OXYGEN8

Designing High-Efficiency, All-Electric, and Integrated Ventilation Solutions for Improved Occupant Health and Comfort

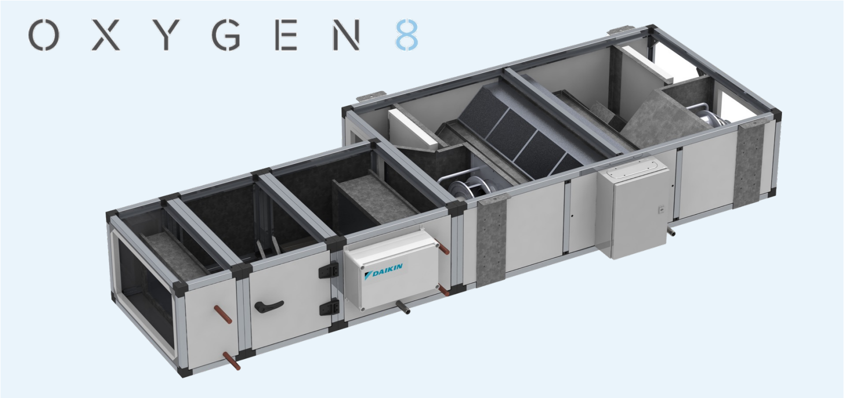
James Dean and Erdem Kokgil | oxygen8.ca

James Dean

- Founder and CEO of Oxygen8
- Cleantech Entrepreneur: Previously founded CORE/dPoint and Greenlight Power
- Passive House Enthusiast

Erdem Kokgil

- Application Engineering Manager at Oxygen8
- Over 15 years of HVAC experience
- PHIUS Consultant



Agenda

- Industry Trends
- Options for Heat and Energy Recovery Ventilation
- What is a DOAS?
- DOAS with Heat Pump/Recovery Systems for All Electric Ventilation and/or Cooling Solution
- Designing for Decentralized Ventilation

Industry Trends: Dynamic Times for Buildings & HVAC Design

More Awareness on IAQ, Ventilation, and Filtration

WH.GOV

Clean Air in Buildings

PLEDGE OPPORTUNITY

Sign the Clean Air in Buildings Pledge

1

Create a Clean Indoor Air Action Plan

Create a plan for upgrades and improvements, including HVAC inspections and maintenance if applicable.

2

Optimize Fresh Air Ventilation

Bring clean outdoor air indoors and circulate it when it is safe to do so.

3

Enhance Air Filtration and Cleaning

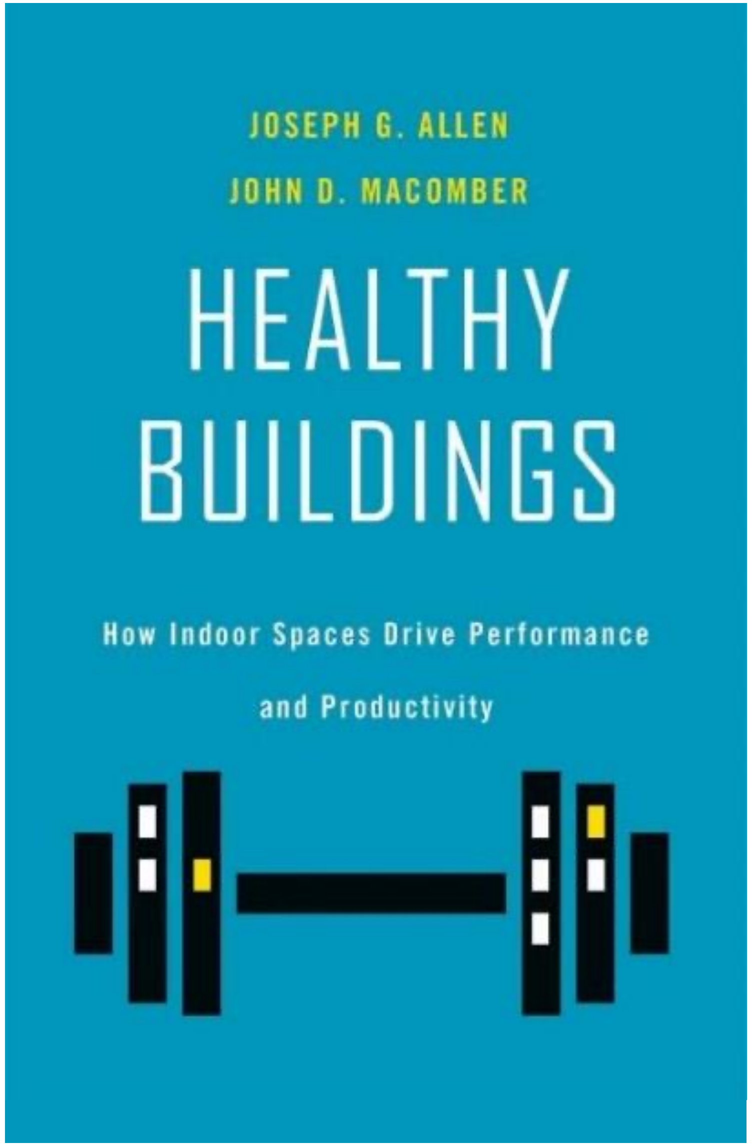
By taking steps such as improving your central HVAC system and/or installing in-room air cleaning devices including HEPA filters.

4

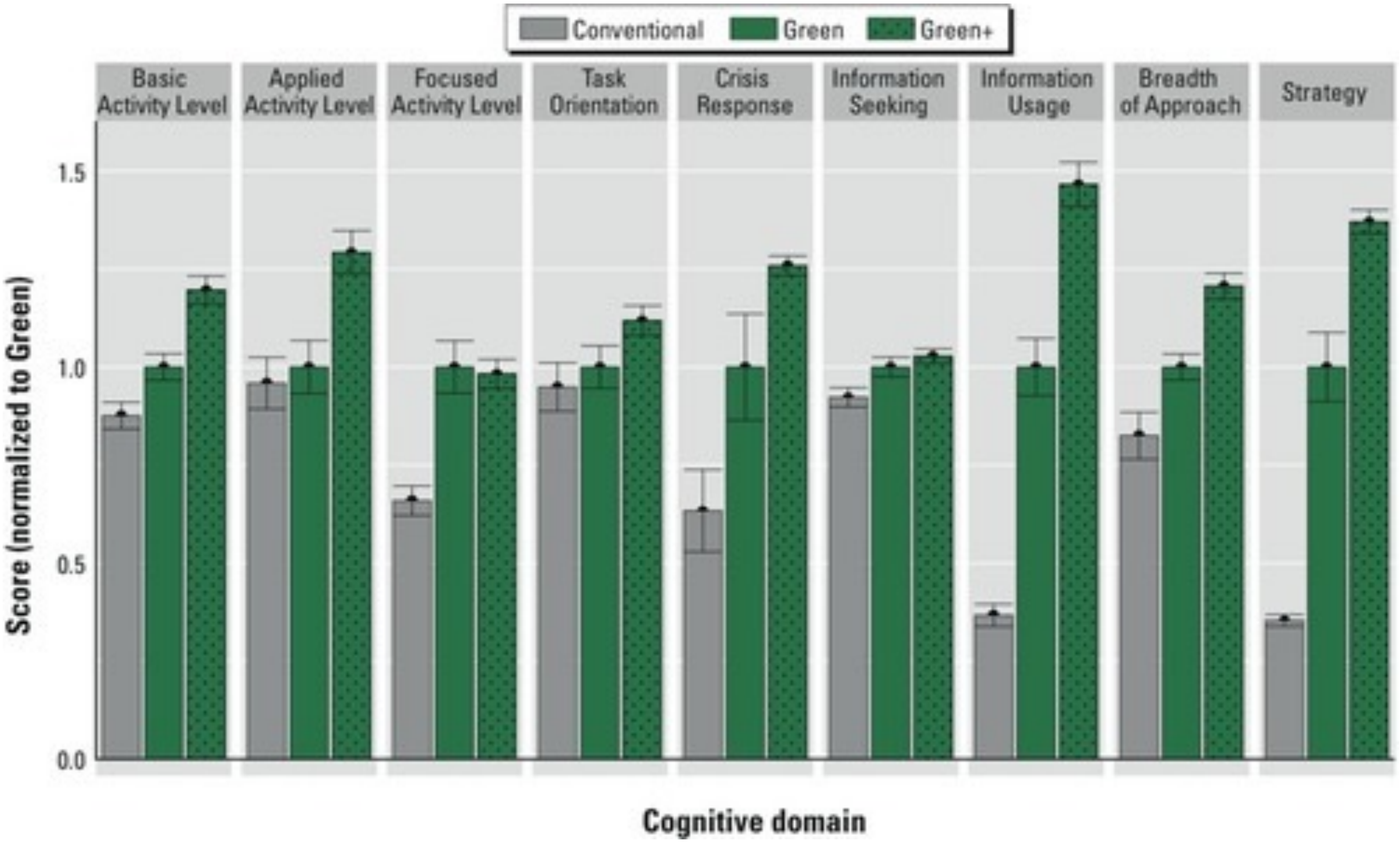
Engage the Building Community

Communicate with building occupants to increase awareness, commitment, and participation.

Healthy Buildings and Cognitive Function



Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments




SUSTAINABILITY

Can Energy Efficiency For Buildings And Indoor Air Quality Ever Be Reconciled?

Jamie Hailstone Contributor

I write about air quality and the environment.

Oct 21, 2022, 03:52am EDT

Forbes

Yes: Increase Ventilation Rates with a Low Energy Penalty

"Increase ventilation rates from 20/cfm/person to 40 cfm/person with a cost of less than $10/person/year"

Joseph Allen

- High Efficiency Energy Recovery Ventilation
- Less Fan Energy: ECM Fans, Lower Pressure Drop from Short Duct Runs
- Bypass for Free Cooling
- Heat-Pumps with a High COP
- Demand Control Ventilation: using Smart Controls

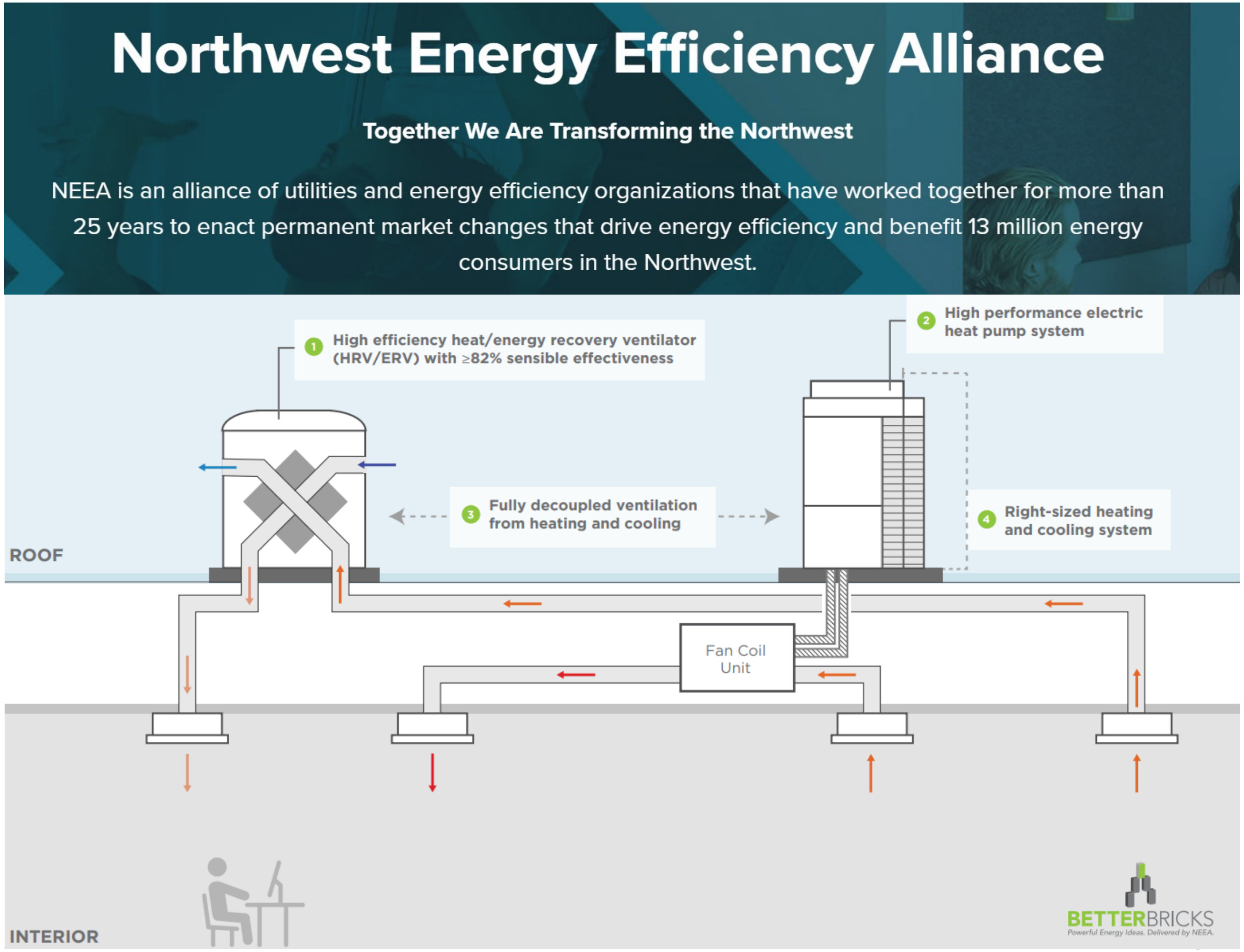
Financial Incentives for Very High Efficiency DOAS

> 82% SRE

Approved List of OEMs

Recommendations

- Variable Speed Fans
- Bypass: Free Cooling
- MERV 13 Filters
- Oversized Ductwork
- Supplemental Heating/Cooling through ERV



