refrigerant flow (VRF) system and carefully consider zoning plans (e.g., core or perimeter) to ensure effective use of the VRF's heat recovery feature.	Evaluating whether VRF refrigerant heat recovery is necessary and omitting when possible will help ensure the cost-effectiveness of the HVAC system.

Heating/Cooling System Sizing	Added Value
When using the very high efficiency DOAS approach, typical HVAC system sizing estimates are no longer feasible. Case studies have shown that typical sizing estimates don't account for the high efficiency heat recovery of the HRV/ERV, and therefore result in grossly oversized heating/cooling systems. These case studies have also demonstrated that the following sizing guidelines are achievable for typical office buildings in the Northwest region: ○ Climate Zone 4C: no less than 750 sq.ft./ton of system cooling capacity. ○ Climate Zone 5 & 6: no less than 600 sq. ft./ton of system cooling capacity.	Careful right-sizing of the heating/cooling system that accounts for the high efficiency heat recovery allows heating/cooling equipment to cycle less frequently and improves the first cost of the overall system.

Construction/Installation

Commissioning	Added Value
The commissioning agent should functionally test equipment installation, all dynamic control components and associated sequences of operation. The commissioning agent should also observe and verify ventilation system air balancing and duct leak testing. They should then make their report available to the system operator and building owner.	Commissioning helps ensure that all components and the system as a whole operates as designed.

[6] Exception: Systems using active chilled beams or when space heating/cooling system fan power is less than 0.12 W/cfm.

HRV/ERV Ductwork Insulation and Sealing	Added Value
Insulation of ventilation ductwork should follow these guidelines: ◦ Tempered air ducts (HRV/ERV supply/return) installed exterior to the building: R-12. ◦ Tempered air ducts (HRV/ERV supply/return) installed in unconditioned spaces: R-8. ◦ Tempered air ducts (HRV/ERV supply/return) installed in conditioned spaces: none. ◦ Outside air (entering HRV/ERV) and exhaust air (leaving HRV/ERV) ducts installed in conditioned spaces: R-16. ◦ Consider sealing existing ductwork used as ventilation supply or return/exhaust to SMACNA Seal Class B standards where accessible, or if delivering greater than 500 CFM at design conditions. Then insulate ventilation supply and exhaust as per relevant code requirements for heating and cooling ductwork.	Duct insulation prevents condensation in conditioned spaces and energy losses in unconditioned spaces. Sealing contributes to indoor air quality by ensuring that adequate ventilation air is delivered to all spaces. *Informative note:* These insulation guidelines meet or exceed all applicable code requirements in the Pacific Northwest region, and are also intended to prevent condensation on outside air and exhaust ductwork in conditioned spaces.

Startup and Testing, Adjusting, Balancing (TAB)	Added Value
The manufacturer (or a manufacturer approved technician) should provide startup of HRV. Consider requiring TAB of the entire HVAC system (including ventilation system airflow verification), with the following TAB conditions: ◦ Air at each diffuser and heating/cooling system air handler tested and balanced to within +/- 10% (or 5 CFM, whichever is greater) at design flow.[7] ◦ HRV/ERV system airflow tested and balanced to within +/- 5% of design airflow at HRV unit.[8]	Ensures system is installed and operates as designed.

Other Considerations

Energy Modeling	Added Value
Conventional energy modeling practices may misrepresent very high efficiency DOAS energy performance. Most hourly simulation tools do not support explicit modeling of the system's components, making modeling workarounds necessary. Workarounds can include fan power adjustments, post-processing requirements and control system adjustments.	Energy models can be used to demonstrate life cycle savings associated with a very high efficiency DOAS System. These may allow for custom energy savings incentives outside of those offered through the VHE DOAS Program. Contact your local utility for details.

[7] *TAB technician should use a flow hood measuring accurately down to 10 cfm, for both supply and exhaust airflows in a typical ventilation system.*
[8] *This is accomplished using reliable duct traverse at HRV unit discharge, or the manufacturer's on-board control output values.*

[BACK TO TOP]

APPENDIX A:
HRV/ERV MINIMUM REQUIREMENTS AND COMPLIANT PRODUCTS

HRV/ERV equipment can meet Core VHE DOAS System Requirements in one of two ways. Equipment can satisfy the Prescriptive Requirements listed in the left column below, in which case they will be listed on the Compliant Products List (CPL) on the next page. Alternatively, equipment can be selected at project design conditions to meet all Design Requirements listed in the right column below.

