

AHRI Guideline W (I-P)

**2014 Guideline for
Selecting, Sizing, & Specifying
Packaged Air-to-Air Energy
Recovery Ventilation Equipment**



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2111 Wilson Boulevard, Suite 500
Arlington, VA 22201, USA
www.ahrinet.org
PH 703.524.8800
FX 703.562.1942

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Note:

This guideline supersedes AHRI Guideline W-2005.
For SI, see AHRI Guideline W (SI)-2014.

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SELECTING, SIZING, & SPECIFYING PACKAGED AIR-TO-AIR ENERGY RECOVERY VENTILATION EQUIPMENT

Section 1. Purpose

1.1 *Purpose.* The purpose of this guideline is to provide information to support the application of Air-to-Air Energy Recovery Ventilation Equipment (AAERVE). This guideline supports AAERVE that is manufactured using Air-to-Air Heat Exchangers (energy recovery components) rated in accordance with AHRI Standard 1060 (I-P). These energy recovery components include Heat Pipe Heat Exchangers, Plate Heat Exchangers, and Rotary Heat Exchangers.

1.1.1 *Intent.* This guideline is intended for the guidance of the industry, including architects, engineers, contractors, manufacturers, and end users.

1.1.2 *Review and Amendment.* This guideline is subject to review and amendment as the technology advances.

Section 2. Scope

2.1 *Scope.* This guideline applies only to AAERVE.

2.2 *Applications.* This guideline is intended to apply primarily to commercial and institutional applications.

2.3 *Exclusions.* This guideline does not apply to heat exchangers joined by circulated heat transfer medium (run-around loop). A run-around loop employs liquid-containing coils connected in a closed loop and placed in each of two or more airstreams.

Section 3. Definitions

All terms in this document will follow the standard industry definitions in the *ASHRAE Terminology* website (<https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology>) unless otherwise defined in this section.

3.1 *Air-to-Air Energy Recovery Ventilation Equipment (AAERVE).* Energy recovery components and packaged energy recovery ventilation units which employ Air-to-Air Heat Exchangers to recover energy from exhaust air for the purpose of pre-conditioning outdoor air prior to supplying the conditioned air to the space, either directly or as part of an air-conditioning (to include air heating, air cooling, air circulating, air cleaning, humidifying and dehumidifying) system.

3.2 *Air-to-Air Heat Exchanger.* A device that transfers heat from an exhaust airstream to a separated supply airstream. Air-to-Air Heat Exchangers are also referred to as energy recovery components.

3.2.1 *Heat Pipe Heat Exchanger.* A device employing tubes charged with a fluid for the purpose of transferring sensible energy from one airstream to another. Heat transfer takes place through the vaporization of the fluid exposed to the warmer airstream and condensation of the fluid in the cooler airstream.

3.2.2 *Plate Heat Exchanger.* A device for the purpose of transferring energy (sensible or total) from one airstream to another with no moving parts. This exchanger may incorporate parallel, cross or counter flow construction or a combination of these to achieve the energy transfer.

3.2.3 *Rotary Heat Exchanger.* A device incorporating a rotating cylinder or wheel for the purpose of transferring energy (sensible or total) from one airstream to the other. It incorporates heat transfer material, a drive mechanism, a casing or frame, and includes any seals, which are provided to retard the bypassing and leakage of air from one air stream to the other.

3.3 *Airflow.*

3.3.1 Entering Supply Airflow (OA). The supply airstream (outdoor air) before passing through the Exchanger, also referred to as outdoor air, indicated in Figure 1 as Station 1. Sometimes referred to as the outdoor Airflow.

3.3.2 Leaving Supply Airflow (SA). The supply airstream (outdoor air) after passing through the Exchanger, indicated in Figure 1 as Station 2. Sometimes referred to as the supply Airflow.

3.3.3 Entering Exhaust Airflow (RA). The exhaust airstream (indoor air) before passing through the Exchanger, indicated in Figure 1 as Station 3. Sometimes referred to as the return Airflow.

3.3.4 Leaving Exhaust Airflow (EA). The exhaust airstream (indoor air) after passing through the Exchanger, indicated in Figure 1 as Station 4. Sometimes referred to as the exhaust Airflow.

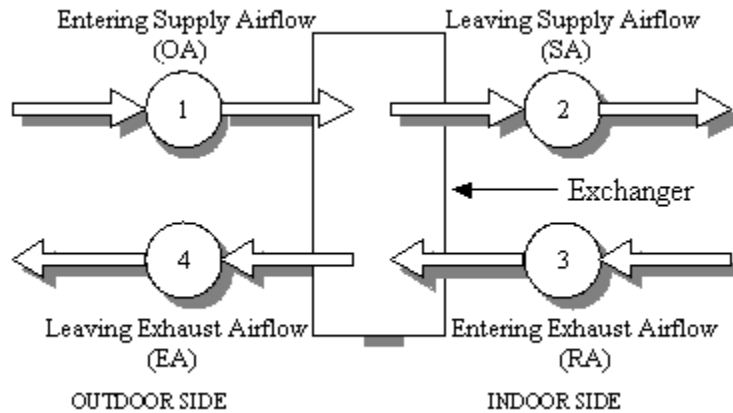


Figure 1. Scheme of Airflows for Exchangers

3.4 Economizer. A system of controls and dampers that introduces outside air to a space when the space requires cooling, and the heat of the outside air is lower than the heat of the space.

3.4.1 Sensible Only. A system that utilizes an outdoor air sensor that measures outdoor dry-bulb temperature only. If the space has a cooling requirement, outside air will be used if the outdoor dry-bulb temperature is less than or equal to the control setpoint.

3.4.2 Enthalpy. A system that utilizes an outdoor sensor that measures the total heat (both the sensible and latent) of the outside air. If the space has a cooling requirement, outside air will be used to cool the space if the total heat of the outside air is less than or equal to the control setpoint.

3.5 Effectiveness. A ratio of the actual energy transfer (sensible, latent, or total) to the product of the minimum energy capacity rate and the maximum difference in temperature, humidity ratio, or enthalpy (refer to AHRI Standard 1060 (I-P)).

3.6 Entering Air Conditions. The dry-bulb and wet-bulb temperature that is entering the space on a standalone system, or entering the air-conditioning system on integrated, standalone-coupled or unitized systems. These conditions typically replace the “outdoor air conditions” in most design load software programs. These are also referred to as the Tempered Outside Air conditions. On standalone systems these are also referred to as Supply Airflow conditions.