More Stringent Building Energy Codes

C403
> 60% Sensible Recovery
or
> 50% Total Recovery
Fan Power: < **1W/cfm**

C406
> 80% Sensible Recovery
Fan Power: < **0.5W/cfm**

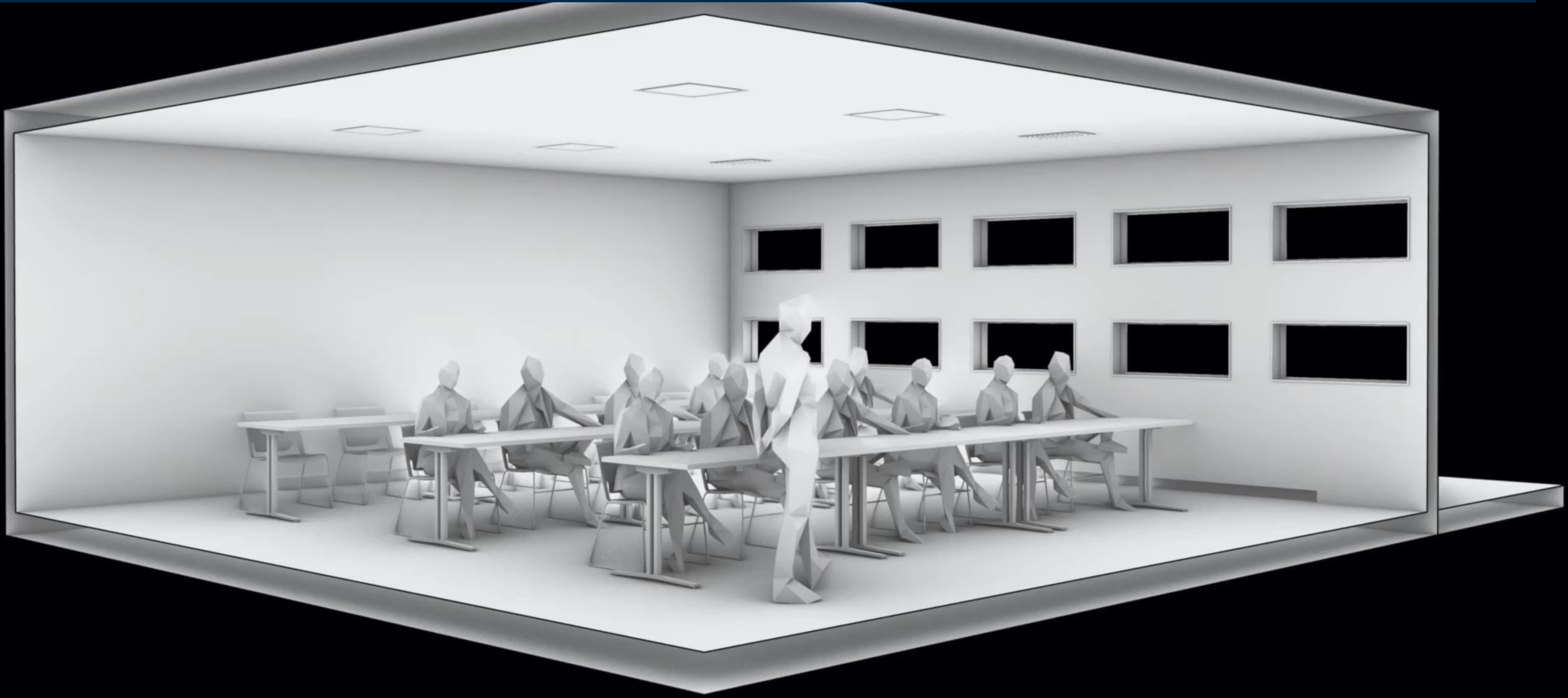
C403 – Mechanical Systems Energy Recovery Ventilation with DOAS

- **403.3.5.1** "The energy recovery system shall have a 60% minimum sensible recovery effectiveness or have 50% enthalpy recovery effectiveness…"
- "… for DOAS having a total fan system motor nameplate hp less than 5 hp, total combined fan power shall not exceed 1 W/cfm of outdoor air.

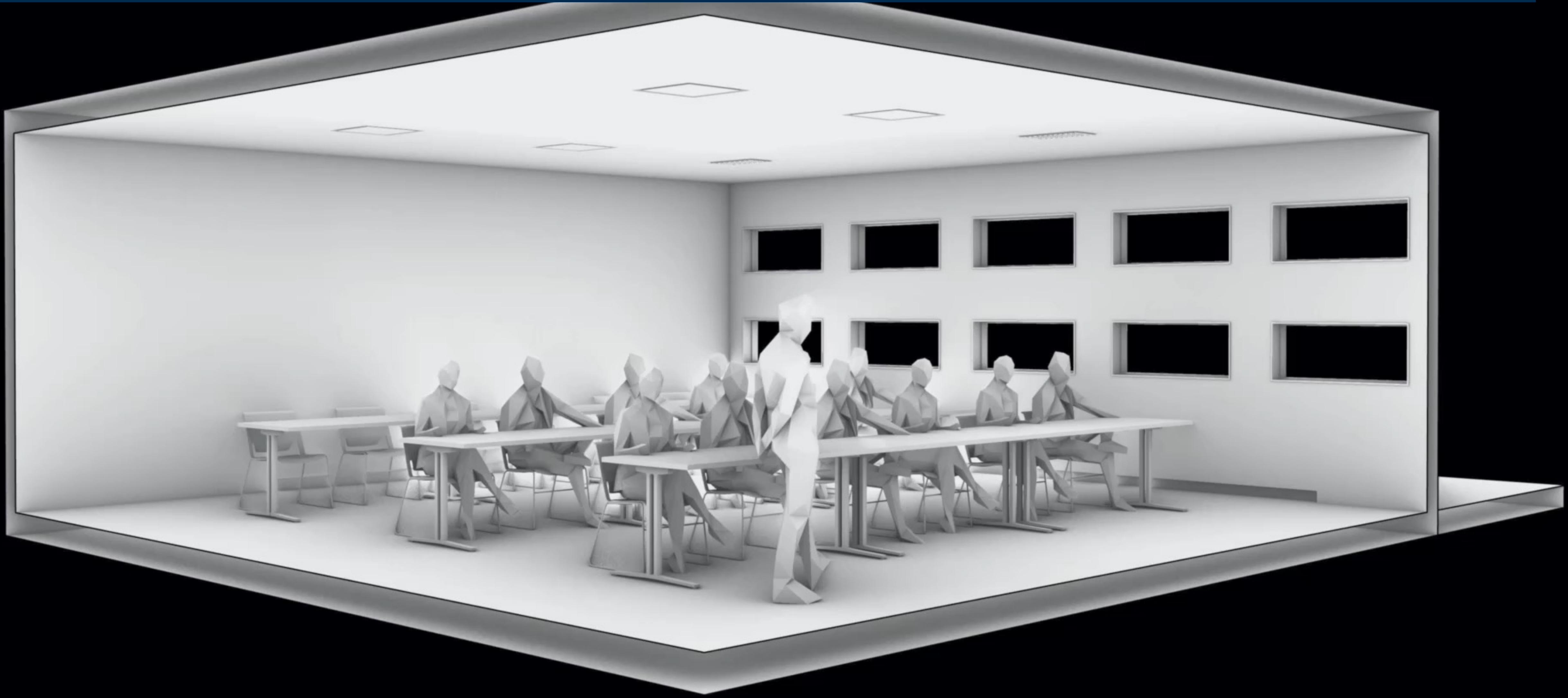
C406 – Efficiency Packages High Performance DOAS

- **C406.1** …" New buildings and changes in space conditioning, change of occupancy and building additions in accordance with Chapter 5 shall comply with sufficient packages from Table C406.1 as to achieve **a minimum number of six credits.** Each area shall be permitted to apply for different packages provided all areas in the building comply with the requirement for six credits. Areas included in the same permit within mixed use buildings shall be permitted to demonstrate compliance by an area weighted average number of credits by building occupancy achieving **a minimum number of six credits.**
- **406.7 High Performance Dedicated Outdoor Air Systems (DOAS)** …"a DOAS complying with Section C406.6 shall also provide minimum sensible effectiveness of heat recovery of 80% and DOAS total combined fan power less than 0.5 W/cfm of outdoor air… total combined fan power includes all supply, exhaust, recirculation and other fans used for the purpose of ventilation."

CFD Analysis: Traditional Overhead Ventilation



CFD Analysis: Displacement Ventilation

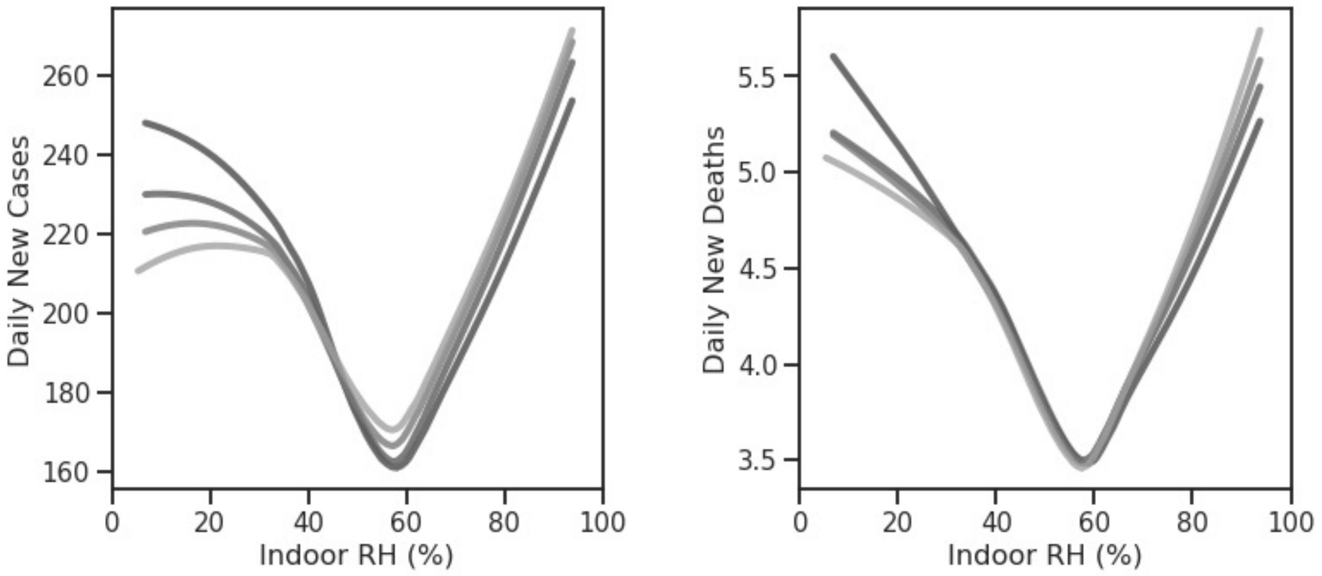


Importance of Relative Humidity

HEALTH

The Right Level of Humidity May Be Important Weapon in Fighting Coronavirus, New Studies Show

BY **DAVID H. FREEDMAN** ON 6/2/20 AT 5:30 AM EDT

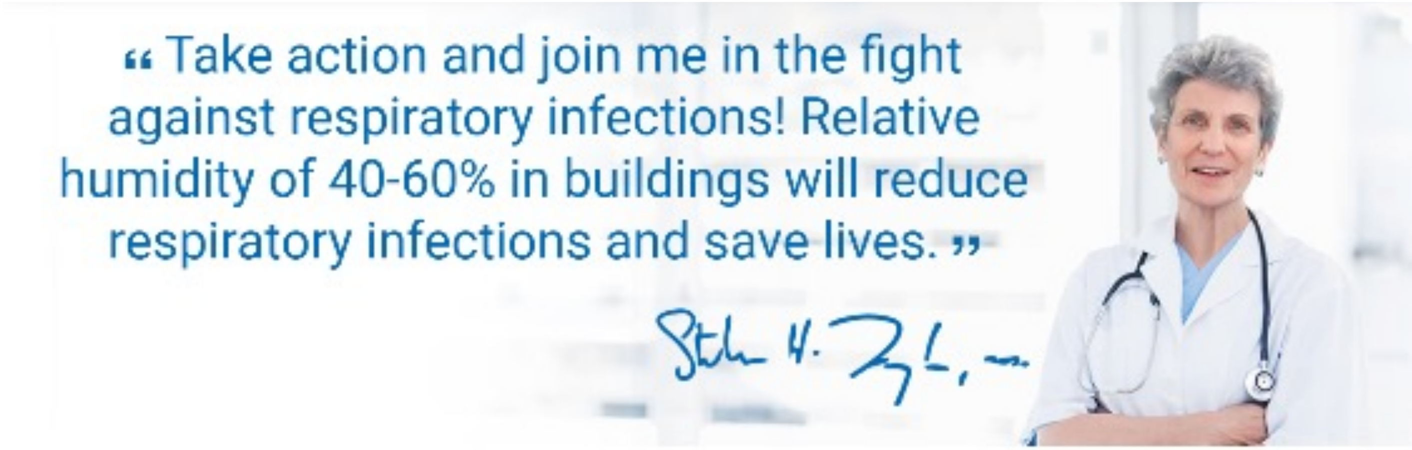


Humidification (Winter)

- Active (Steam)
- Passive (ERV)

Dehumidification (Summer)

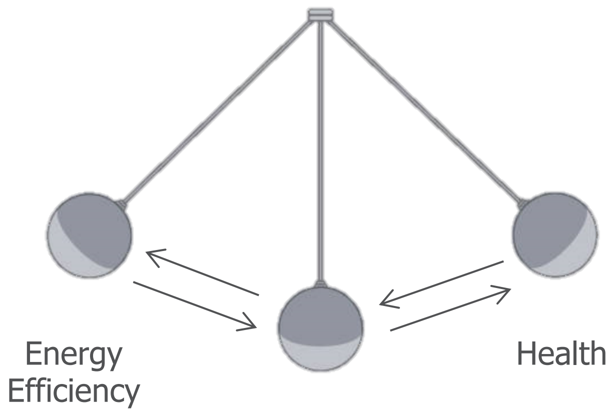
- Active (Heat-Pumps and Hot-Gas Reheat for Low Energy Dehumidification)
- Passive (ERV)