Minimum Requirements

Table A1: Compliant Heat/Energy Recovery Ventilator (HRV/ERV)		
Prescriptive Requirements (i.e., CPL)	**- OR -**	**Design Requirements**
HRV/ERV thermal efficiency		
• Passive House Institute (PHI) certified, **OR** • Minimum 82% Sensible Effectiveness of heat exchanger (HX) according to AHRI 1060-2023 certified software when selected at AHRI 1060-2014 winter conditions[9] at 75% of *nominal airflow*. [10] [11]		• Minimum HRV heat exchange of 82% sensible effectiveness as selected using AHRI 1060-2023 certified software at winter and summer design temperatures and airflows.
ERVs meeting the above minimum sensible effectiveness are allowed and may be preferable in some designs to offset indoor humidity loads and decrease defrost energy requirements.		
HRV/ERV fan efficacy		
• PHI certified, **OR** • Minimum 1.3 cfm/watt at 0.5" w.g. external static pressure at 75% of nominal air flow.[12] Variable speed supply and exhaust fans are required.		• Minimum 1.3 cfm/watt at design operating conditions[13]. Variable speed supply and exhaust fans are required.
Cross-flow leakage/Exhaust Air Transfer Ratio (EATR): Less than 3%.		
• PHI certified; internal leakage must be <3%, **OR** • EATR must be less than 3% when selected at 100% of nominal airflow, at both 0 in w.g. and 0.5 in w.g. differential pressure using AHRI 1060-2023 certified software (or as verified by third party testing).		• AHRI 1060-2023 certified products, EATR must meet the specified requirement based on AHRI Certified Selection Software when selected at design airflows and external static pressures.
Minimum HRV/ERV Capabilities:		
• Compliant HRV/ERV, must have a compliant defrost control method option available. Compliant defrost control methods include electric resistance pre-heat with modulating (SCR) control or wheel modulation via VFD. A compliant defrost control method does not need to be the default/standard defrost control method for the HRV/ERV, BUT • When project design weather conditions require HRV/ERV defrost (i.e., Project Design winter dry-bulb temperature < temperature at which defrost typically begins to form on the wheel or core), the HRV/ERV specified for the project **must include** a compliant defrost control method. In these cases, defrost control **cannot be** any of the following prohibited methods: recirculation of return air, electric resistance without modulating control.		

[9] *AHRI 1060-2014 winter conditions: 35°F DBT, 33°F WBT (OA); 70°F DBT, 58°F WBT (RA) at 75% of manufacturer-identified nominal airflow. Supply and exhaust airflows shall equal within ±1.5% or 5 scfm, whichever is greater, in accordance with AHRI 1060-2014 requirements.*

[10] ***Nominal airflow** is defined by manufacturer for determination of product compliance with Prescriptive HRV/ERV Requirements (CPL Review) and should represent typical peak application airflow. Defined **nominal airflow** will be used to determine any applicable HRV/ERV program incentive.*

[11] *Independent third-party test results demonstrating sensible effectiveness when tested in accordance with the specified conditions (per ASHRAE Standard 84) is acceptable in lieu of AHRI 1060-2023 certified software results.*

[12] *Fan energy shall be measured using a certified test method, such as AMCA 210 or ISO 5801.*

[13] *Fan efficacy shall be determined by the following equation at design operating conditions:* $\frac{Supply\ Fan\ CFM}{Total\ Fan\ Power\ (Supply\ Fan\ Watts + Exhaust\ Fan\ Watts)}$, *with total fan power rated per AMCA 210/211 test standards.*

[BACK TO TOP]

Compliant Products

The following HRV/ERV equipment is compliant with the prescriptive requirements path in table A1: Minimum Requirements above. Models listed do not indicate compliance with comprehensive very high efficiency DOAS requirements.