3.7 Exhaust Air Transfer Ratio (EATR). The tracer gas concentration difference between the Leaving Supply Airflow and the Entering Supply Airflow divided by the tracer gas concentration difference between the Entering Exhaust Airflow and the Entering Supply Airflow at the 100% rated Airflows, expressed as a percentage (refer to AHRI Standard 1060 (I-P)).

3.8 Net Building Load. The total calculated space conditioning energy required for a building including the impact of energy recovery. This is the total building load less the total energy recovered from the exhaust air. The Net Building Load may be calculated for both heating and cooling design conditions.

3.8.1 Example. Total building cooling load is 200 tons including outside air without the AAERVE. The AAERVE reduced the outdoor air load by 75 tons. The Net Building Load is 125 tons (200 tons -75 tons).

3.9 Net Effectiveness. The Effectiveness adjusted to account for that portion of the psychrometric change in the Leaving Supply Airflow that is the result of leakage of Entering Exhaust Airflow rather than exchange of heat or moisture between the airstreams. The derivation of Net Effectiveness is given in AHRI Standard 1060 (I-P) Appendix C.

3.10 Net Zone Load. The total space conditioning energy required for a particular Zone of a building including the impact of energy recovery. This is the Total Zone Load less the total energy recovered from the exhaust air for the Zone by the AAERVE. The Total Zone Load may be calculated for both cooling and heating design conditions.

3.10.1 Example. Total zone cooling load is 20 tons including outside air without the AAERVE. The AAERVE reduced the outdoor air load by 7.5 tons. The Net Zone Load is 12.5 tons (20 tons -7.5 tons).

3.11 Net Supply Airflow. That portion of the Leaving Supply Airflow that originated as Entering Supply Airflow. The Net Supply Airflow is determined by subtracting air transferred from the exhaust side of the heat exchanger from the gross airflow measured at the Supply Airflow leaving the heat exchanger as shown in AHRI Standard 1060 (I-P).

3.12 Outdoor Air Correction Factor (OACF). The ratio of the Entering Supply Airflow to the measured (gross) Leaving Supply Airflow.

3.13 Published Rating. A statement of the assigned values of those performance characteristics at stated Rating Conditions, by which a unit may be chosen for its application. These values apply to all AAERVE of like size and type (identification) produced by the same manufacturer. The term Published Rating includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated Rating Conditions.

3.13.1 Application Rating. A rating based on tests performed at application Rating Conditions (other than Standard Rating Conditions).

3.13.2 Standard Rating. A rating based on tests performed at Standard Rating Conditions as defined in AHRI Standard 1060 (I-P).

3.14 Purge. The removal of exhaust air that may be carried to the supply (intake) airstream by a Rotary Heat Exchanger. It is accomplished by shunting a portion of the supply air back into the exhaust air.

3.15 Rating Conditions. Any set of operating conditions under which a single level of performance results and which cause only that level of performance to occur.

3.15.1 Standard Rating Conditions. Rating conditions used as the basis for comparison for performance characteristics.

3.16 Should. “Should” is used to indicate provisions which are not mandatory but which are desirable as good practice.

3.17 Station. The location in the test apparatus at which conditions such as temperature, humidity, pressure, or Airflow are measured for each of the Airflows defined in Section 3.3 and shown in Figure 1. These locations are identified as “Station 1”, “Station 2”, “Station 3” and “Station 4”.

3.18 Tempered Outside Air. The leaving supply air from the Air-to-Air Heat Exchanger. The Tempered Outside Air conditions typically replace the “outdoor air conditions” in most design load software programs. This is also referred to as *Entering Air*.

3.19 Total Building Load. The total calculated space conditioning requirements for a building.

3.20 Total Zone Load. The total calculated space conditioning requirements for a specific Zone, including its interior heat sources and sinks (people, lights, computers, refrigerated cases, etc.), infiltration, outdoor air ventilation load, solar load, and orientation. The Total Zone Load may be calculated for both cooling and heating design conditions.

3.21 Zone. A space or group of spaces, within a building with heating, cooling, and ventilating requirements, that are sufficiently similar so that desired conditions (e.g., temperature) can be maintained throughout using a single sensor (e.g., thermostat or temperature sensor).

Section 4. Air-to-Air Energy Recovery Ventilation Equipment (AAERVE) Classifications

4.1 Integrated Systems.

4.1.1 Air-handling System. An integrated air-handling system has the air-handling unit manufactured with the Air-to-Air Heat Exchanger installed as part of the air handler. This system does not require a separate duct system because it utilizes the air-conditioning unit's duct system.

4.1.2 Packaged System. An integrated packaged system has the air-conditioning unit manufactured with the Air-to-Air Heat Exchanger component installed as part of the unit. This system does not require a separate duct system because it utilizes the air-conditioning unit's duct system.

4.2 Standalone System. A standalone system utilizes the AAERVE in a configuration that has a totally separate duct system (for the supply air and the exhaust air) from any other air-conditioning system in the building.

4.3 Standalone Coupled System. A standalone coupled system utilizes the AAERVE in a configuration that has part or all of the AAERVE air (supply or exhaust) ducted to the duct system of an air-conditioning system.

4.4 Unitized System. A unitized system has an AAERVE accessory attached directly to the air-conditioning equipment, typically in the field. This system does not require a separate duct system.

Section 5. Frost and Condensation

5.1 Frost Control. In cold climates, means of avoiding frost or removing frost from the Air-to-Air Heat Exchanger may be required.

5.1.1 Exhaust Only. When frost is indicated on the component, the intake blower is de-energized for a period of time to allow exhaust air to warm component, melt frost, and drain or evaporate condensate. Alternately, exhaust-only operation is determined based on outside air temperature to avoid frosting.

5.1.2 Preheat.

5.1.2.1 Outdoor Air Preheat. Heat is provided in the outdoor air intake to heat the air to a temperature above the Air-to-Air Heat Exchanger frost threshold before it enters the component.

5.1.2.2 Return Air Preheat. Heat is provided in the return air before it enters the Air-to-Air Heat Exchanger to prevent frost from forming.

5.1.3 Re-circulation.

5.1.3.1 Return Air Re-circulation. Return air is substituted, in whole or in part, for outside air passing through the Air-to-Air Heat Exchanger for defrost purposes.