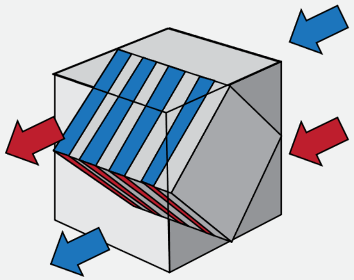
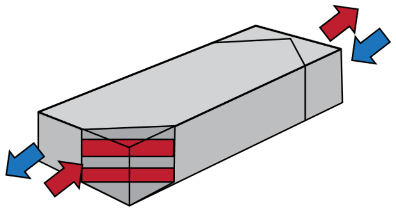
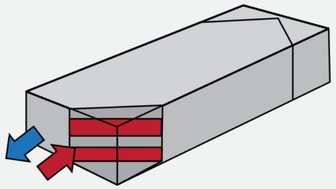
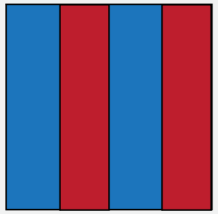
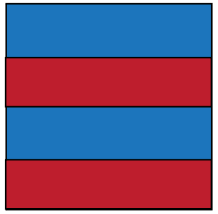
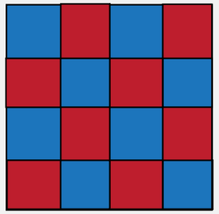


Options for Heat and Energy Recovery Ventilation

Indoor Air Quality vs. Energy Efficiency

Advancements in Energy Recovery Technology



Principle			
Profile			
Counter Current Heat Exchanger	Vertical Flat Plate	Horizontal Flat Plate	Cellular
Efficiency	**ERV: 50-55% TRE**	**ERV: 65-70% TRE**	**HRV: 80-85% TRE**

Enthalpy Core VS. Wheel

Fixed Plate Exchangers

Advantages

Low maintenance, static device

Low transfer of odors to indoor airstream (<0.5% EATR)

Flexible configuration

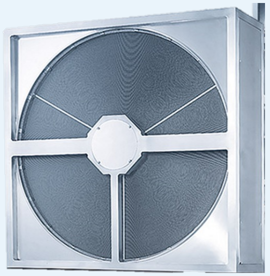
Less expensive in lower airflows

Disadvantages

More expensive than wheels in larger airflows

Lower sensible & latent recovery (cross-flow)

Energy Recovery Wheels



Advantages

Narrow width (shorten length of AHU)

High Sensible and latent recovery

More affordable than Cores in larger airflows

Disadvantages

Maintenance Issues (moving parts)

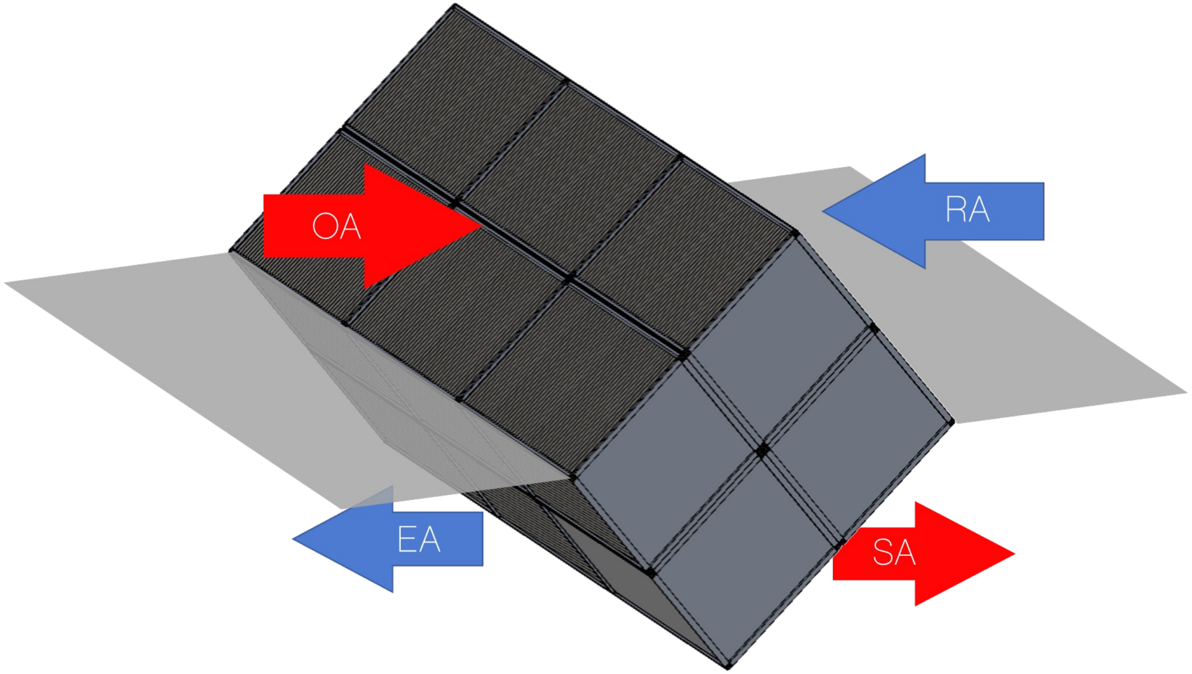
Leakage (higher EATR)

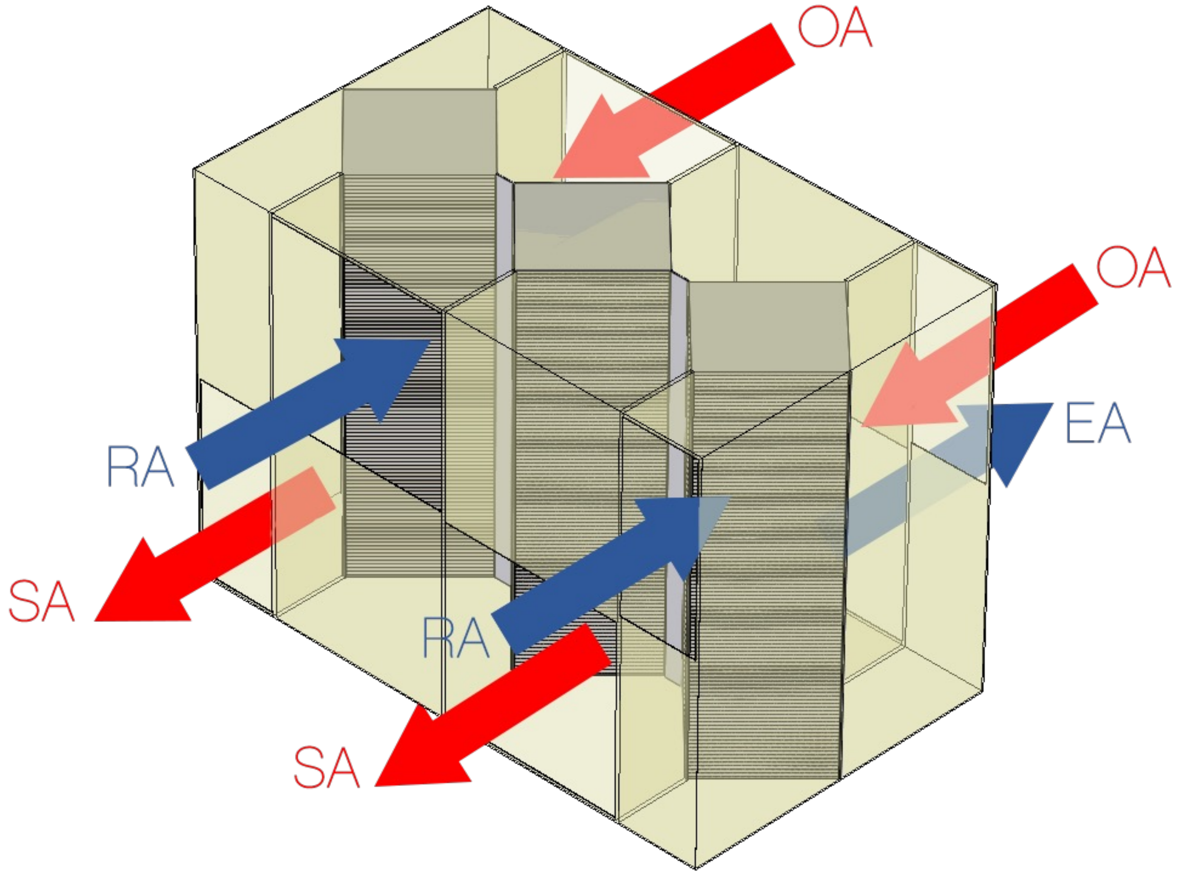
Higher OACF

Potential for "dirty sock smell"

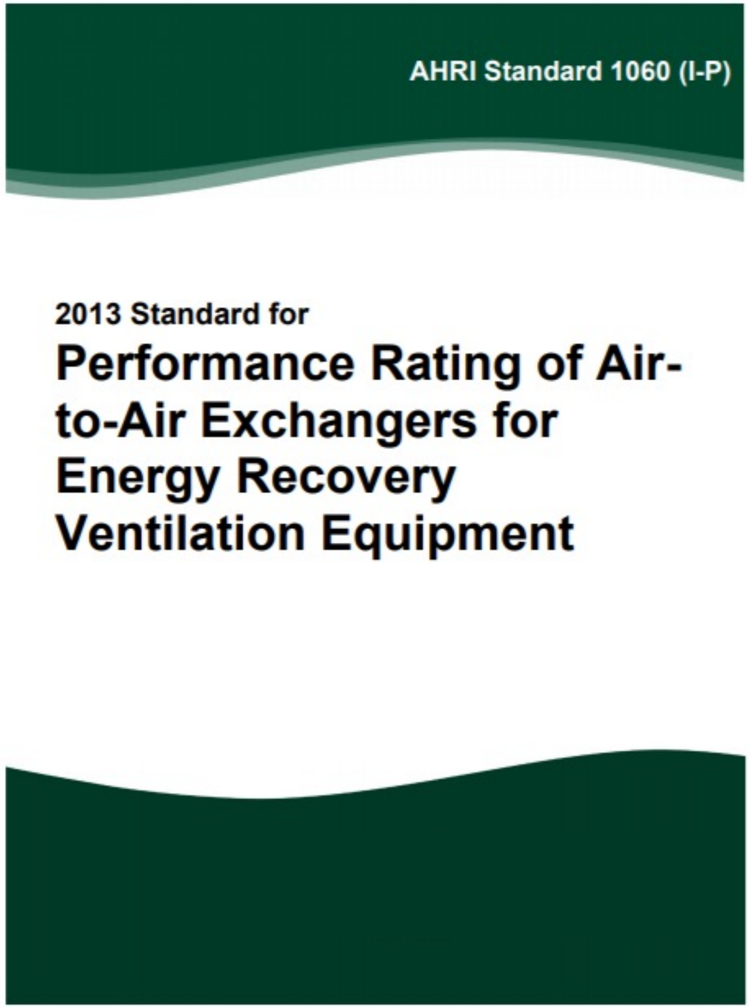
Potential latent decline over time

Fixed Plate Exchanger Flow Configurations





Energy Recovery Certification Programs


AHRI Standard 1060 (I-P)

2013 Standard for

Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment

Commercial H/ERVs

Residential H/ERVs

AHRI 1060: Key Performance Metrics

Performance

Sensible effectiveness

Latent effectiveness

Total effectiveness

Pressure Drop

Leakage

Exhaust Air Transfer Ratio (EATR)
Cross Contamination

Outdoor Air Correction Factor (OACF)
Cross Leakage

HVI Certified Products Directory, CSA439

Model Detail

Brand Owner	Oxygen8 Solutions Inc	Brand Name	Oxygen8	Model	Vita 120HRV
Product Category	HRVs				

Volts	Amps	EATR 50	EATR 100
120		2.3	2.5

Airflow Ratings

Ext. Static Pressure (Pa)	Ext. Static Pressure (in. wg)	Net Supply Airflow (L/s)	Net Supply Airflow (cfm)
25	0.1	56	119
50	0.2	55	117
75	0.3	53	112
100	0.4	50	106
125	0.5	48	102
150	0.6	45	95
175	0.7	42	89
200	0.8	38	81
225	0.9	35	74

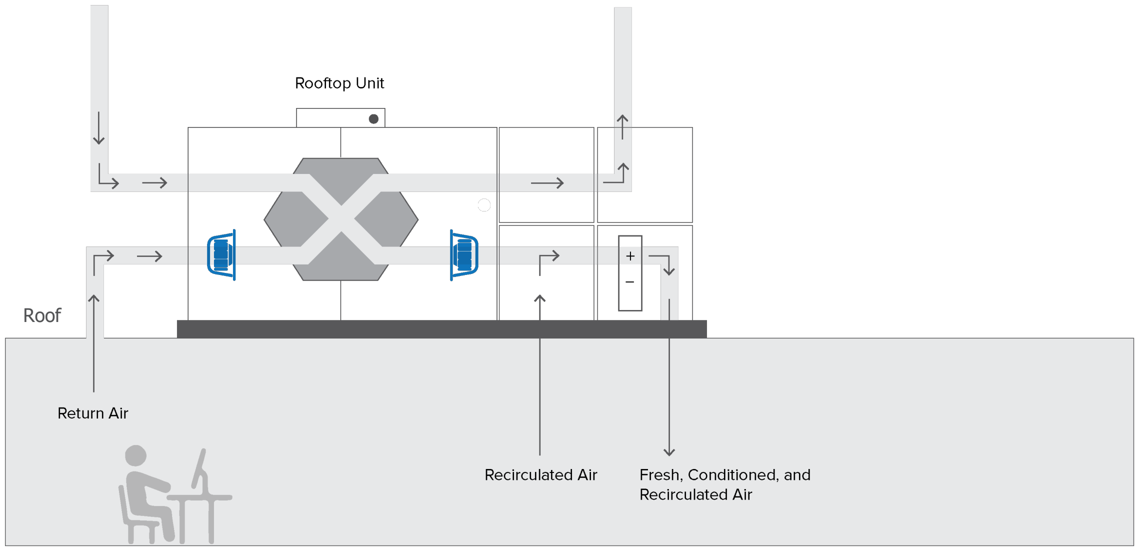
Energy Ratings

Brand Name	Model	Temp Mode	Â°C2	Â°F2	Net Airflow (L/s)	Net Airflow (cfm)	Power Consumed (Watts)	SRE	ASRE	Latent Recovery / Moisture Transfer
Oxygen8	Vita 120HRV	HEATING	0	32	30.0	64	32	82.0	86	0.00
Oxygen8	Vita 120HRV	HEATING	0	32	37.0	78	46	80.0	84	0.00
Oxygen8	Vita 120HRV	HEATING	0	32	43.0	91	56	78.0	83	0.00

