tech primer

# Dedicated Outdoor Air Systems (DOAS) and Energy Recovery Ventilators (ERV)

## Controlled ventilation for enhanced comfort and savings.

tech overview

applicable building types
commercial
implementation
anytime, at mid-cycle or refinance
fast facts
- reduces GHG emissions
- improves air quality
- reduces heating and cooling loads
- reduces maintenance costs
- reduces utility costs

New York Botanical Garden, Marlon Co. Photography

costs & benefits*

GHG Savings

Tenant Experience Improvements

Utility Savings

Capital Costs

Maintenance Requirements

*ratings are based on system end use, see back cover for details.

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# getting to know DOAS and ERV systems

## Dedicated Outdoor Air Systems (DOAS) and Energy Recovery Ventilators (ERVs) provide controlled and conditioned ventilation that improves indoor air quality and occupant health, while reducing greenhouse gas emissions and saving energy.

### how do DOAS and ERVs work?

All commercial buildings in the US are required to supply fresh air to occupied spaces. Fresh, clean air supports human health and is critical to indoor air quality and comfort. Although ventilation methods may differ, tempering fresh air can be an energy demanding process.

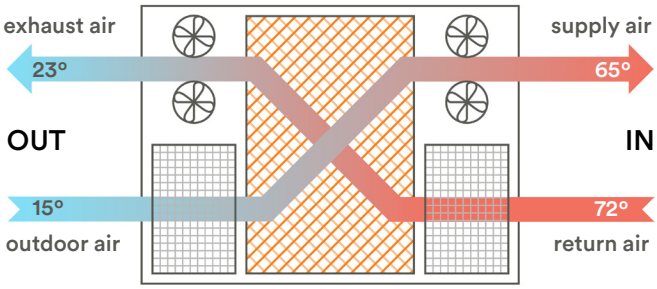
A Dedicated Outdoor Air System (DOAS) with a high efficiency Energy Recovery Ventilator (ERV) is an alternative ventilation system design that can significantly reduce a building's heating and cooling loads. Pairing DOAS and ERV with a ductless heating and cooling system, such as Variable Refrigerant Flow or Mini-Split heat pumps, can further reduce heating and cooling loads while enhancing comfort.

Conventional Heating, Ventilation and Air-Conditioning (HVAC) systems must fully temper fresh air before distributing it throughout the building. This contributes to high heating and cooling loads, and means that fresh air is only provided simultaneously with heating or cooling. A DOAS, on the other hand, brings fresh air into interior spaces independently from heating or cooling, greatly increasing efficiency and allowing the downsizing of heating and cooling equipment.

An ERV tempers incoming outdoor air with heat from the exhaust air, significantly reducing the demand on heating and cooling equipment. ERVs work by transferring heat contained in exhausted (indoor) air to incoming (outdoor) air or vice versa, depending on the season (see Fig 1). The two air streams do not mix, keeping odor and pollutants in exhausted air separate from fresh supply air. This technique, called preconditioning, conserves a significant amount of energy that would otherwise be lost with traditional exhaust ventilation methods.

This tech primer outlines a high performance ventilation upgrade option for commercial buildings using a DOAS with ERV and recommends the installation of an efficient, ductless heating and cooling system (VRF or Mini-Split) to fully realize savings.

**Fig 1. During winter, heat from the return air is transferred to the supply air in the heat recovery core (orange hatch) of an ERV. The system reverses in summer, where heat from the outdoor air is transferred to the exhaust air, helping to cool the supply air.**




**Assess**
Always consult a qualified service provider before undertaking any building upgrades.

**Coordinate Upgrades for Maximum Savings**
Implementing a DOAS retrofit in conjunction with building envelope improvements that reduce heat loss and infiltration can enhance the ventilation system performance.

*Establish a tight building envelope through general air sealing. Updating windows and adding insulation can further reduce heating and cooling loads.*

**Plan Ahead for Success**
A DOAS retrofit is most easily applied to buildings with existing ventilation systems that are either floor by floor or have both supply and return air ductwork.

*Buildings that are currently supply or exhaust-only ventilated will require additional duct work.*

# how to upgrade to DOAS and ERV systems

## A DOAS and ERV will greatly reduce the heating and cooling loads of a building. Coordinate heating and cooling retrofits in order to size equipment based on these load reductions.

### retrofit solutions

A DOAS and ERV system combined with a properly downsized heating and cooling system and programmed HVAC controls will generate significant energy savings. There are multiple steps to achieving these savings:

**A** **Install a DOAS with an ERV–** Typical ERV efficiencies are around 70%. However, very high efficiency ERVs (on the order of 85% to 93%) have long been used in Europe and are now available in North America. A high performance ventilation retrofit requires the installation of an ERV at the highest efficiency available.

- A building's existing ventilation system may either be centralized, providing ventilation to the entire building, or decentralized, providing ventilation to individual floors or spaces.
- For successful implementation of this retrofit, both supply and exhaust air must be balanced and ducted to the same location. This is usually easier to accommodate in decentralized ventilation systems but can also be achieved in centralized systems.
- The ERV should be sized to operate at 40%- 60% of its rated capacity during design conditions. The additional capacity allows the ERV to run as an economizer during mild weather. An economizer provides free cooling by using outdoor air to cool indoor spaces when the outdoor air is at a temperature that does not need tempering. This is considered free cooling as the air is simply brought into the building without using energy to temper it.