5.1.3.2 Exhaust Air Re-circulation. Exhaust air leaving the Air-to-Air Heat Exchanger is substituted, in whole or in part, for outside air passing through the Air-to-Air Heat Exchanger for defrost purposes.

5.1.4 Modulated Effectiveness.

5.1.4.1 Bypass. A portion of the outdoor air is bypassed around the heat exchanger until the frost threshold is avoided.

5.1.4.2 Variable Speed. For Rotary Heat Exchangers the speed of rotation is slowed, reducing Effectiveness, until the frost threshold is avoided.

5.1.4.3 Tilt Mechanism. For Heat Pipe Heat Exchangers relying solely or in part on gravity for liquid refrigerant transport. The tilt angle is changed, reducing Effectiveness until the frosting threshold is avoided; or the tilt angle is reversed, effectively stopping heat transfer.

5.1.4.4 Cold Corner Damper or Traversing Defrost. For Plate Heat Exchangers, outdoor air is prevented from entering a portion of the Air-to-Air Heat Exchanger to enable the exhaust air energy to defrost that section of the component.

5.2 Condensation Removal. Means of removing condensate may be required. If so, observe applicable codes for piping and trapping of condensate drain(s).

Section 6. System Balancing

6.1 Equal and Unequal Air Flows. The amount of outside air and exhaust air required may be the result of the building design. Many facilities have exhaust air removed from a variety of sources, other than the AAERVE. In order to maintain a proper air balance in the building, this may result in the need to exhaust less air than the outdoor air requirement. In this case, Effectiveness will be increased by definition (because the percentage of energy extracted from the reduced exhaust airflow is increased), however, the conditions of the supply air will be less favorable and the performance of the building system will be affected (due to induced exfiltration without benefit of energy recovery). If the exhaust air is greater than the outdoor air intake, then Effectiveness would again be increased by definition; supply air conditions would improve, but again, building system performance would be affected (in this case due to induced infiltration without benefit of energy recovery).

6.1.1 Energy Impacts. Equal (balanced) Supply and Exhaust Airflows provide the maximum energy recovery for a given AAERVE. The system should be balanced as closely as possible as long as other conditions, such as requirements for building pressurization, are met.

6.1.2 Conditions Impact. Unequal airflows will influence the conditions of the supply air. Example: Reducing the Supply Airflow as compared to the exhaust will improve the supply air psychrometric conditions, but reduce the energy recovered from the exhaust air. On the other hand reducing the Exhaust Airflow as compared to the supply will degrade the supply air psychrometric conditions. Again, energy recovered will be reduced.

6.1.3 Variable Air Flow. On systems that vary total system airflow and/or outdoor air (demand control ventilation, variable air volume, etc.) provisions should be made to control both supply and exhaust airflows in concert. In no case should the airflows be lower than needed to provide the required outdoor air ventilation rate per ASHRAE standards or local codes.

6.1.4 Building or Zone Pressurization. Requirements for building or zone pressurization should be considered when designing and/or balancing the system. If building pressurization requirements would cause the AAERVE to be severely unbalanced, the designer should consider additional methods of building pressurization.

6.2 Balancing Methods. Provisions should be made for adjusting the airflows to required rates. The methods listed below can be used independently or in combination.

6.2.1 Dampers. Dampers may be used to balance airflows to the space to insure proper air distribution to individual Zones or connected air-handling equipment. Dampers may also be used to balance AAERVE Supply and Exhaust Airflows. However, controlling blower speed is a more energy efficient method of volume control than dampers.

6.2.2 Blower Settings. Methods such as multiple speed motors, adjustments in blower sheaves, etc., may be used to adjust airflows.

6.2.3 Variable Speed. Variable frequency drives, electronically commutated motors, and similar variable speed technologies may be used to adjust airflows.

6.2.4 Unitized. Operation of the main unitary blower can impact the AAERVE Supply and Exhaust Airflows. Methods should be provided to balance these flows and unitary airflow.

6.2.5 *Integrated.* Operation of the main unitary blower can impact the AAERVE Supply and Exhaust Airflows. Methods should be included to balance these flows.

6.2.6 *Measurement of Flows.* Methods should be provided to measure Exhaust and Supply Airflows for the purpose of balancing. Methods can include static pressure across the component, conventional velocity methods in the duct, or other airflow measuring devices.

6.2.7 *Outdoor Air Correction Factor (OACF).* Consider the impact of OACF to ensure that the correct amount of outside air is introduced to meet the ventilation requirements for the building. Example: If the outdoor air is being measured at the outside air inlet and the OACF = 1.1, the measured air volume should be 110% of the required (ventilation design) supply airflow. This will ensure that the specified level of outdoor air is being introduced into the building – after the OACF impact from the Air-to-Air Heat Exchanger.

Section 7. Economizer Operation

7.1 *Economizer Operation.* Some applications and standards/codes may require an air economizer be provided for the air-conditioning system. In these cases, provisions should be made to bypass or control the energy recovery system to permit air economizer operation. The bypass or separate economizer should be sized to handle the maximum outdoor air required during economizer operation.

7.1.1 *Economizer Bypass.*

7.1.1.1 *Unitized and Integrated Systems.* Outdoor air is brought into the conditioned space without crossing the component, thus not recovering energy. This can be accomplished by utilizing dampers, bypass duct and dampers, or by moving the Air-to-Air Heat Exchanger out of the outdoor airstream.

7.1.1.2 *Coupled Systems.* A system to introduce outdoor air into the conditioned space without crossing the Air-to-Air Heat Exchanger which utilizes the Economizer on the air-conditioning unit.

7.1.2 *Wheel Economizer.* System to introduce outdoor air into the conditioned space while crossing a Rotary Heat Exchanger without energy recovery. The component is stopped during the Economizer period when energy recovery is not desired. All of the outdoor air crosses the component, thus limiting the outdoor air amount to the component's airflow capacity at the application static pressure. Typically, full 100% outside air Economizer function can be provided with this method only for 100% outdoor air systems.

7.2 *Modulation.* All the above methods can be controlled to provide partial or modulated Economizer function.

7.3 *Exhaust Air Relief.* Barometric relief or power exhaust is often provided in conjunction with Economizers. The exhaust fan in the AAERVE may be able to provide or assist with this function. This should be considered in design.

7.4 *AAERVE Shut Down.* When a separate air economizer is provided, the control system should shut down the AAERVE's supply air stream at a minimum and typically also the AAERVE's exhaust air stream.