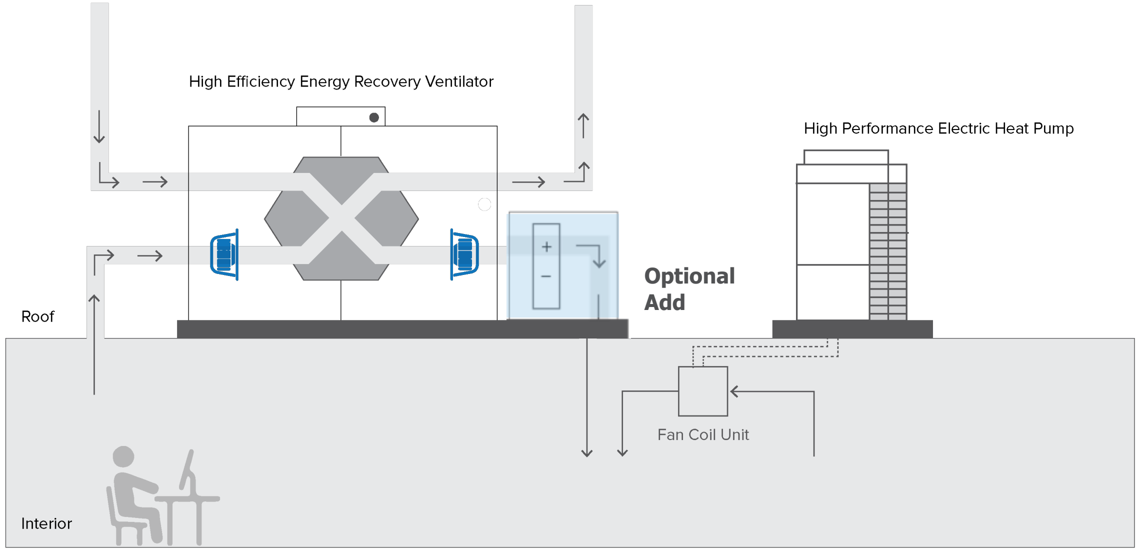
Integrating DOAS with Heat Pump/Recovery Systems

What is a DOAS?

"A **dedicated outdoor air system (DOAS)** is a type of heating, ventilation and air-conditioning (HVAC) system that consists of two parallel systems: a dedicated system for delivering outdoor air ventilation that handles both the latent and sensible loads of conditioning the ventilation air, and a parallel system to handle the (mostly sensible heat) loads generated by indoor/process sources and those that pass through the building enclosure."



Ventilation + Heating + Cooling in One Rooftop Unit



Ventilation System & Heating + Cooling System

High Efficiency Split DOAS

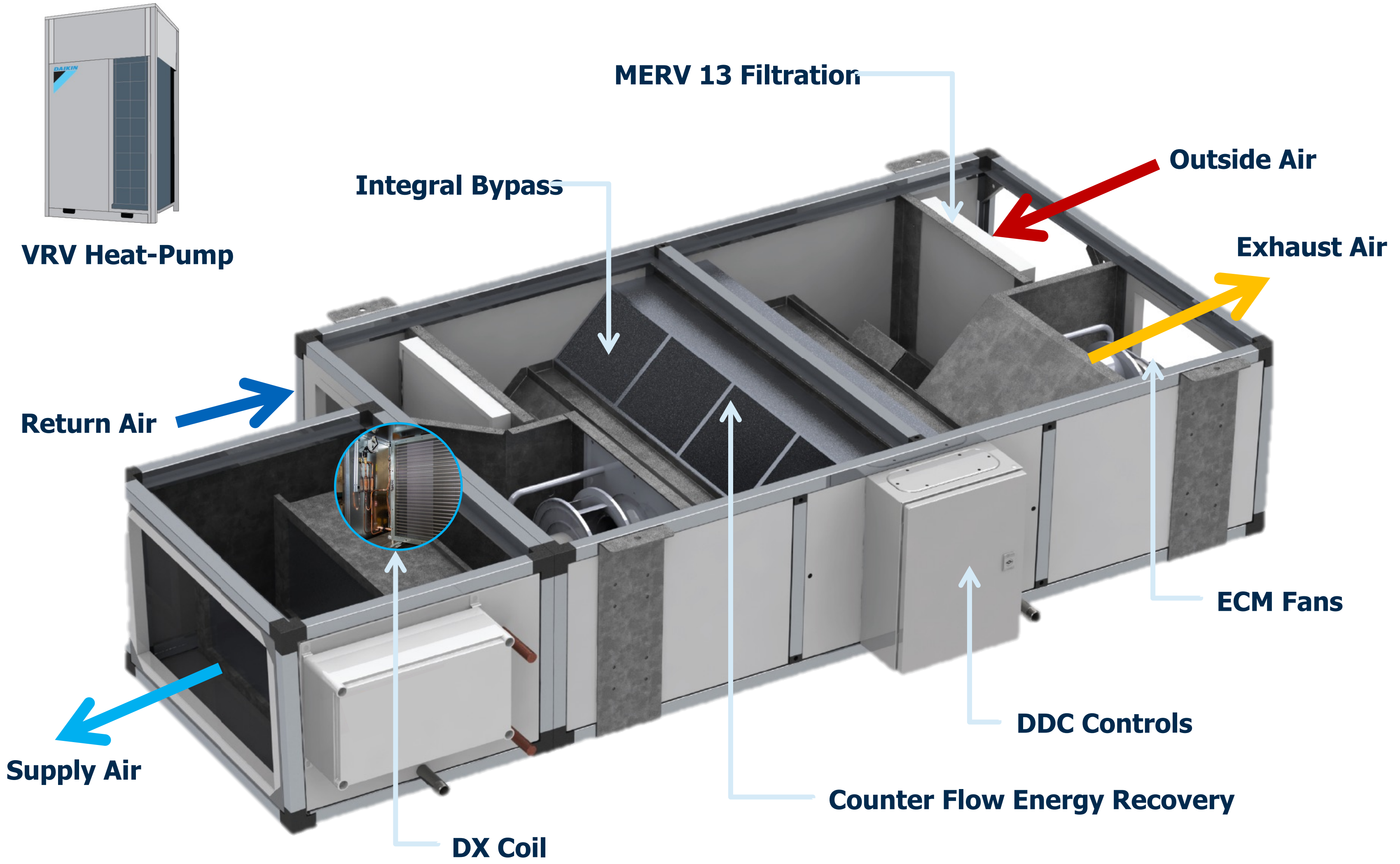
Counter Flow Energy Recovery
~75% SRE, ~62% LRE, ~70% TRE

ECM Fans
<1 W/CFM

Enthalpy Controlled bypass
Benefit economizer hours, free cooling

Electric Heat Pump
COP 3-4

Temperature Control
Cooling or heating



High Efficiency Split DOAS: Chicago Conditions

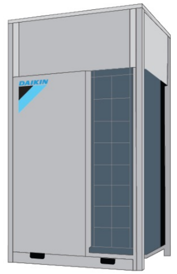
Summer
OA 92F DB/75F WB
RA 75F DB/63F WB
Airflow
SA/RA 2000CFM
ESP 0.75 in.w.c.

Counter Flow Energy Recovery
73.7% SRE, 64.4% LRE, 68.3% TRE

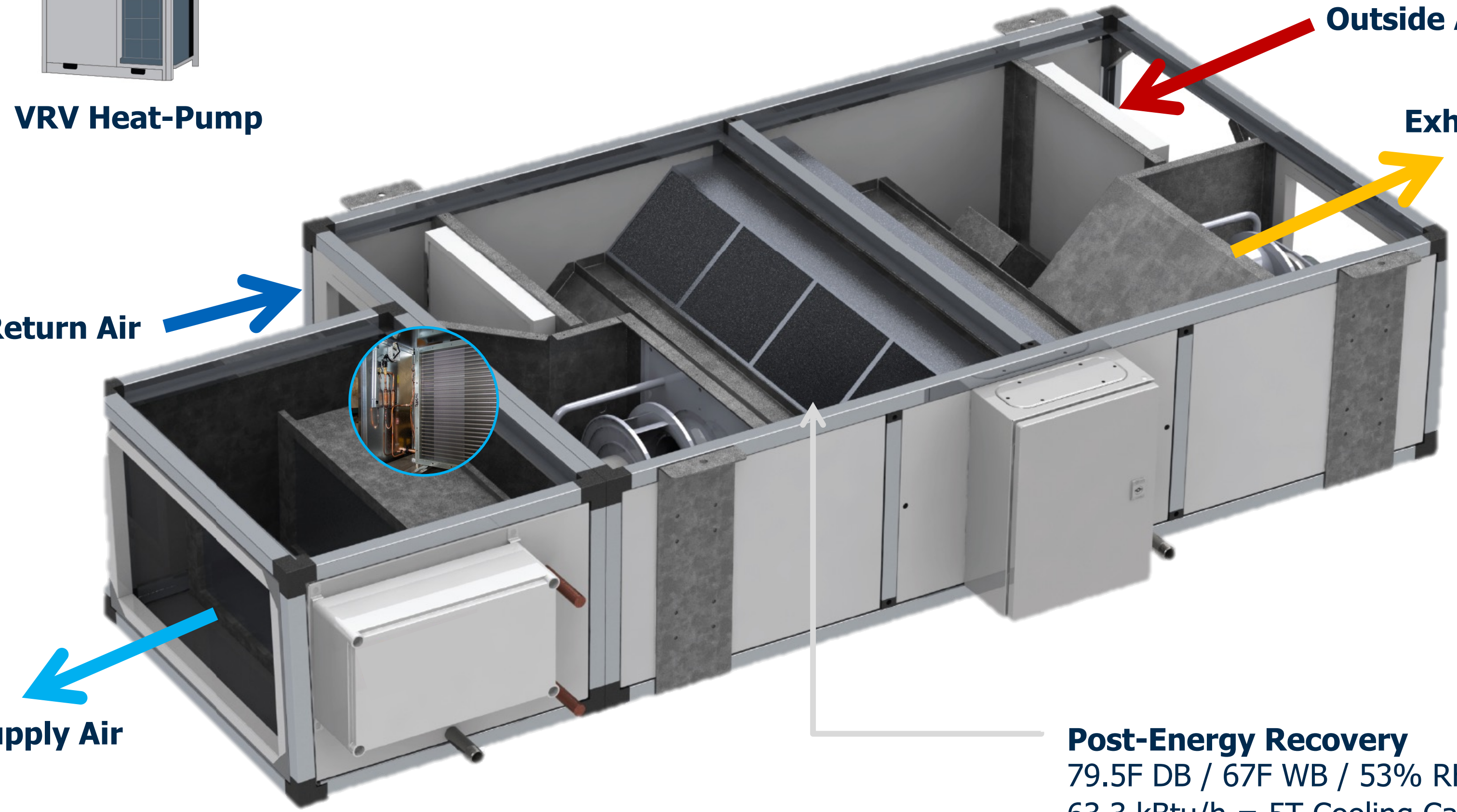
ECM Fans (Supply + Return)
0.76 W/CFM

Temperature Control
Cooling=55 F

Electric Heat Pump
COP 3-4



VRV Heat-Pump



Post-Energy Recovery
79.5F DB / 67F WB / 53% RH
63.3 kBtu/h = 5T Cooling Capacity Savings