Table A2: HRV/ERV Compliant Products[5]

Manufacturer	Model #	HRV/ERV	Nominal CFM
Greenheck	ERV-10-20H-VG	ERV	667
Greenheck	ERV-20-15L	ERV	1434
Greenheck	ERVe-20-15L	ERV	1434
Greenheck	ERV-20-30L[1]	ERV	1734
Greenheck	ERVe-20-30L[1]	ERV	1734
Greenheck	ERVe-35-30L[1]	ERV	2600
Greenheck	ERV-45-15H	ERV	2600
Greenheck	ERV-45-15L	ERV	3034
Greenheck	ERV-45-30L[1]	ERV	3700
Greenheck	ERVe-45-30L[1]	ERV	3700
Greenheck	ERV-90-15L	ERV	6000
Greenheck	ERV-90-30L[1]	ERV	7400
Oxygen8	Ventum H05	HRV	600
Oxygen8	Ventum H10	HRV	1000
Oxygen8	Ventum H15	HRV	1150
Oxygen8	Ventum H20	HRV	1530
Oxygen8	Ventum H25	HRV	2250
Oxygen8	Ventum H30	HRV	3000
Oxygen8	Ventum H10	ERV	1000
Oxygen8	Ventum H15	ERV	1350
Oxygen8	Ventum H20	ERV	1800
Oxygen8	Ventum H30	ERV	3000
Oxygen8	Ventum Lite H04[4]	HRV	3000
Oxygen8	Ventum+ V20	HRV	1800
Oxygen8	Ventum+ V25	HRV	2400
Oxygen8	Ventum+ V30	HRV	3200
Oxygen8	Ventum+ V40	HRV	4000
Oxygen8	Ventum+ V20	ERV	1800
Oxygen8	Ventum+ V25	ERV	2400
Oxygen8	Ventum+ V30	ERV	3200
Oxygen8	Ventum+ V40	ERV	4000
Oxygen8	Ventum+ V50	ERV	4800
Oxygen8	Ventum+ V60	ERV	6400
Oxygen8	Ventum+ V80	ERV	8000
Oxygen8	Ventum+ V100	ERV	10000
RenewAire	HE07	ERV	233
RenewAire	HE10[6]	ERV	350
RenewAire	HE1.5	ERV	520
SEMCO	EP-03[1]	ERV	1700
SEMCO	EP-05[1]	ERV	3000
SEMCO	EP-09[1]	ERV	5100
SEMCO	EP-13[1]	ERV	7900
SEMCO	EP-18[1]	ERV	10900

Table A2: HRV/ERV Compliant Products[5]

Manufacturer	Model #	HRV/ERV	Nominal CFM
SEMCO	EP-24[1]	ERV	14300
SEMCO	EP-28[1]	ERV	17000
SEMCO	EP-35[1]	ERV	21100
SEMCO	EP-43[1]	ERV	25700
SEMCO	EP-46[1]	ERV	28000
SEMCO	EP-56[1]	ERV	33600
SEMCO	EP-70[1]	ERV	42200
Swegon	Gold RX 05	HRV	840
Swegon	Gold RX 07	HRV	1430
Swegon	Gold RX 08	HRV	1530
Swegon	Gold RX 11	HRV	2200
Swegon	Gold RX 12	HRV	2370
Swegon	Gold RX 14	HRV	3530
Swegon	Gold RX 20	HRV	3570
Swegon	Gold RX 25	HRV	4730
Swegon	Gold RX 30	HRV	4730
Swegon	Gold RX 35	HRV	7600
Swegon	Gold RX 50	HRV	10670
Swegon	Gold RX 05 MTE	ERV	840
Swegon	Gold RX 07 MTE	ERV	1430
Swegon	Gold RX 08 MTE	ERV	1530
Swegon	Gold RX 11 MTE	ERV	2200
Swegon	Gold RX 12 MTE	ERV	2370
Swegon	Gold RX 14 MTE	ERV	3530
Swegon	Gold RX 20 MTE	ERV	3570
Swegon	Gold RX 25 MTE	ERV	4730
Swegon	Gold RX 30 MTE	ERV	4730
Swegon	Gold RX 35 MTE	ERV	7600
Swegon	Gold RX 40 MTE	ERV	7870
Swegon	Gold RX 50 MTE	ERV	10670
Swegon	Gold RX 60 MTE	ERV	10710
Swegon	Gold RX 70 MTE	ERV	14400
Swegon	Gold RX 80 MTE	ERV	14670
Swegon	Gold RX 05 STE	ERV	1300
Swegon	Gold RX 07 STE	ERV	1500
Swegon	Gold RX 08 STE	ERV	2000
Swegon	Gold RX 11 STE	ERV	2300
Swegon	Gold RX 12 STE	ERV	2850
Swegon	Gold RX 14 STE	ERV	3150
Swegon	Gold RX 20 STE	ERV	4200
Swegon	Gold RX 25 STE	ERV	4750
Swegon	Gold RX 30 STE	ERV	5800
Swegon	Gold RX 35 STE	ERV	7000