Section 8. Design Considerations and Air-Conditioning Equipment Selection

8.1 *Building Design.* The type of building will determine the type of AAERVE required for the application. The design may require that the AAERVE be utilized in a mechanical room application, a rooftop application, a through-the-wall application, or a combination.

8.2 *Codes and Standards.* The authority having jurisdiction will require that the system adhere to all applicable codes and standards.

8.2.1 *Building Codes.* AAERVE should be designed as applied to meet the effectiveness requirements of local building codes. The definition of effectiveness included in local building codes may be different than the definition of Effectiveness in this guideline. Building codes may also include additional items, e.g. maximum horsepower, construction details and other requirements.

8.2.2 *Ventilation Standard.* The designer is referred to the latest ventilation standard, for information on:

8.2.2.1 Outside air ventilation volumes consistent with good indoor air quality for various building types

8.2.2.2 Consideration of equipment design and construction details which may have an impact on indoor air quality, including removal of standing water, rain entrainment, and airstream surfaces.

8.2.3 *Energy Standard.* The designer is referred to the latest energy standard for information on:

8.2.3.1 Guidance on building and climate types for which application of AAERVE has been shown to be both energy-saving and cost-effective.

8.2.3.2 Requirements for minimum effectiveness and maximum input fan power consistent with the above guidance. The definition of effectiveness in ASHRAE Standard 90.1 is currently different than the definition of Effectiveness in this guideline.

8.3 *Climate.* The location of the building may determine the type of AAERVE required. The temperature and humidity conditions should be considered when determining the system to be used.

8.4 *Building Operation.* Controls should be provided to operate the system as required.

8.5 *Building Air-conditioning System.* The air-conditioning system type utilized in the building structure will influence which AAERVE system will be easiest to install and maintain.

8.6 *Building Outdoor Air Requirements.* The required amount of outside air will affect the size and design of the AAERVE.

8.7 *Building Outdoor Air Intake Location.* The location of the outdoor air intake should be considered. Never use outdoor air from an area that generates contaminated air. Examples of this are (1) areas where idling cars, trucks, or buses are abundant, (2) a processing facility that produces odors, and (3) restaurants kitchen (grease) exhaust areas.

8.8 *Building Inside Air Conditions.* The quality of the air inside the building may be important to the selection and design of the AAERVE. If the quality of the exhaust air is objectionable, the EATR should be evaluated. The EATR may be minimized through technology selection, mechanical purge, and/or pressure management. Separate spaces that must remain absolutely separated due to concerns for smoking odor transfer, for example, should be treated with different systems. When exhaust air presents a safety hazard and is not acceptable for recirculation in any amount, the use of AAERVE may not be advisable. Table 1 provides a summary of classes of air as they are treated in ASHRAE Standard 62.1.

Table 1: Classes of Air and Energy Recovery Ventilation Applications		
Classification of Exhaust Air (Refer to ASHRAE 62.1)	ASHRAE 62.1 Recommendations	AHRI Recommendations
Class 1 Air - Air with low contaminant concentration, low sensory-irritation intensity, and inoffensive odor.	Re-circulation or transfer of Class 1 exhaust air to supply air entering any space is permitted.	Use EATR and OACF to calculate adjusted intake rates and insure that proper outside air ventilation is provided.
Class 2 Air - Air with moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors (Class 2 air also includes air that is not necessarily harmful or objectionable but that is inappropriate for transfer or recirculation to spaces used for different purposes.)	When using an ERV, transfer of Class 2 exhaust air to supply air entering a Class 1 space is acceptable when no more than 10% is Class 2 air. Class 2 air can be returned to a Class 2 space.	Minimize EATR to reduce re-circulation of exhaust air. Most devices will require no special measures to achieve this level of dilution. System design, including multiple exhaust points from a variety of spaces can increase dilution performance.
Class 3 Air - Air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor	When using an ERV, transfer of Class 3 exhaust air to supply air entering a Class 1 or 2 space is acceptable when no more than 5% is Class 3 air. Class 3 air can be returned to a Class 3 space.	Minimize EATR to reduce re-circulation of exhaust air. System design, including separate exhaust air duct systems for Class 3 exhaust, multiple exhaust points including Class 1 and 2 air, purge, etc., will influence dilution performance.
Class 4 Air – Air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols, or gases, at concentrations high enough to be considered harmful	Re-circulation or transfer of Class 4 exhaust air to supply air entering any space is prohibited.	AAERVE may not be an acceptable technology. AAERVEs should only be used when the specific and qualified authority having jurisdiction allows.

8.8.1 Fouling. Spaces that generate dust, powder, grease, wax, etc. may require special treatment of the exhaust air or may not be candidates for AAERVE. Verify with the AAERVE manufacturer.

8.8.2 Humidity Control. AAERVE in combination with the air-conditioning system may provide adequate humidity control to meet ASHRAE Standard 62.1 requirements. In applications where humidity must be closely controlled (within 5%) additional dehumidification equipment may be required.

8.8.3 Smoking Areas. If smoking is allowed inside the space, additional amounts of outdoor air may be required. Consult local codes for the minimum amount required. Consult the AAERVE manufacturer for appropriate product application.

8.9 Building Structure Installation Considerations. Listed below are examples of limitations created due to the structure of a building. This is just a partial list.

8.9.1 The amount of room required for ductwork.

8.9.2 The size of the mechanical room as it relates to the size of the equipment.

8.9.3 The location of exhaust and flue gas and plumbing vents on a roof.

8.9.4 Maintenance access to the AAERVE.

8.9.5 Electrical requirements.

8.10 Selection of Cooling Design Conditions. Outside air can be a significant source of humidity. ASHRAE Handbook - Fundamentals provides three different sets of cooling design conditions. The dry-bulb/mean wet-bulb data prioritizes sensible load; the wet-bulb/mean dry-bulb data prioritizes latent load; the dewpoint/mean dry-bulb data prioritizes humidity ratio. The choice of design conditions may impact the efficiency of the system and its ability to control indoor humidity.

8.11 *Tonnage Reduction Method.* The air-conditioning equipment size can be determined by reducing the Total Building Load by the tonnage saved due to the AAERVE.

8.11.1 *Total Air-Conditioning Requirement.* Determine the total air-conditioning required for the Total Building Load including the amount required for the ventilation.