Dehumidification with Split DOAS

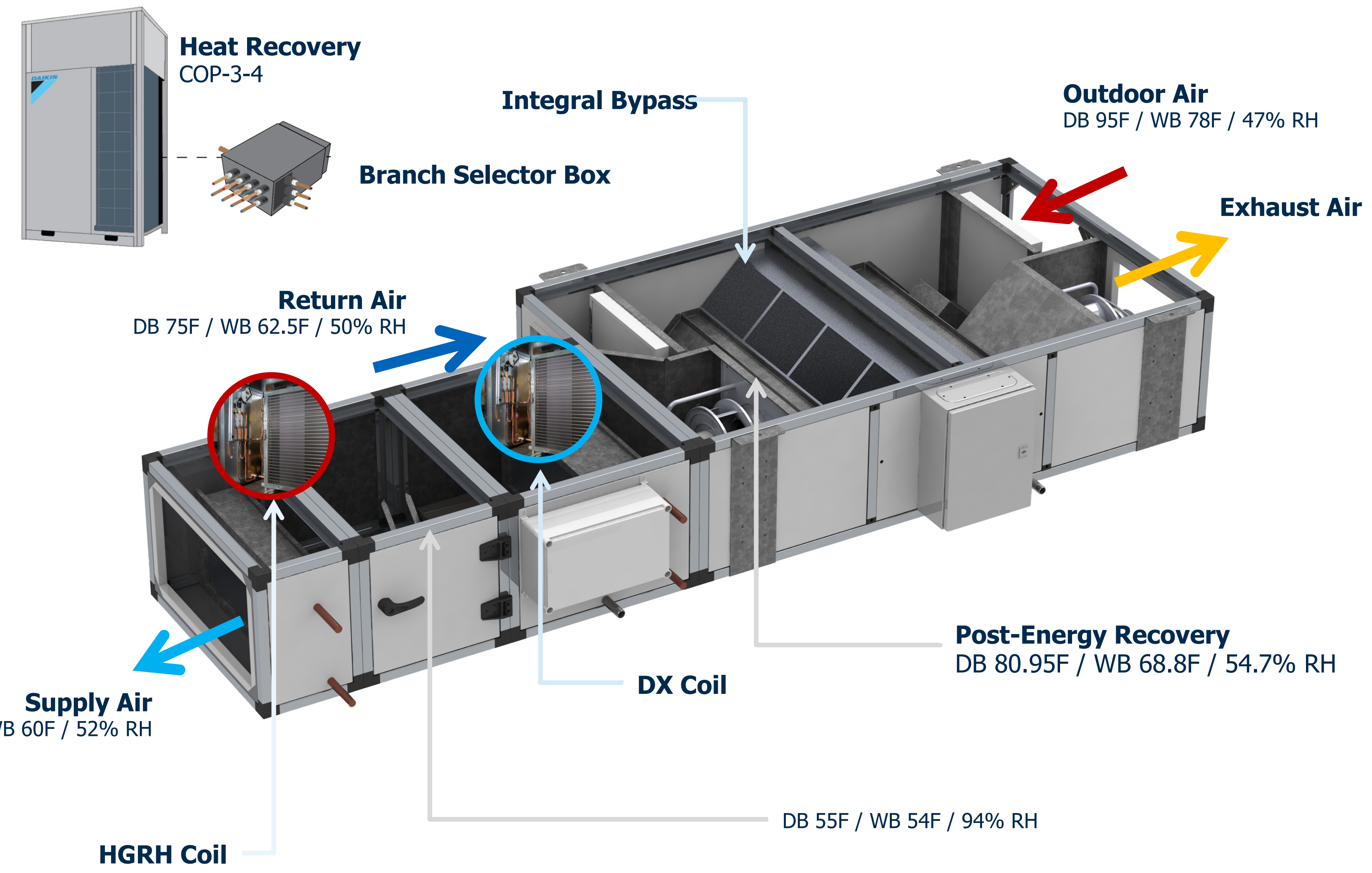
Counter Flow Energy Recovery
~75% SRE, ~62% LRE, ~70% TRE

ECM Fans
<1 watt/cfm

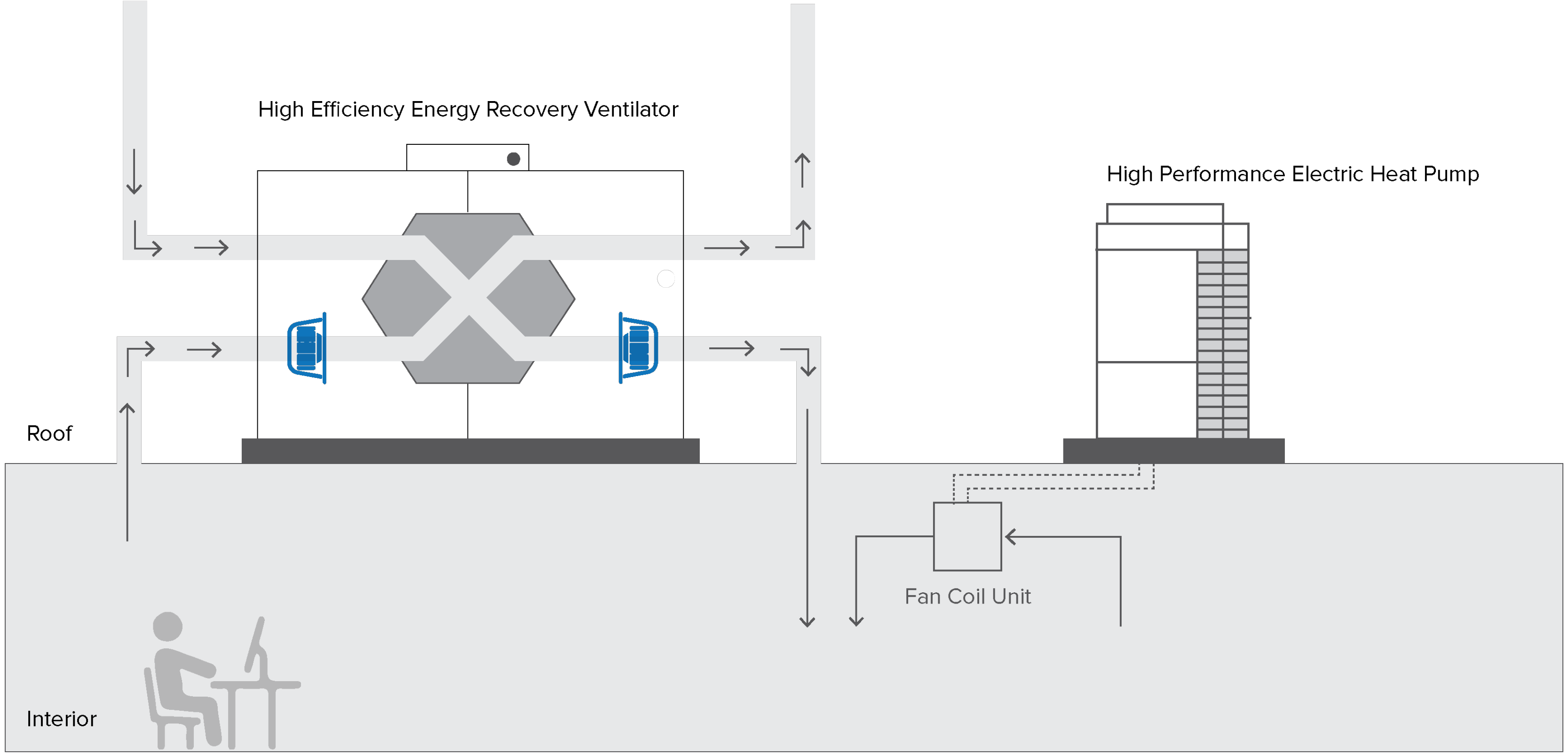
Enthalpy Controlled bypass
Benefit economizer hours, free cooling

Electric Heat Recovery
COP 3-4

Temperature & Humidity Control
Simultaneous cooling & heating



Typical Office Building Sizing Exercise



Ventilation Rate Procedure Calculation

$V_{bz} = R_p \times P_z + R_a \times A_z$

$V_{bz} = [5 \times 120] + [0.06 \times 10{,}000] =$ **1,200CFM**

$[1{,}200 \times 60] \div [10{,}000 \times 9] =$ **0.8 ACH**

$1200 \div 120 =$ **10 CFM/person**

Cooling Capacity of Ventilation Air

$Q_T = 4.5 \times CFM \times (h_2 - h_1)$

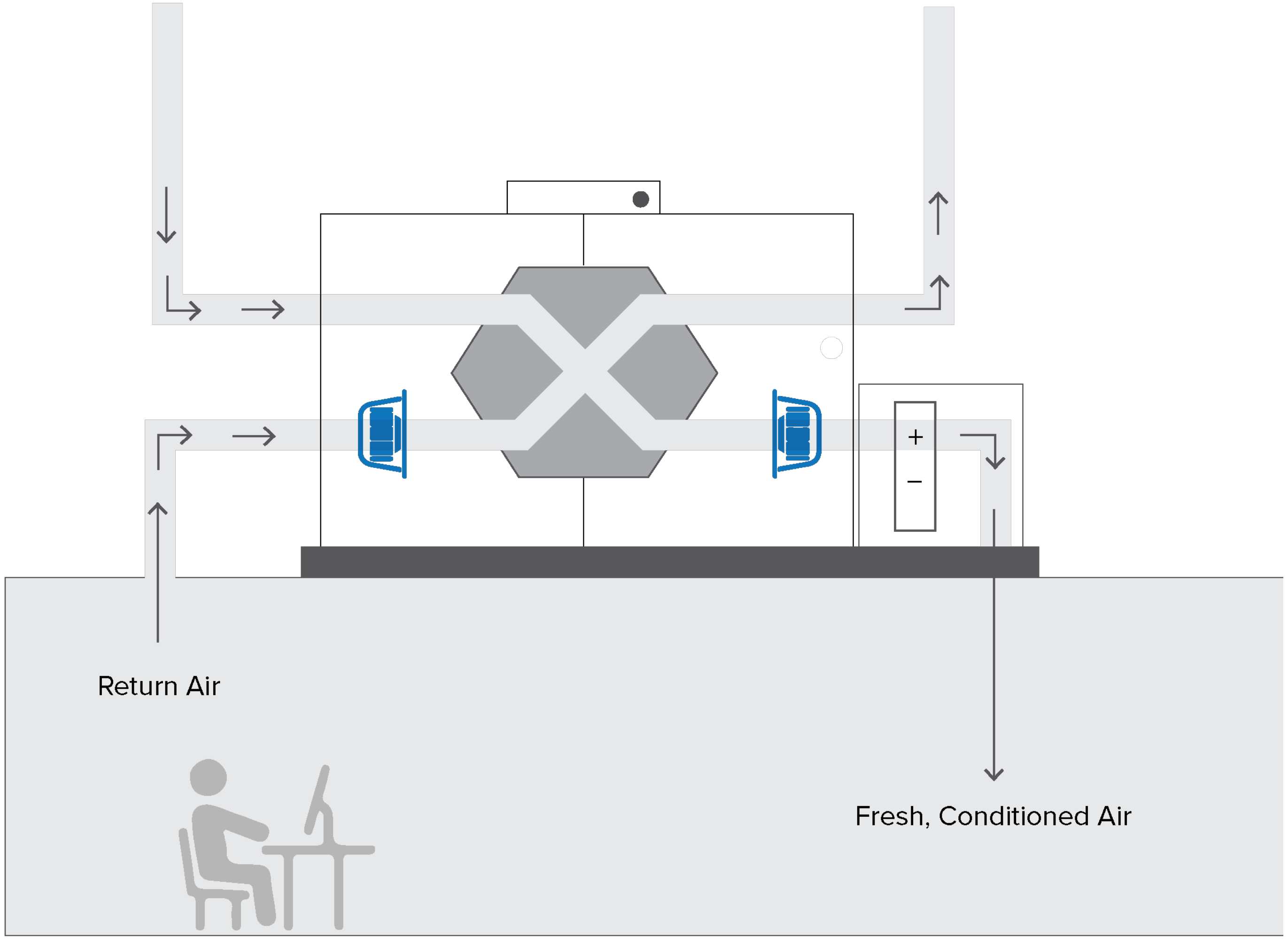
$Q_T = 4.5 \times 1{,}200 \times (28.15 - 22.6) = 29{,}970$ Btu/h $\div$ 10,000 = **2.99 Btu/sqft.h**

h_1 is the enthalpy of 55F/54F=22.6 Btu/lb

h_2 is enthalpy of 75F, 50%RH=28.15 Btu/lb

10,000 sq. ft. (9' ceilings) | 120 Occupants | ASHRAE 62.1 2019 Minimum Ventilation Rate

Ventilative Cooling



Increase the ventilation rate to the point where heating and cooling is no longer required, while improving the overall IAQ!

	0.8 ACH	1.6 ACH	3 ACH	6 ACH
Ventilation Rate (CFM)	1200	2400	4500	9000
CFM/person	10	20	37.5	75
Cooling Capacity of Ventilation Air (Btu/sqft.h)	3	6	11.25	22.5
Additional H&C System Required?	Yes	Yes	Maybe	No

Ventilative Cooling

Study conducted on a 16-story institutional high rise building with BAS in Montreal, Canada. Measured data from the BAS were used to validate models.

Key Findings

- Ventilative cooling can achieve huge amount of saving (up to 43%)
- Savings achieved with low SFP
- Decentralized ventilation has better energy savings (SFP of decentralized ventilation is 50% lower than centralized ventilation in high rise buildings)

ELSEVIER

Contents lists available at ScienceDirect

Energy & Buildings

journal homepage: www.elsevier.com/locate/enb

Investigation of mechanical ventilation for cooling in high-rise buildings

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A R T I C L E I N F O

Article history:
Received 13 April 2020
Revised 11 July 2020
Accepted 30 August 2020
Available online 16 September 2020