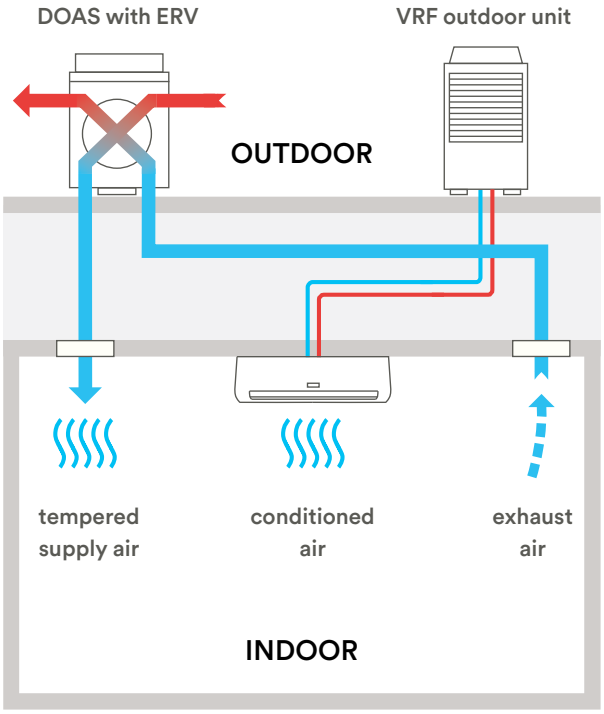
**B** **Install a Ductless Heating and Cooling System–** A high efficiency ductless heating and cooling system, such as a Variable Refrigerant Flow (VRF or Mini-Split) heat pump system, paired with a DOAS and ERV system creates a complete, high performance HVAC solution (see Fig 2.). These two systems complement each other and dramatically reduce energy costs while improving occupant comfort.

- See our tech primers on VRFs and Mini-Splits for information about implementing these systems.

**C** **Upgrade Controls–** Further optimization of the building's HVAC system can be achieved by programmed heating, cooling, and ventilation controls based on demand, measured CO2 levels, or an occupancy schedule.

- The HVAC controls must coordinate the operation of the DOAS with ERV and the heating and cooling system.
- The DOAS terminal units must be controlled by occupancy and CO2 sensors to provide fresh air to individual spaces when needed.
- When fresh air is not needed, the control system must reduce airflow at the terminal units and reduce the ERV fan to minimize energy consumption.
- The control system should automatically enable the ERV economizer setting in mild weather.

**Fig 2. When paired with a VRF heating and cooling system, a DOAS with ERV creates a complete HVAC solution. In cooling mode, the ERV uses the exhaust air to transfer heat from the outdoor air, tempering the supply air to the building. The VRF does less work because the supply air temperature from DOAS is closer to the desired indoor temperature.**



## costs & benefits of DOAS and ERV*

### Greenhouse Gas (GHG) Savings

In a DOAS with ERV system, almost all of the energy in exhausted air can be recovered by the incoming fresh air (or vice versa), dramatically lowering heating and cooling loads and related GHG emissions. Further GHG reductions occur when the DOAS and ERV are paired with a ductless heating and cooling system and upgraded HVAC controls, depending on the existing ventilation strategy and heating and cooling fuel type.

### Tenant Experience Improvements

A DOAS installation dramatically improves tenant satisfaction by delivering fresh air where it's needed, resulting in a controlled indoor environment with reduced temperature extremes and improved indoor air quality.

### Utility Savings

Although DOAS with ERV significantly reduces heating and cooling loads, electricity is a significantly more expensive form of energy than natural gas, fuel oil, or district steam. Future changes in utility costs should be considered when evaluating project feasibility.

### Capital Costs

A DOAS installation requires a very high capital investment, although actual installation costs will depend on the building's existing conditions. Buildings with a decentralized ventilation system will generally be simpler and cheaper to convert, while buildings with central ventilation systems, particularly where the total supply and exhaust rates are not already balanced, may be more difficult and expensive. Further due diligence is recommended for determining site specific costs, benefits and retrofit considerations.

### Maintenance Requirements

A DOAS with ERV system requires a low level of maintenance. ERVs and DOAS terminal units have air filters that require regular cleaning. ERV controls detect dirty filters and automatically alert operators, however it is recommended to visually inspect ERV units every 3 months and fully clean the unit every 6 months.

**The Costs & Benefits rating system is based on a qualitative 1 to 4 scale where 1 ( ) is lowest and 4 ( ) is highest. Green correlates to savings and improvements, orange correlates to costs and requirements. Ratings are determined by industry experts and calculated relative to the system end use, not the whole building.*

Note: Existing ventilation assumed to supplied floor by floor. Existing heating and cooling system to be replaced with VRF or Mini-Split system.

## Take Action

**This document is one of more than a dozen High Performance Technology Primers prepared by Building Energy Exchange and the NYC Accelerator to introduce decision-makers to solutions that can help them save energy and improve comfort in their buildings. Access the complete library of Tech Primers here:**

**be-exchange.org/tech-primers**

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