Table A2: HRV/ERV Compliant Products[5]			
Manufacturer	***Model #***	***HRV/ERV***	***Nominal CFM***
Swegon	Gold RX 50 STE	ERV	9700
Swegon	Gold RX 70 STE	ERV	15800
Swegon	CASA R5	HRV	250
Swegon	CASA R7	HRV	460
Swegon	CASA R9	HRV	510
Swegon	CASA R5	ERV	310
Swegon	CASA R7	ERV	450
Swegon	CASA R9	ERV	850
Tempeff	RG 1000[3]	HRV	1000
Tempeff	RG 1500[3]	HRV	1500
Tempeff	RG 2000[3]	HRV	2000
Tempeff	RG 3000[3]	HRV	3000
Tempeff	RG 4000[3]	HRV	4000
Tempeff	RG 5500[3]	HRV	5500
Tempeff	RG 6500[3]	HRV	6500
Tempeff	RGL 1000[3]	HRV	1000
Tempeff	RGL 1500[3]	HRV	1500
Tempeff	RGL 2000[3]	HRV	2000
Tempeff	RGL 3000[3]	HRV	3000
Tempeff	RGL 4000[3]	HRV	4000
Tempeff	RGL 5500[3]	HRV	5500
Tempeff	RGL 6500[3]	HRV	6500
Valent	ERW-E2-20H	ERV	667
Valent	ERW-E2-30L[1]	ERV	1734
Valent	ERW-E3-30L[1]	ERV	2600
Valent	ERW-E4-30L[1]	ERV	3700
Ventacity	VS1000 RTh	HRV	1000
Ventacity	VS1000 RTe	ERV	1000
Ventacity	VS3000 RTh	HRV	3000
Ventacity	VS3000 RTe	ERV	3000
Ventacity	VS1200CMh	HRV	1200
Ventacity	VS900CMh	HRV	900
Ventacity	VS400CMh	HRV	400
Ventacity	VS250CMh	HRV	250
Ventacity	VS500SQh	HRV	500

Compliance Notes

[1] Compliant unit must include energy recovery purge section to minimize exhaust air leakage. Unit must be selected to operate at greater than 0 in. wg. differential pressure between outside air and exhaust air pathways.
[2] HRV/ERV units less than 300 CFM are not listed on the CPL unless they are part of a larger compliant product family.
[3] Compliant unit must be mounted outdoors and without exhaust ductwork to meet crossflow leakage requirement.
[4] Unit requires Central DDC for defrost control and the defrost activation should be controlled via differential pressure sensor or exhaust air temperature.
[5] When project design weather conditions require HRV/ERV defrost (i.e., Project Design winter dry-bulb temperature < temperature at which defrost typically begins to form on the wheel or core), the HRV/ERV specified for the project must include a compliant defrost control method. In these cases, defrost control cannot be any of the following prohibited methods: timed exhaust, recirculation of return air, electric resistance without modulating control.
[6] Product may not be installed with the 460V/3 phase advanced EC direct drive fan.

[BACK TO TOP]

[REVISED SEPTEMBER 2024]

APPENDIX B:
HEATING/COOLING EQUIPMENT MINIMUM EFFICIENCY REQUIREMENTS

Heating/cooling equipment used in VHE DOAS compliant projects shall meet the minimum heating and cooling efficiency requirements shown in Table B1 below.