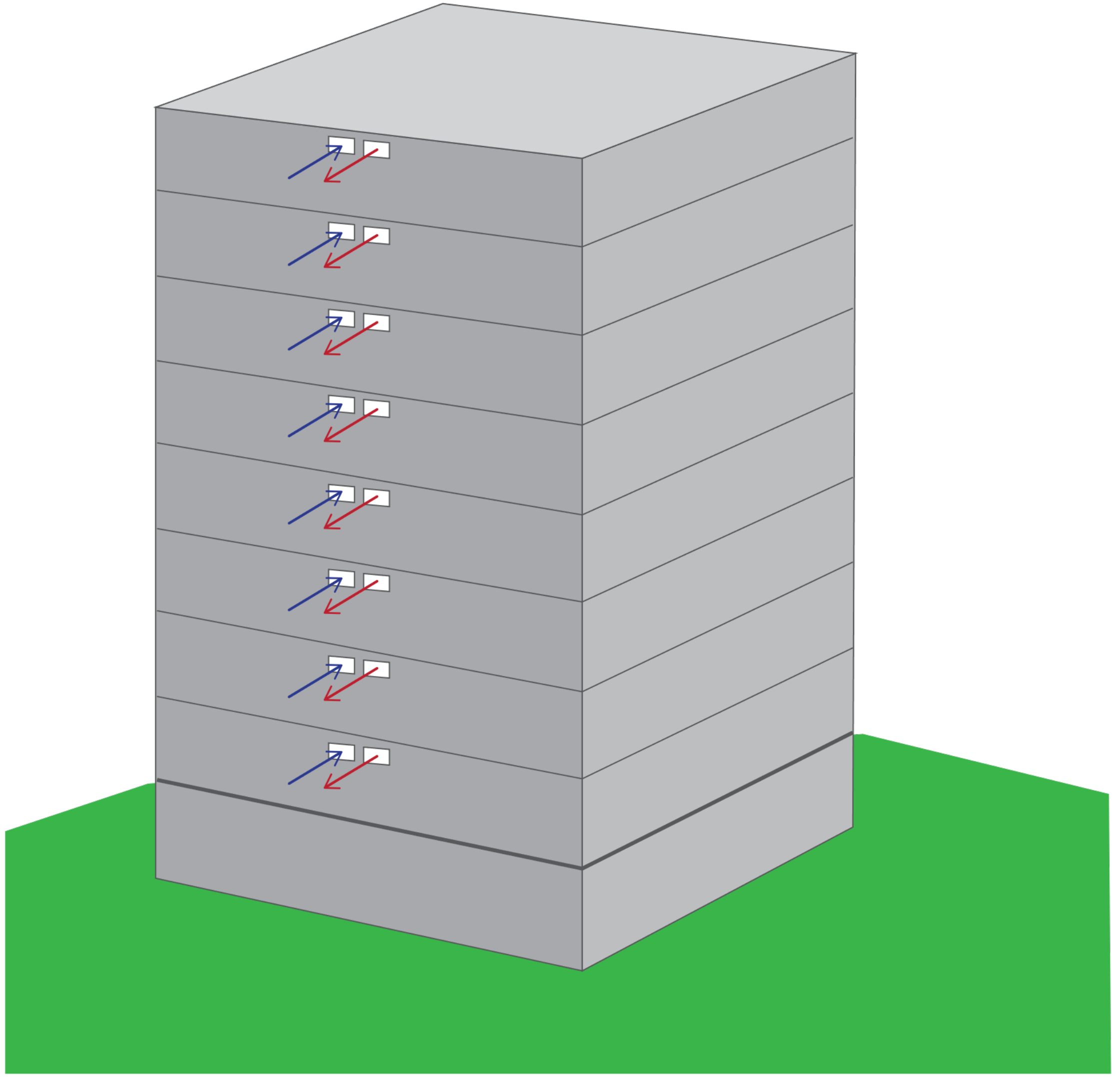
Keywords:
Mechanical ventilation
Ventilative cooling
Building energy
High-rise buildings

A B S T R A C T

Cooling-related energy consumption is growing rapidly in buildings. High-rise buildings usually have high cooling loads and cooling-related energy consumptions. Reducing the cooling load of high-rise buildings is critical for decreasing cooling-related energy consumption and peak electricity demand. Due to their cold climates, ventilative cooling (VC) is available for a long time throughout the year in Canada and Northern Europe, not only during shoulder seasons, but also in summer periods. Mechanical ventilation is an option for providing VC and reducing high-rise cooling load. However, the mechanical ventilation system in high-rise buildings is typically designed and used for maintaining indoor air quality, rather than for removing indoor heat. This study aims to use the mechanical ventilation system for VC in high-rise buildings and explore the associated energy saving approaches. Energy models of components in the cooling system were developed. Based on the models developed, different energy saving approaches were proposed, including applying the optimal control method, using energy efficient fans, and increasing nominal fan flow rates. A case study was conducted on an institutional high-rise building to validate the models developed and evaluate the proposed energy saving approaches. It was found that with energy efficient fans, applying the optimal control method and increasing the nominal ventilation flow rate can achieve energy savings for cooling. Increasing the optimal nominal ventilation rate further does not significantly increase energy savings. The conclusions of this study provide vital information regarding high-rise VC for new building design and HVAC system retrofit in existing buildings.

Designing for Decentralized Ventilation

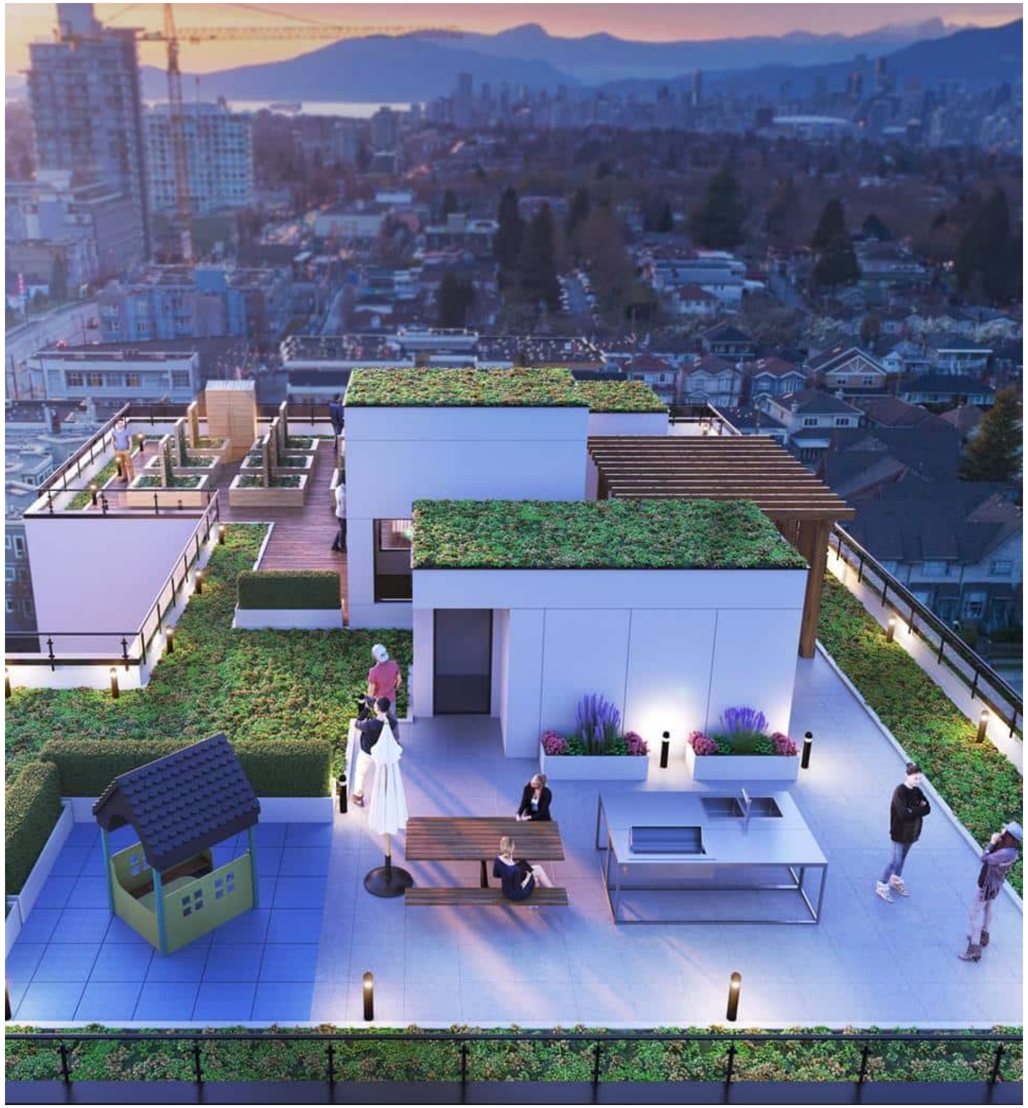
Decentralized Ventilation: What is It?



Decentralized System Construction

- Distributed mechanical system designs turn one building into many buildings constructed on a single structure.
- Many complexities associated with large systems, like stack effect, are mitigated by drastically shrinking system size.

Decentralized Ventilation in Offices

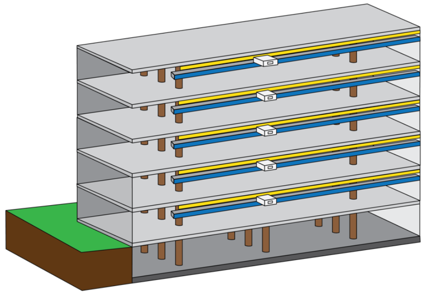


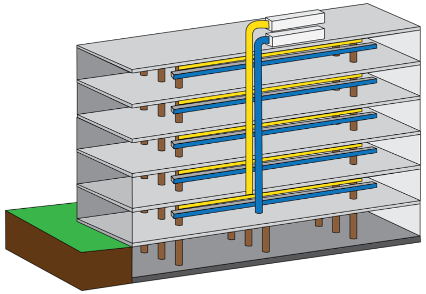
Advantages

1. Frees up space and does not require any roof penetrations
2. Easier to control flow of air to zones (DCV)
3. No smoke/fire dampers
4. No vertical duct chases
5. Longer equipment life
6. Low fan energy (with short duct runs)
7. Redundancy (with multiple units)
8. Easy to install for ventilation retrofits

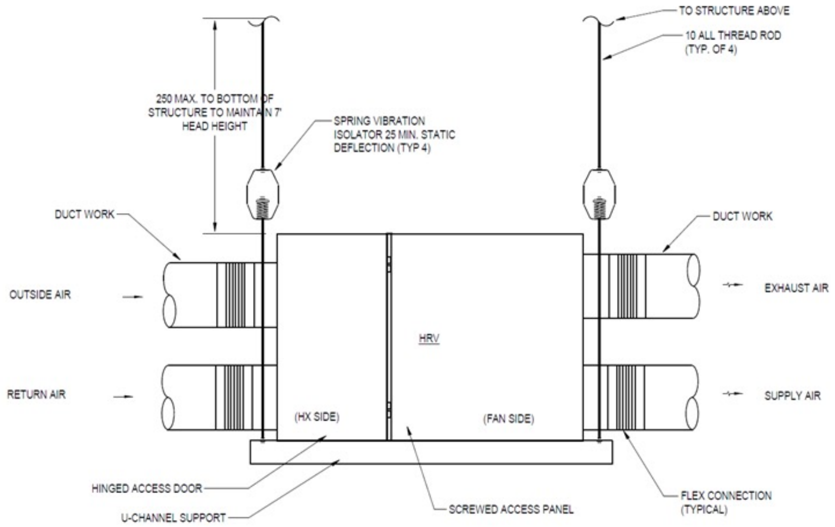
Disadvantages

1. More maintenance for filters
2. Need space in the ceiling, wall or small mechanical room
3. Additional louvers to building envelope



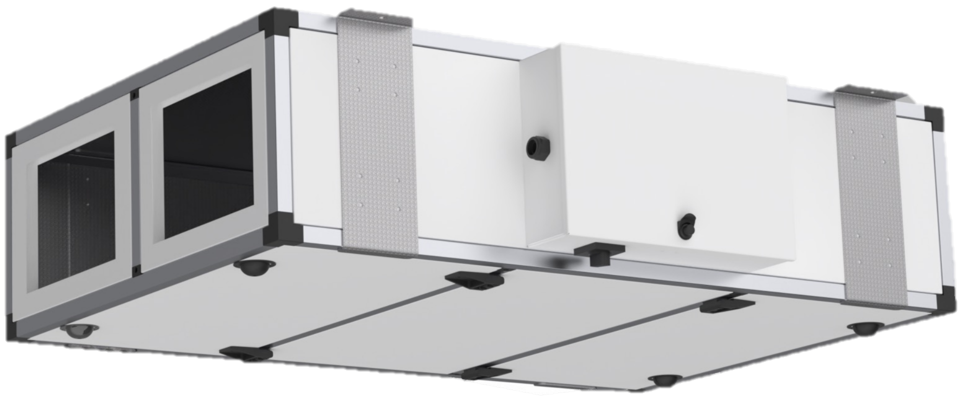


Decentralized Ventilation in a New Office Tower

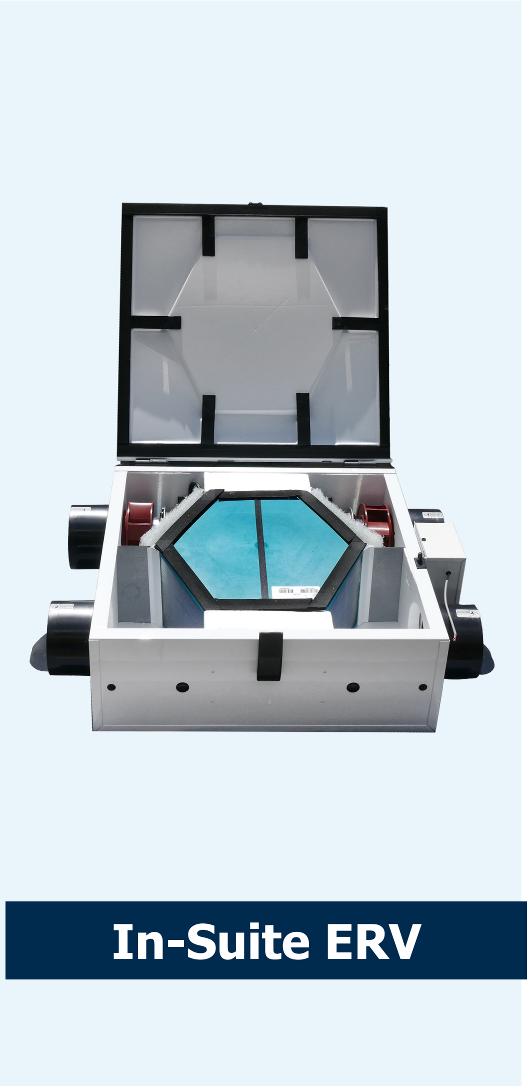


Life Span

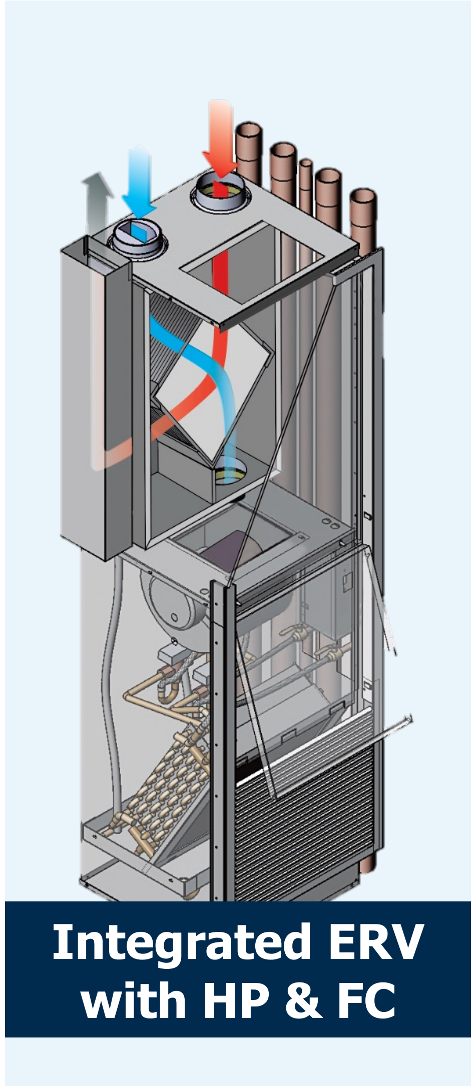
Packaged systems are located on the roof of the building, the units are exposed to the elements and are more susceptible to weather damage and rust