8.11.2 *AAERVE Tonnage Savings.* Determine the amount of air-conditioning tonnage that the AAERVE is saving from the manufacturer's data. Reduce the total air-conditioning requirement by the savings amount to determine the net air-conditioning requirement.

8.12 *Entering Outdoor Air Method.* Determine the total air conditioning load by replacing the entering outdoor air conditions in load programs with the entering Tempered Outside Air conditions.

Section 9. AAERVE Sizing

9.1 *General.* The following information is required to determine the AAERVE needs.

9.1.1 *Outside Air Required Per Zone.* Use ASHRAE Standard 62.1 to determine the minimum outside air required for ventilation. This is the minimum required for air delivered to the Zone from the AAERVE. Also consider if there is an extra requirement for outside air that would increase the minimum required such as like exhaust hoods.

9.1.2 *Exhaust Air Required Per Zone.* Consider if there are exhausts that will not go through the AAERVE that must be accounted for when determining outside air ventilation.

9.1.3 *Summer Design Conditions.* Use peak sensible design conditions in calculation of peak load reduction by the AAERVE for purposes of downsizing the air conditioning equipment. In some cases, the maximum design dew point condition may also be considered for purposes of determining the air conditioning equipment's part-load dehumidification capability.

9.1.4 *Winter Design Conditions.* Use peak sensible design conditions and consider how a defrost system, if required, will affect the potential to downsize the heating equipment.

9.1.5 *Desired Sensible Effectiveness and Fresh Air Delivery Temperature, Winter and Summer.* This is typically an iterative process in which the benefits of high Effectiveness and lower fan power input is balanced against increased size and cost of the AAERVE equipment.

9.1.6 *Desired Latent Effectiveness and Fresh Air Delivery Humidity, Winter and Summer.* As with sensible Effectiveness, this is typically an iterative process.

9.1.7 *External Static Pressure Requirements.* Consider both supply and exhaust.

9.2 *Determine Airflow.* After selecting the equipment to be used, determine the airflows required with consideration of the EATR and OACF ratings. It should be noted that for a particular application the actual airflows may be different than those determined in Section 9.1 above. The results are the final airflows for the selected equipment.

9.3 *Determine Effectiveness and Fresh Air Delivery Conditions.* After selecting the equipment to be used, determine the Effectiveness and fresh air delivery conditions of the AAERVE as it will be applied.

Note: Consult published literature or software from the proposed manufacturer of the AAERVE for assistance.

Section 10. Specification Practices for AAERVE

10.1 *AAERVE Requirements.*

10.1.1 *Energy Recovery Performance and Effectiveness.* Specify either sensible or enthalpy type recovery device with the desired Effectiveness. Enthalpy devices should be used where it is advantageous to conserve or reject

humidity. Sensible devices provide an advantage when it is desirable to allow dehumidification with outside air (winter ventilation of pools or other spaces with excessive humidity, for example).

10.1.2 Other Performance Requirements. Specify additional performance ratings that may be applicable to the design such as pressure drop, EATR, and OACF.

10.1.3 Recovery Type. Specify either Heat Pipe Heat Exchanger, Plate Heat Exchanger, or Rotary Heat Exchanger that corresponds to the recovery performance and Effectiveness selected.

10.1.4 Installation Type. Specify installation and application for AAERVE that is applicable for the recovery type selected. Example: Rooftop, indoor, coupled, unitized etc.

10.2 AAERVE Design Information.

10.2.1 Balancing Method. Specify the method to be used for balancing the airflow of exhaust and supply (intake) air. Specify the airflows and locations for airflow measurement, including the impact of OACF and EATR on those flows.

10.2.1.1 Integrated Systems should have an internal means of controlling exhaust air without being overwhelmed by the air handler supply blower.

10.2.1.2 Standalone Systems should have balancing dampers installed for each Zone to control the amount of outdoor air for each Zone.

10.2.1.3 Standalone-coupled Systems that are connected to the air-conditioning duct of multiple air-conditioning systems should have balancing dampers installed at each location where the AAERVE is attached to each individual air-conditioning duct.

10.2.1.4 Unitized Systems should provide an internal balancing damper to control exhaust air without being overwhelmed by the air-conditioning unit supply blower.

10.2.2 Design Conditions. Specify the summer and winter design conditions. Include both dry-bulb and wet-bulb conditions.

10.2.3 Economizer Requirement. Specify economizer type to be utilized (if any) for the AAERVE.

10.2.4 Exhaust Air Requirement. Specify the amount of exhaust air to be removed from the conditioned space.

10.2.5 External Static Pressure. On standalone and standalone-coupled systems the amount of external duct static that the AAERVE must overcome to provide the outdoor air and exhaust air required should be specified. On integrated and unitized systems, the air-conditioning system should be sized to overcome the external duct static.

10.2.6 Component Pressure Loss. When specifying a component for use in an overall system, you should specify static pressure loss.

10.2.7 Frost Protection. Specify type of frost protection required per the Air-to-Air Heat Exchanger manufacturer's guidelines.

10.2.8 Maintenance Requirement. Specify the access required to properly maintain the Air-to-Air Heat Exchanger. This should provide a method of accessing all motors, controls, and the component.

10.2.8.1 Component Cleaning. The Air-to-Air Heat Exchanger is located in both supply and exhaust airstreams. As such, this component will require cleaning on a periodic basis. Access to the component and a method of cleaning should be specified to insure longevity of the component.

10.2.9 Filtration. Specify type of filtration required per the Air-to-Air Heat Exchanger manufacturer's guidelines.

10.2.10 Mating Unit. Specify the air-handler or the standalone-coupled or unitized system mated with an AAERVE.

10.2.11 Outdoor Air Requirement. Specify the amount of outdoor air to be brought into the conditioned space. On integrated, standalone-coupled, or unitized systems the outdoor air should not exceed the air-conditioning system's scfm capacities.

10.2.12 Airflow Verification. Specify the procedure for verifying the amount of outdoor air and exhaust air. This information should be part of the commissioning of the building.

10.2.13 Electrical. Specify the voltage, phase, and amperage requirements for the AAERVE low voltage control interface.

10.2.14 Ducts. Specify the type and size of ducts to be used, along with the method of insulating and sealing the ducts. When tempered outside air or exhaust air leaving the AAERVE is ducted through a conditioned space, ducts should be properly insulated and sealed to prevent energy loss and or formation of condensate or frost. Similar cautions apply to ducts carrying conditioned air and located outside of the building envelope.

