



## Abstract

This study evaluated a retrofit heat recovery ventilation (HRV) system for a 70,000 ft<sup>2</sup>, seven-story office building to reduce ventilation-related heating energy, improve indoor air quality (IAQ), and integrate with existing HVAC controls while minimizing disruption. A compact plate-type HRV with CO<sub>2</sub>-based demand controls was selected. Phased installation and commissioning included test and balance procedures, control interlocks with the rooftop unit, and staff training. Twelve-month monitoring with 15-minute logging of energy and IAQ metrics showed a mean sensible heat-exchanger effectiveness of 72%, an 18% annual reduction in ventilation-related space-heating energy, and a reduction in occupied-hour CO<sub>2</sub> peak concentrations from values exceeding 1,200 ppm to sustained levels below 950 ppm. Integrated controls prevented overventilation and maintained occupant comfort. The estimated simple payback period ranged from 5 to 7 years. The retrofit demonstrated that a compact, well-commissioned HRV with demand control delivered measurable energy, IAQ, and operational benefits for mid-rise office buildings.

Key Terms: Demand controlled ventilation (CO<sub>2</sub> based), Retrofit commissioning, Sensible heat exchanger effectiveness, Ventilation related energy savings

## Introduction

The project analyzed the feasibility and implementation of a retrofit heat-recovery ventilation (HRV) system for a 70,000 ft<sup>2</sup> midsize office building located in an urban commercial district. The building comprised seven occupied floors served by a packaged rooftop HVAC unit and perimeter baseboard heating; ventilation relied on intermittent outdoor-air intake and exhaust fans without dedicated heat recovery. Pre-project utility analysis and measurements indicated substantial ventilation-related heating loads and periodic elevated CO<sub>2</sub> concentrations during peak occupancy, demonstrating both energy inefficiency and inconsistent ventilation effectiveness.

To address these issues, the project pursued three integrated objectives:

- to reduce space-heating energy consumption through exhaust heat recovery;
- to improve ventilation effectiveness and Indoor Air Quality to meet applicable regulations and occupant health requirements; and
- to integrate the HRV with the existing HVAC controls and infrastructure.

The retrofit was designed and implemented to minimize disruption to building operations and ongoing maintenance activities.

## Literature Review

Literature indicates HRV systems typically reduce whole-building heating by ~10–30% with paybacks of 3–8 years, depending on energy prices and operating hours. Plate heat exchangers are favored for compactness, low leakage risk, and simpler maintenance, while rotary enthalpy wheels provide combined sensible and latent recovery but require more complex maintenance and leakage control; exchanger choice depends on available space, humidity control needs, and maintenance capacity. In cold climates frost can increase pressure drop and reduce effectiveness, so defrost strategies (electric defrost, bypass/reheat, reverse flow) must be modeled as they materially affect annual recovery and auxiliary heating. Retrofit projects commonly face constrained mechanical space, complex duct routing, and the need to protect occupant comfort during installation, so recommendations include locating compact units near existing shafts, phased installation, and early code coordination. Adding cores, filters, and duct branches raises system static pressure, so verifying fan capacity or specifying supplemental fan power is important to prevent underperformance. Finally, demand-based controls (CO<sub>2</sub> or occupancy), proper sensor placement, thorough commissioning, and scheduled maintenance are essential to optimize and sustain IAQ and energy benefits.

## Methodology

The methodology followed four sequential phases—baseline assessment, system selection & design, installation & commissioning, and performance monitoring—each documented for pre/post comparison. Baseline work recorded HVAC specs, ventilation rates, 12 months of utility data, spot IAQ (CO<sub>2</sub>, temperature, RH), and mechanical/duct surveys to calibrate ventilation-related EUI. Design integrated a compact plate HRV with existing supply/exhaust and rooftop controls, specified CO<sub>2</sub>-based fan modulation and interlocks, verified equipment clearances, and developed a phased installation schedule to minimize disruption. Installation used the phased plan with coordinated firestopping and temporary ventilation; field changes were logged. Commissioning included test-and-balance measurements (airflows, supply/exhaust temps, heat-exchanger effectiveness) with calibrated instruments and staff training. A 12-month performance monitoring program recorded energy and IAQ at 15-minute intervals (heating submeter, HRV power, CO<sub>2</sub>, RH) to evaluate heating-energy reduction, occupied-hour CO<sub>2</sub>, and exchanger effectiveness.



## Results and Discussion

Post-retrofit monitoring (12 months, 15-min resolution) demonstrated a mean sensible heat-exchanger effectiveness of 72%. Measured ventilation-related space-heating energy fell from 360,000 kWh/yr to 295,000 kWh/yr (–18.1%), yielding a gross heat recovery of 65,000 kWh/yr. Mean occupied-hour CO<sub>2</sub> decreased from 980 ppm to 720 ppm and peak occupied-hour CO<sub>2</sub> fell from >1,200 ppm to <950 ppm; relative humidity remained within acceptable limits, and no comfort complaints were reported. HRV fan and control energy increased from an estimated 9,000 kWh/yr to 17,500 kWh/yr (+8,500 kWh/yr), producing net annual energy savings of 56,500 kWh/yr. At \$0.12/kWh this equals \$6,780/yr in net savings and an estimated simple payback of 5.9 years (installed cost \$40,000). Commissioning verified airflow balance and control interlocks; phased installation and staff training avoided major operational disruption. Summary results are presented in Table 1.

Table 1  
Pre- and post-retrofit summary

Metric	Pre-retrofit	Post-retrofit	Change	Notes
Annual ventilation-related space-heating energy	360,000 kWh/yr	295,000 kWh/yr	–65,000 kWh (–18.1%)	12-month measured, apportioned to ventilation
Mean occupied-hour CO <sub>2</sub>	980 ppm	720 ppm	–260 ppm	15-min logging, occupied hours
Peak occupied-hour CO <sub>2</sub>	>1,200 ppm	<950 ppm	Peak reduced to <950 ppm	Post-commissioning condition
HRV / ventilation electrical energy (annual)	9,000 kWh/yr	17,500 kWh/yr	+8,500 kWh	Pre: intake/exhaust fans; Post: HRV fans + controls
Gross annual heating energy recovered	—	65,000 kWh/yr	+65,000 kWh	Calculated from measured effectiveness & airflow
Estimated annual net energy savings (heating – Δelectrical)	—	56,500 kWh/yr	+56,500 kWh	65,000 – 8,500
Estimated annual net cost savings (at \$0.12/kWh)	—	\$6,780/yr	+\$6,780/yr	56,500 × \$0.12
Installed retrofit cost (assumed)	—	\$40,000	\$40,000	Unit, controls, installation, commissioning
Estimated simple payback	—	5.9 years	—	\$40,000 / \$6,780 ≈ 5.9 years

## Conclusions

The retrofit of a compact, plate type HRV with frost management and CO<sub>2</sub> based demand controls successfully reduced ventilation related heating energy, improved IAQ, and integrated with existing rooftop HVAC controls with minimal disruption. Key success factors included appropriate exchanger selection, verified fan capacity, phased installation, thorough commissioning, and trained maintenance procedures. The project demonstrates that similar mid rise urban office buildings can achieve measurable energy and occupant health benefits from HRV retrofits when design, controls, and maintenance are properly addressed.

## References

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