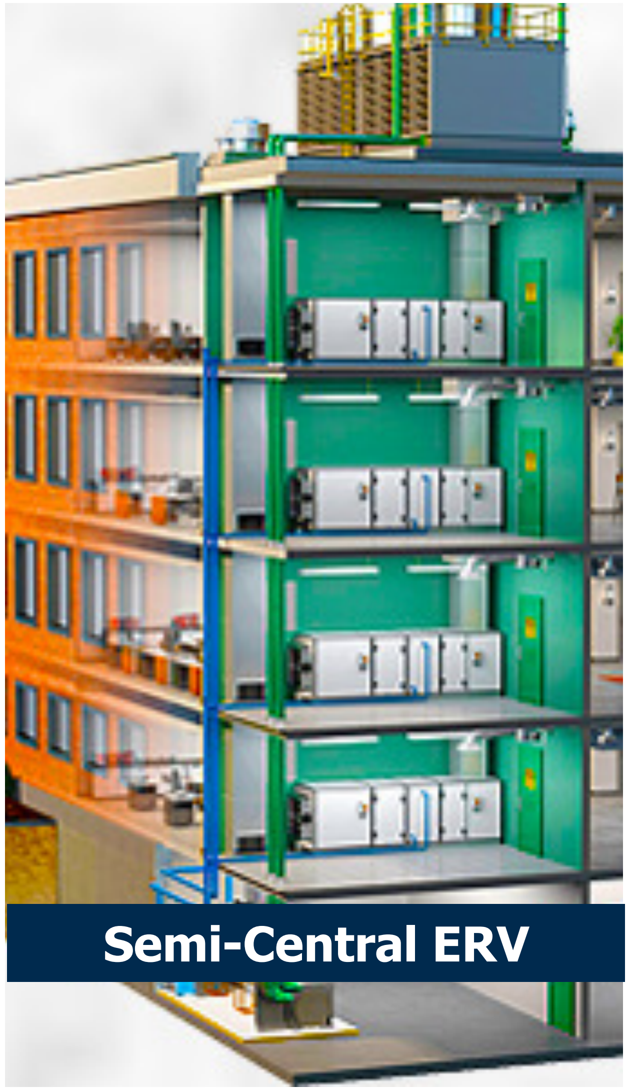
Decentralized Ventilation for Multi-Unit Residential



In-Suite ERV



Integrated ERV with HP & FC



Semi-Central ERV

Central ERV

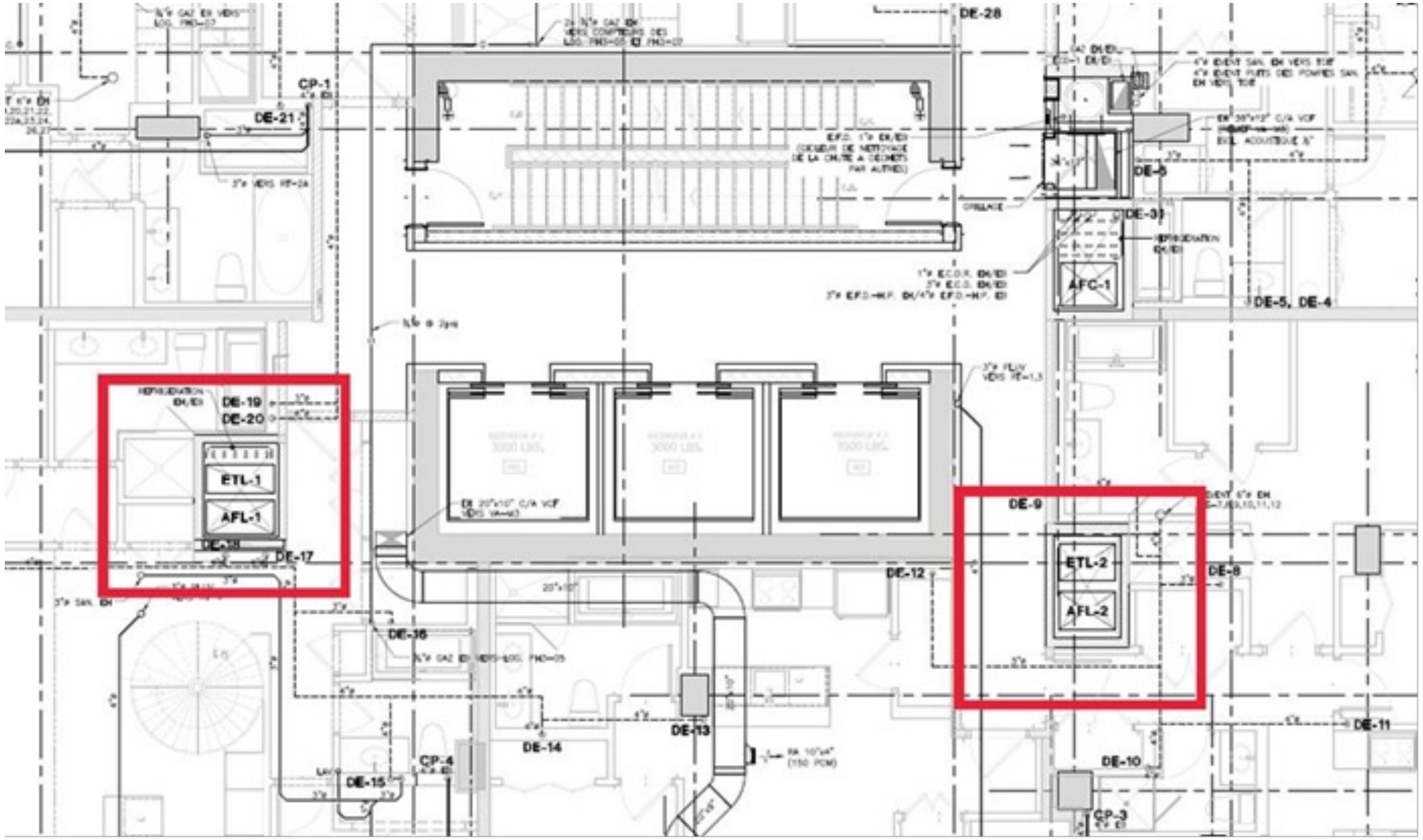
Comparison of Buildings with Different Approaches to ERV

Montreal
(Central ERV)

Vancouver
(In-suite ERV)

Toronto
(ERV Integrated with Fan-coil)

Central ERV: Lost Floor Space from Duct Chases

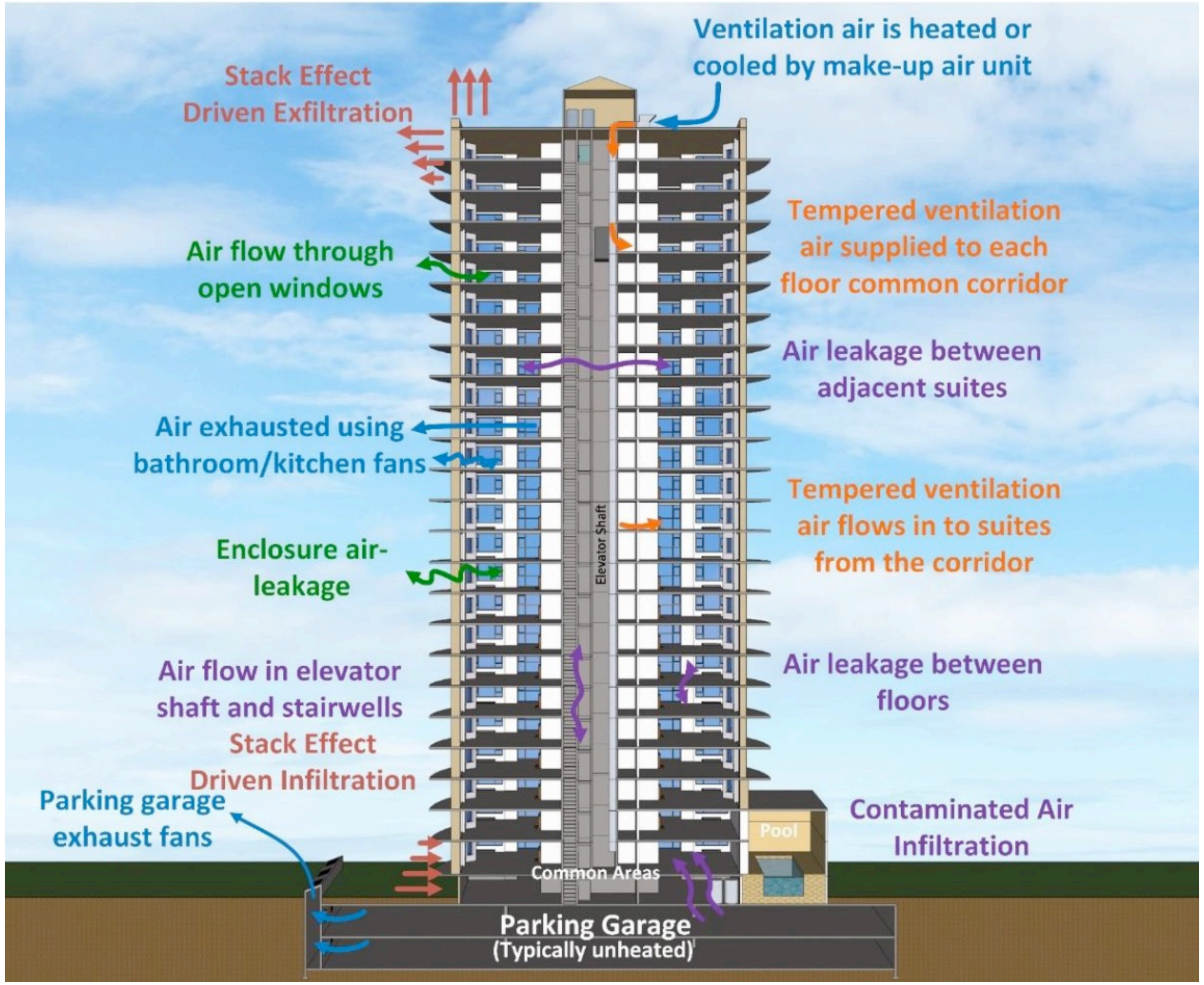


780 ft^2 (72.5 m^2) of chases x \$1000/ft^2 = **\$780,000 in Sales** **|** 250 Suites @ \$960/ERV = **\$240,000 (Total ERV Cost)**

NYC: \$2,577/sq-ft Toronto: \$1,000/sq-ft Vancouver: \$1,200/sq-ft Montreal: \$500/sq-ft

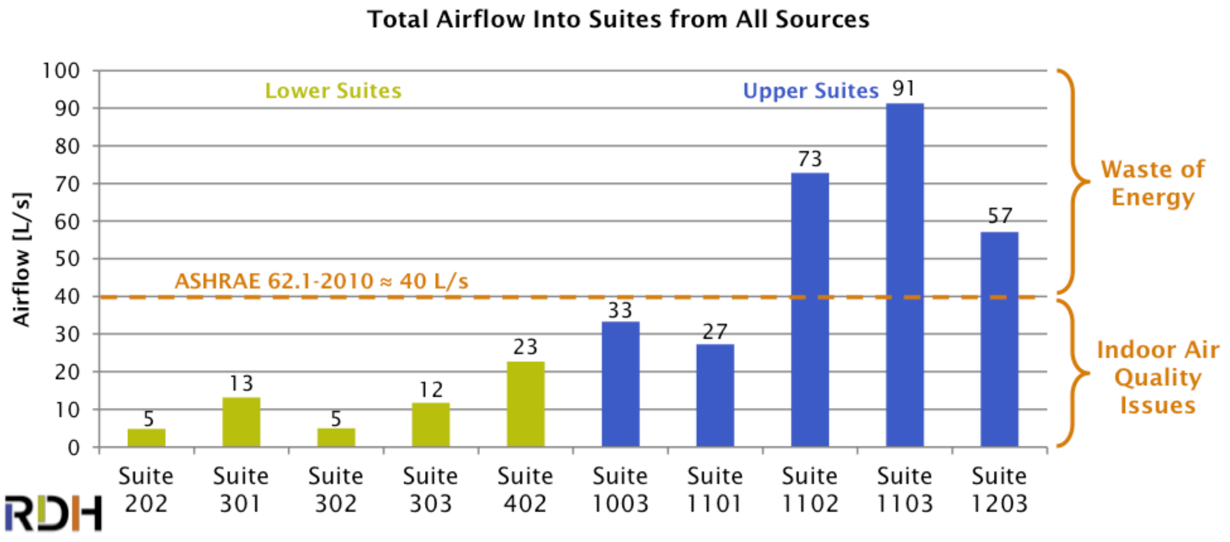
RDH Study: Pressurized Corridor Impact on IAQ