10.2.15 Agency Approvals. Specify the agency approvals required for the Air-to-Air Heat Exchanger and AAERVE. This should include the AHRI Standard 1060 certification mark.

APPENDIX A. REFERENCES – NORMATIVE

None.

APPENDIX B. REFERENCES – INFORMATIVE

B1 Listed here are standards, handbooks and other publications which may provide useful information and background, but are not considered essential. References in this appendix are not considered part of the guideline.

B1.1 AHRI Standard 1060 (I-P)-2014 , *Performance Rating Air-to-Air Exchangers for Energy Recovery Ventilation Equipment*, 2013, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

B1.2 ANSI/ASHRAE Standard 90.1-2013, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, 2013, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

B1.3 ANSI/ASHRAE Standard 84-2013, *Method of Testing Air-to-Air Heat Exchangers*, 2013, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

B1.4 ANSI/ASHRAE Standard 62.1-2013, *Ventilation for Acceptable Indoor Air Quality*, 2004, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

B1.5 AHRI Guideline V-(I-P)-2011, *Calculating the Efficiency of Energy Recovery Ventilation and its Effect on Efficiency and Sizing of Building HVAC Systems*, 2011, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

B1.6 ASHRAE Handbook - Fundamentals, 2013, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

B1.7 ASHRAE Handbook - Systems and Equipment, 2012, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

B1.8 ASHRAE, Terminology, <https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology>, 2014, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

B1.9 International Mechanical Code, 2012, International Code Council, 5203 Leesburg Pike, Suite 600, Falls Church, VA 22041, U.S.A.

APPENDIX C. EXAMPLE SPECIFICATION FOR STANDALONE SYSTEM – INFORMATIVE

Table C1 demonstrates an example of a standalone energy recovery equipment schedule.

Table C1. Standalone Energy Recovery Equipment Schedule					
Mark		HRV-1	ERV-2		
Area Served		Class 2	Library		
Manufacturer		ABC Inc.	ABC Inc.		
Model		A-1000	B-2000		
Summer Conditions	Outdoor Air Temperature, Dry-Bulb, °F		89		
	Outdoor Air Temperature, Wet-Bulb, °F		73		
	Indoor Air Temperature, Dry-Bulb, °F		75		
	Indoor Air Temperature, Wet-Bulb, °F		63		
	Effectiveness – Sensible, %		71	75	
	Effectiveness – Latent, %		0	67	
Winter Conditions	Outdoor Air Temperature, Dry-Bulb, °F		1		
	Outdoor Air Temperature, Wet-Bulb, °F		0		
	Indoor Air Temperature, Dry-Bulb, °F		72		
	Indoor Air Temperature, Wet-Bulb, °F		54		
	Effectiveness – Sensible, %		71	75	
	Effectiveness – Latent, %		0	67	
Supply	Net Outdoor Airflow, cfm		1,000	1,800	
	Gross Outdoor Airflow, cfm		1,000	1,870	
	OACF		1	0.96	
	Supply Conditions, Dry-Bulb / Wet-Bulb, °F		79 / 70	79 / 66	
	Winter Conditions, Dry-Bulb / Wet-Bulb, °F		51 / 35	51 / 41	
	Blower Motor	Horsepower		1	1.5
		Volts		460	
		Phase / Hertz		3 / 60	
External Static Pressure, in H ₂ O		0.25	0.3		
Exhaust	Net Exhaust Airflow, cfm		1,000	1,700	
	Gross Exhaust Airflow, cfm		1,000	1,770	
	Blower Motor	Horsepower		1	1.5
		Volts		460	
		Phase / Hertz		3 / 60	
		External Static Pressure, in H ₂ O		0.2	0.25
Minimum Circuit Ampacity		4.8	5.7		
Maximum Fuse Size		6	10		
Remarks (refer to notes regarding defrost, economizers, balancing dampers, etc.)		1, 2, 4	1, 3		

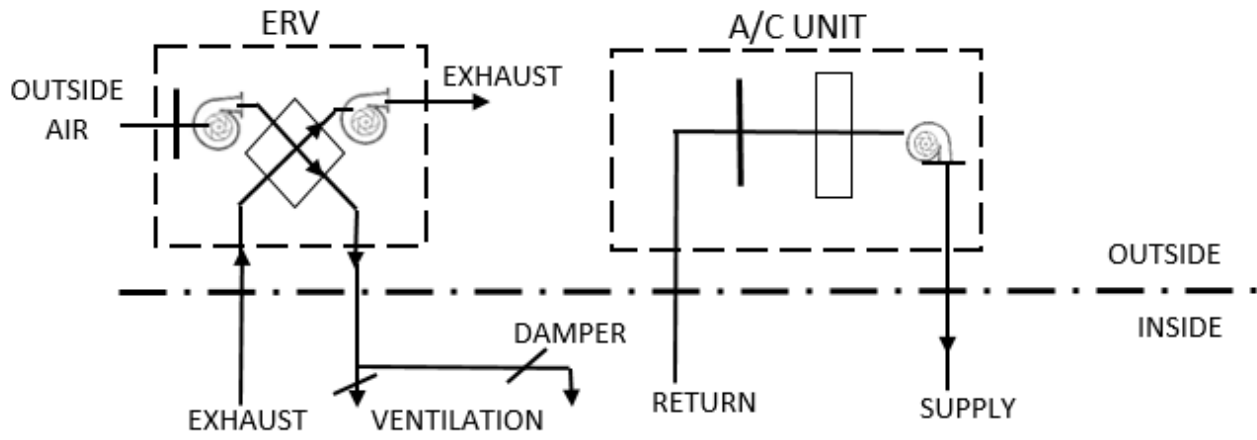


Figure C1. Typical Standalone System

APPENDIX D. EXAMPLE SPECIFICATION FOR STANDALONE - COUPLED SYSTEM– INFORMATIVE

Table D1 demonstrates an example of a standalone coupled energy recovery equipment schedule.