Table B1: Allowable Heating/Cooling Equipment and minimum efficiency requirements

Heating/Cooling Equipment	***Minimum Heating Efficiency***	***Minimum Cooling Efficiency***	***Efficiency Reference***	***Notes***
Mini-split or ductless multi-zone heat pump (<65 kBtu/hr.)	9.5 HSPF, or 8.1 HSPF2	16 SEER, or 15.2 SEER2	ENERGY STAR Light Commercial HVAC V4.0	HSFP2 and SEER2 are mandatory for equipment purchased after January 1, 2023[14].
Air-source VRF (≥65 kBtu/hr. and <135 kBtu/hr.)	3.4 COP (47°F) 2.25 COP (17°F)	18.9 IEER	ENERGY STAR Light Commercial HVAC V4.0	Applies to both ducted and non-ducted systems and to systems with and without integral refrigerant heat recovery.
Air-source VRF (≥135 kBtu/hr. and <240 kBtu/hr.)	3.25 COP (47°F) 2.07 COP (17°F)	18.0 IEER	ENERGY STAR Light Commercial HVAC V4.0	Applies to both ducted and non-ducted systems, and to systems with and without integral refrigerant heat recovery.
Air-source VRF (≥240 kBtu/hr.)	3.2 COP (47°F) 2.05 COP (17°F)	17.0 IEER	NEEP ccASHP Specification	Applies to both ducted and non-ducted systems, and to systems with and without integral refrigerant heat recovery.
Ground-source heat pump	3.6 COP[16] at 32°F EWT	17.1 EER[17] at 77°F EWT	ENERGY STAR Geothermal Heat Pumps V3.2	Closed loop water-to-air, tested in accordance with ISO 13256-1-1998.
Groundwater-source heat pump	4.1 COP[16] at 50°F EWT	21.1 EER[17] at 59°F EWT	ENERGY STAR Geothermal Heat Pumps V3.2	Open loop water-to-air, tested in accordance with ISO 13256-1-1998.
Water Source Heat Pump	4.8 COP[16] at 68°F EWT	15.0 EER[17] at 86°F EWT	Highest third of AHRI-rated products	Closed loop water-to-air, tested in accordance with ISO 13256-1. Applies to new/replacement units in existing WSHP systems only.
Air-source Heat recovery or heat pump chiller (Air-Water Heat Pump)	3.29 COP	9.2 EER 15.3 IPLV	ASHRAE 90.1	COP @ 47°F dry bulb and LWT of 105°F EER and IPLV rated per AHRI 550/590
Packaged Terminal Heat Pump (<9100 Btu/hr.)[18]	3.6 COP	13 EER	DOE ZEH Program	COP and EER rated per AHRI 310/380. Allowed in multi-family and lodging occupancies only.
Packaged Terminal Heat Pump (9100 Btu/hr. to 10800 Btu/hr.)[18]	3.5 COP	12 EER	DOE ZEH Program	COP and EER rated per AHRI 310/380. Allowed in multi-family and lodging occupancies only.

[14] HSPF2 and SEER2 are determined in accordance with 10 CFR 430 Appendix M1. Appendix M1 of 10 CFR 430 test procedure and ratings, as issued by the U.S. Department of Energy (82 FR 1426, January 2017) are mandatory for equipment purchased after January 1, 2023.
[16] Multi-stage models qualify using the following calculation: EER = (highest rated capacity EER + lowest rated capacity EER) / 2
[17] Multi-stage models qualify using the following calculation: COP = (highest rated capacity COP + lowest rated capacity COP) / 2
[18] Packaged Terminal Heat Pump performance shall be tested and certified to AHRI Standard 310/380 or AHRI 390. Minimum efficiency levels established using DOE Zero Energy Home Guideline as reference.

Table B1: Allowable Heating/Cooling Equipment and minimum efficiency requirements				
Heating/Cooling Equipment	***Minimum Heating Efficiency***	***Minimum Cooling Efficiency***	***Efficiency Reference***	***Notes***
Packaged Terminal Heat Pump (10801 Btu/hr. to 12600 Btu/hr.)[18]	3.4 COP	11.6 EER	DOE ZEH Program	COP and EER rated per AHRI 310/380. Allowed in multi-family and lodging occupancies only.
Packaged Terminal Heat Pump (>12600 Btu/hr.)[18]	3.3 COP	10.4 EER	DOE ZEH Program	COP and EER rated per AHRI 310/380. Allowed in multi-family and lodging occupancies only.
Electric resistance heat	1.0 COP	Not allowed	N/A	Allowed only in PHIUS certified buildings in spaces with no cooling, or in designated semi-heated spaces (per Table 1)