Table D1. Standalone - Coupled Energy Recovery Equipment Schedule					
Mark		HRV-1	ERV-2		
Coupled with		AHU-1	RTU-1		
Manufacturer		ABC Inc.	ABC Inc.		
Model		A-1000	B-2000		
Summer Conditions	Outdoor Air Temperature, Dry-Bulb, °F		89		
	Outdoor Air Temperature, Wet-Bulb, °F		73		
	Indoor Air Temperature, Dry-Bulb, °F		75		
	Indoor Air Temperature, Wet-Bulb, °F		63		
	Effectiveness – Sensible, %		71	75	
	Effectiveness – Latent, %		0	67	
Winter Conditions	Outdoor Air Temperature, Dry-Bulb, °F		1		
	Outdoor Air Temperature, Wet-Bulb, °F		0		
	Indoor Air Temperature, Dry-Bulb, °F		72		
	Indoor Air Temperature, Wet-Bulb, °F		54		
	Effectiveness – Sensible, %		71	75	
	Effectiveness – Latent, %		0	67	
Supply	Net Outdoor Airflow, cfm		1,000	1,800	
	Gross Outdoor Airflow, cfm		1,000	1,870	
	OACF		1	0.96	
	Supply Conditions, Dry-Bulb / Wet-Bulb, °F		79 / 70	79 / 66	
	Winter Conditions, Dry-Bulb / Wet-Bulb, °F		51 / 35	51 / 41	
	Blower Motor	Horsepower		1	1.5
		Volts		460	
		Phase / Hertz		3 / 60	
		External Static Pressure, in H ₂ O		0.25	0.3
Exhaust	Net Exhaust Airflow, cfm		1,000	1,700	
	Gross Exhaust Airflow, cfm		1,000	1,770	
	Blower Motor	Horsepower		1	1.5
		Volts		460	
		Phase / Hertz		3 / 60	
		External Static Pressure, in H ₂ O		0.2	0.25
Minimum Circuit Ampacity		4.8	5.7		
Maximum Fuse Size		6	10		
Remarks (refer to notes regarding defrost, economizers, balancing dampers, etc.)		1, 2, 4	1, 3, 5		

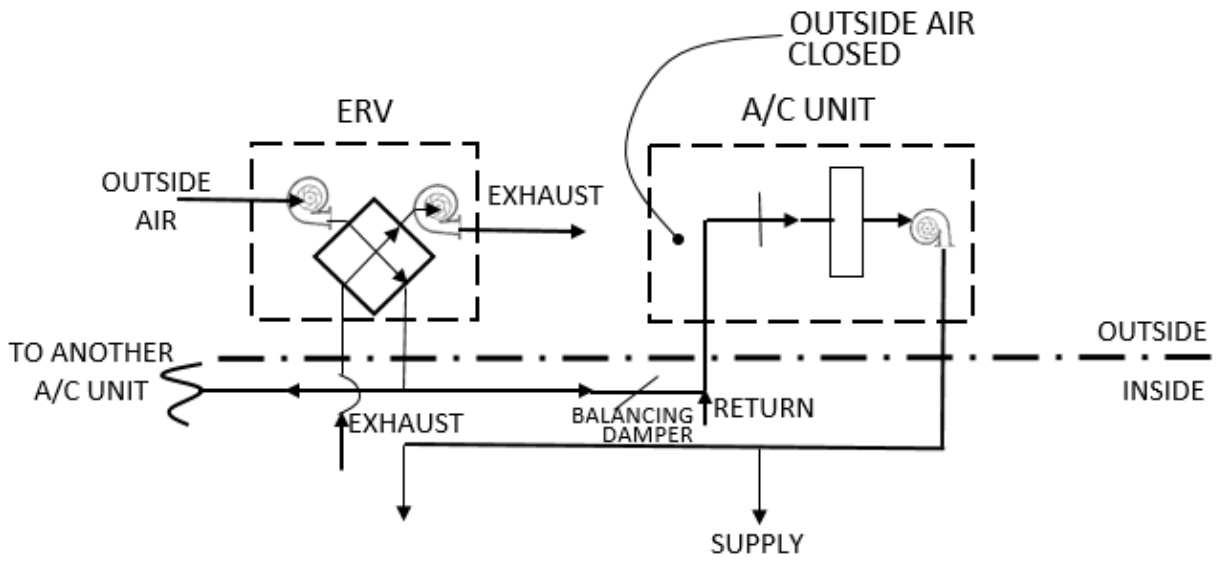


Figure D1. Typical Standalone - Coupled System

APPENDIX E. EXAMPLE SPECIFICATION FOR UNITIZED SYSTEM– INFORMATIVE

Table E1 demonstrates an example of a unitized energy recovery equipment schedule.

Table E1. Unitized Energy Recovery Equipment Schedule					
Mark		HRV-1	ERV-2		
Connected to		AHU-1	RTU-1		
Manufacturer		ABC Inc.	ABC Inc.		
Model		U-1000	U-2000		
Summer Conditions	Outdoor Air Temperature, Dry-Bulb, °F		89		
	Outdoor Air Temperature, Wet-Bulb, °F		73		
	Indoor Air Temperature, Dry-Bulb, °F		75		
	Indoor Air Temperature, Wet-Bulb, °F		63		
	Effectiveness – Sensible, %		71	75	
	Effectiveness – Latent, %		0	67	
Winter Conditions	Outdoor Air Temperature, Dry-Bulb, °F		1		
	Outdoor Air Temperature, Wet-Bulb, °F		0		
	Indoor Air Temperature, Dry-Bulb, °F		72		
	Indoor Air Temperature, Wet-Bulb, °F		54		
	Effectiveness – Sensible, %		71	75	
	Effectiveness – Latent, %		0	67	
Supply	Net Outdoor Airflow, cfm		1,000	1,800	
	Gross Outdoor Airflow, cfm		1,000	1,870	
	Supply Conditions, Dry-Bulb / Wet-Bulb, °F		79 / 70	79 / 66	
	OACF		1	0.96	
	Winter Conditions, Dry-Bulb / Wet-Bulb, °F		51 / 35	51 / 41	
	Blower Motor	Horsepower		1	1.5
		Volts		460	
		Phase / Hertz		3 / 60	
External Static Pressure, in H ₂ O		0.25	0.3		
Exhaust	Net Exhaust Airflow, cfm		1,000	1,700	
	Gross Exhaust Airflow, cfm		1,000	1,770	
	Blower Motor	Horsepower		1	1.5
		Volts		460	
		Phase / Hertz		3 / 60	
		External Static Pressure, in H ₂ O		0.2	0.25
Minimum Circuit Ampacity		4.8	5.7		
Maximum Fuse Size		6	10		
Remarks (refer to notes regarding defrost, economizers, balancing dampers, etc.)		1, 2, 4	1, 3, 5		

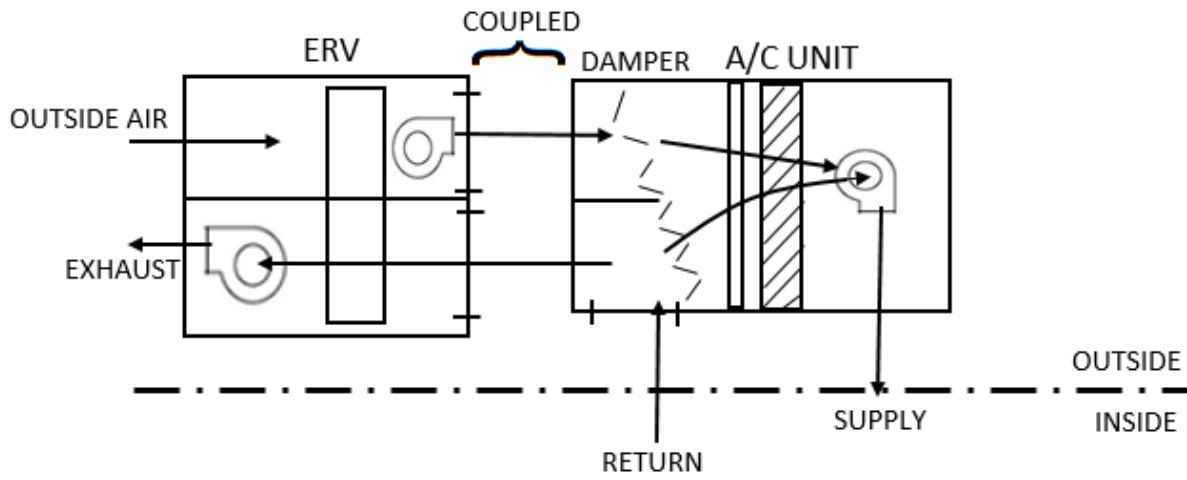


Figure E1. Unitized System

APPENDIX F. EXAMPLE SPECIFICATION FOR INTEGRATED ENERGY RECOVERY SYSTEM – INFORMATIVE

Table F1 demonstrates an example of an integrated energy recovery equipment schedule.

Table F1. Integrated Energy Recovery Equipment Schedule				
Mark		HRV-1	ERV-2	
Area Served		Class 2	Library	
Manufacturer		ABC Inc.	ABC Inc.	
Model		AB120-1000	AB240-2000	
Summer Conditions	Outdoor Air Temperature, Dry-Bulb, °F		89	
	Outdoor Air Temperature, Wet-Bulb, °F		73	
	Indoor Air Temperature, Dry-Bulb, °F		75	
	Indoor Air Temperature, Wet-Bulb, °F		63	
	Effectiveness – Sensible, %	71	75	
	Effectiveness – Latent, %	0	67	
Winter Conditions	Outdoor Air Temperature, Dry-Bulb, °F		1	
	Outdoor Air Temperature, Wet-Bulb - °F		0	
	Indoor Air Temperature, Dry-Bulb, °F		72	
	Indoor Air Temperature, Wet-Bulb, °F		54	
	Effectiveness – Sensible, %	71	75	
	Effectiveness – Latent, %	0	67	
Supply	Net Outdoor Airflow, cfm		1,000	
	Gross Outdoor Airflow, cfm		1,000	
	OACF		1.00	
	Supply Conditions, Dry-Bulb / Wet-Bulb, °F		79 / 70	
	Winter Conditions, Dry-Bulb / Wet-Bulb, °F		51 / 35	
	Blower Motor	Horsepower		1
		Volts		460
		Phase / Hertz		3 / 60
		External Static Pressure, in H ₂ O	0.25	0.3
	Exhaust	Net Exhaust Airflow, cfm		1,000
Gross Exhaust Airflow, cfm		1,000		
Blower Motor		Horsepower		1
		Volts		460
		Phase / Hertz		3 / 60
		External Static Pressure, in H ₂ O	0.2	0.25
Minimum Circuit Ampacity		4.8	5.7	
Maximum Fuse Size		6	10	
Remarks (refer to notes regarding defrost, economizers, balancing dampers, etc.)		1, 2, 4	1, 3, 4	

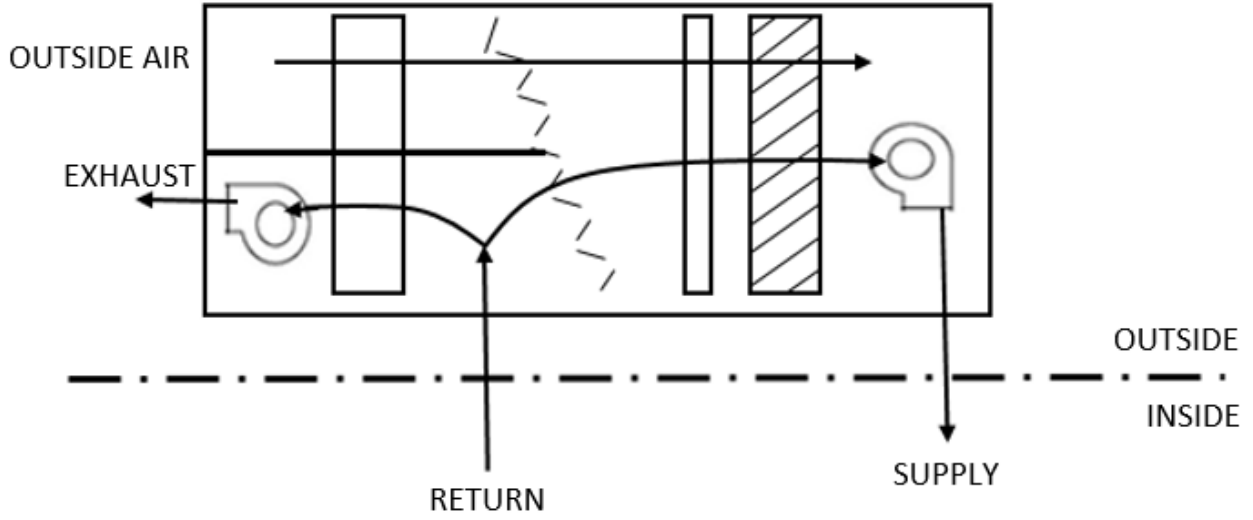


Figure F1. Integrated System