Vancouver, BC

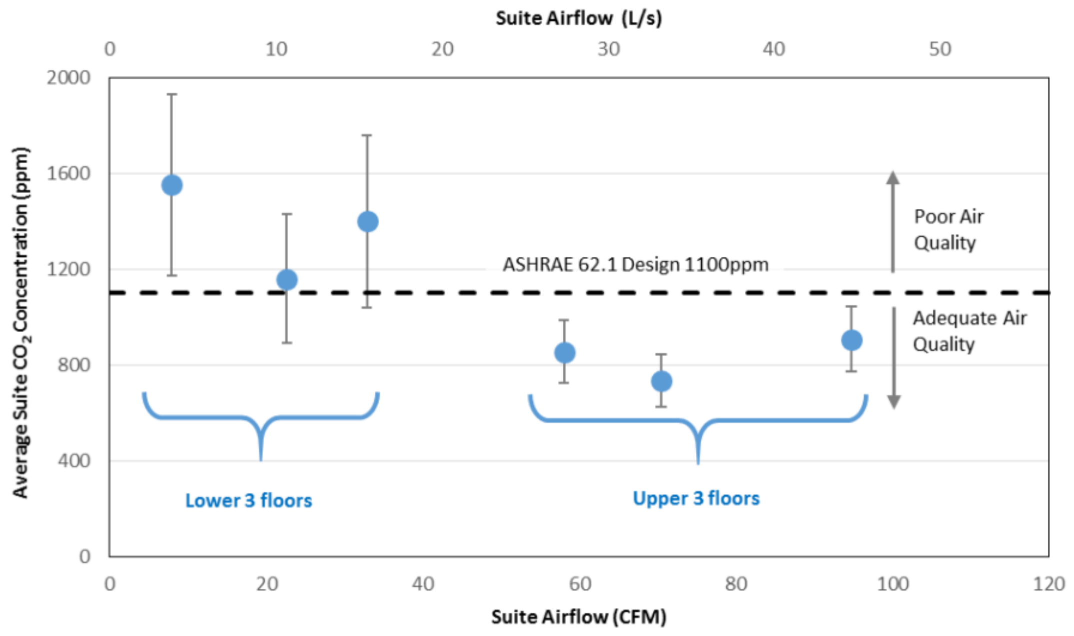


Typical Ventilation Approach in High-Rise MURBs [1]

RDH Study: Pressurized Corridor Impact on IAQ

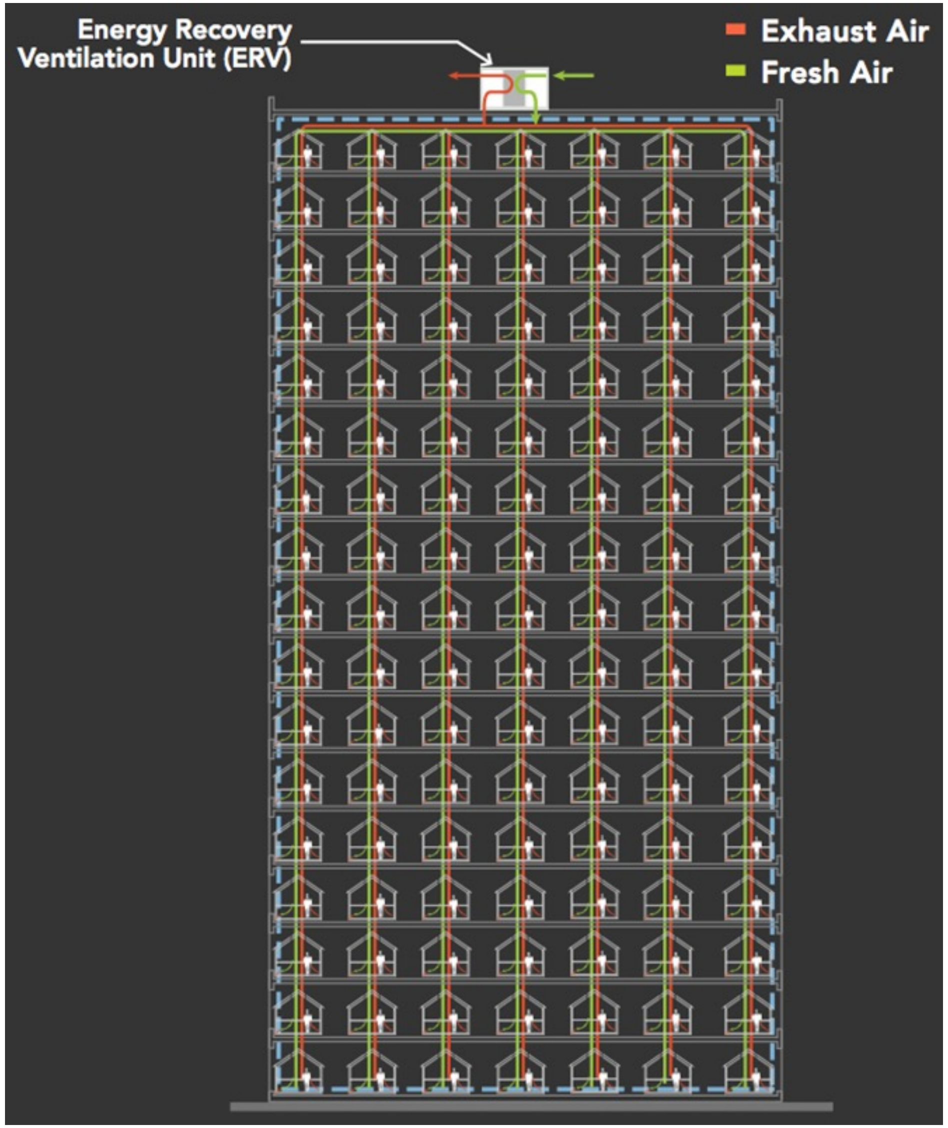


Stack-effect impacts air flow and IAQ in different floors



As newer buildings become more airtight, there is less tolerance for poor performing ventilation

Passive House: Leakage from Multiple Penetrations



Conclusions

Ventilation rates can be **increased to provide better IAQ and cognitive function** with low energy consumption

Ventilation air can be used to **provide some heating and cooling** in high performance buildings

Different ventilation strategies should be evaluated for each project

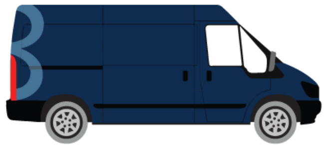
OXYGEN8

Thank You! Questions?

To learn more, visit us online at oxygen8.ca

Contact us at info@oxygen8.ca

@oxygen8canada



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Appendix

Appendix – ACH Calculations

Doubling ASHRAE 62.1 2019 Min. Ventilation Rate

- CFM = **2400CFM**
- [2,400 x 60] ÷ [10,000 x 9] = **1.6 ACH**
- 2,400 ÷ 120= **20 CFM/person**
- Cooling Capacity of Ventilation Air
- Q_T = 4.5 x 2,400 x (28.15-22.6) = 59,940 Btu/h ÷ 10,000 = **5.99 Btu/sqft.h**

For 3 ACH

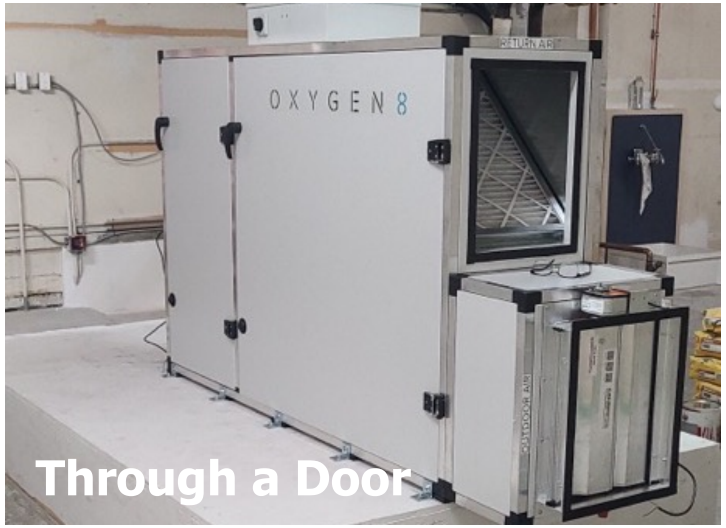
- CFM = [3 x (10,000x 9)] ÷ 60 = **4,500CFM**
- 4500 ÷ 120 = **37.5 CFM/person**
- Cooling Capacity of Ventilation Air
- Q_T = 4.5 x 4,500 x (28.15-22.6) = 112,388 Btu/h ÷ 10,000 = **11.24 Btu/sqft.h**

Fresh Air, That Fits

In a Ceiling

In a Mechanical Room

In a Classroom



Through a Door

In a Closet

On a

Ventilation Retrofits

Offices

Restaurants and Retail


Schools

Senior Care Facility Retrofit

LOCATION: Burnaby, BC

SITUATION: This senior care facility in had equipment that was no longer meeting safety standards and required an upgrade.

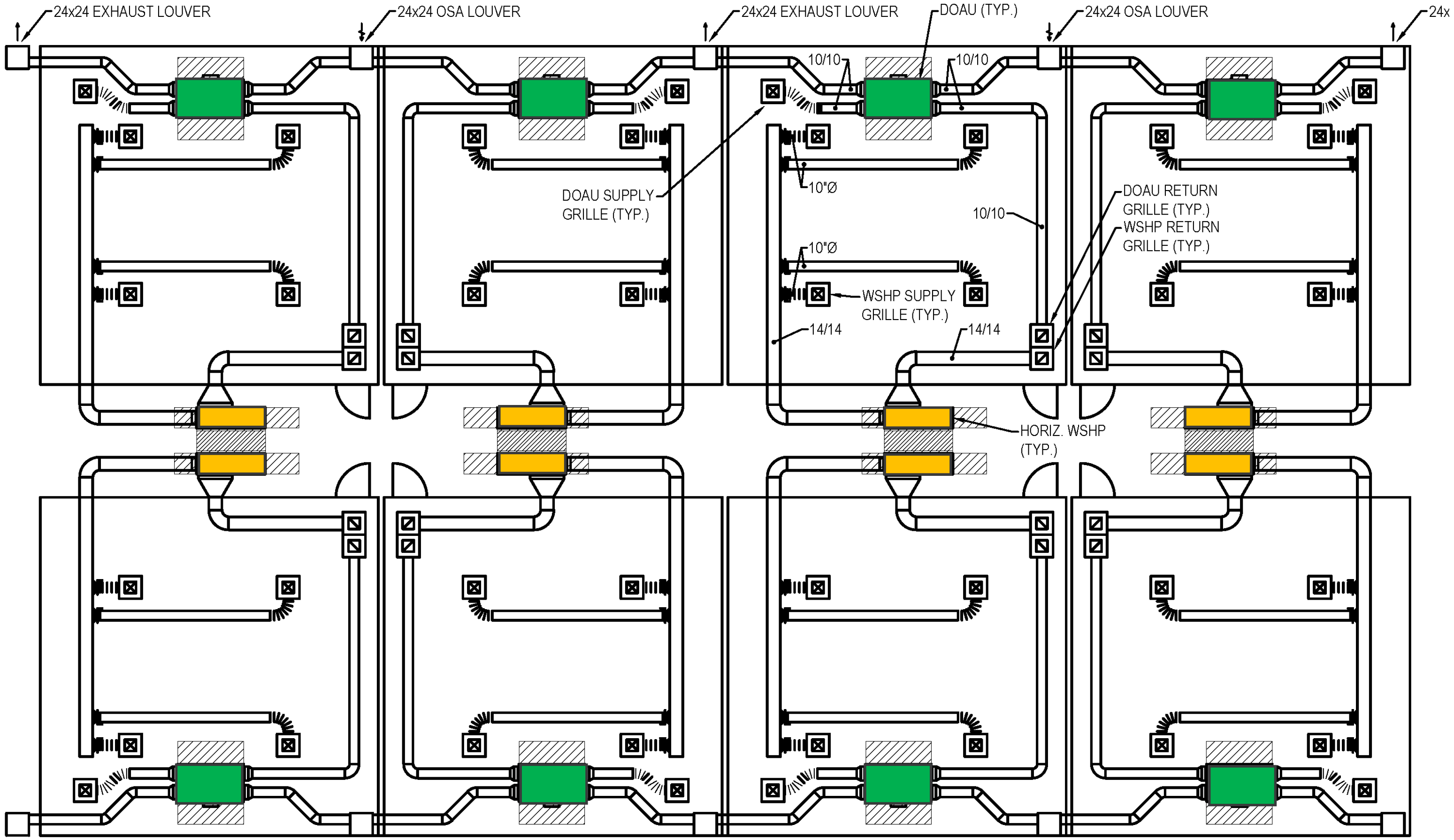
SOLUTION: 4 Nova A16, 2 Nova B20

WHY: Flexibility & Performance
The low-profile units were ideal for being integrated within the existing space with minimal noise output. The heat recovery performance of the units was within the targeted range.

Senior Care Facility Retrofit

Skyline Elementary School: Tacoma, Washington

Oxygen8 High Efficiency HRVs and Daikin Water Source Heat-Pumps



Skyline Elementary School: Tacoma, Washington

Office Retrofit

LOCATION: Vancouver, BC

SITUATION: The office space in this historic building downtown Vancouver required a ventilation retrofit to bring fresh filtered air into the space.

SOLUTION: 1 Nova C24

WHY: IT FIT JUUUUUST RIGHT
The low-profile Nova unit was ideal for the tight installation space in the office building mechanical room.

Office Retrofit, Vancouver BC

Fitness Studio Retrofit

LOCATION: Vancouver, BC

SITUATION:

Fitness studio with insufficient ventilation, was looking for an efficient unit, with a discrete installation since it is visible.

SOLUTION: Ventum H10

WHY:

The low-profile Nova unit was ideal for the tight installation space in the office building mechanical room.

Fitness Studio Retrofit, Vancouver BC

Office Retrofit

LOCATION: Boston, MA

SITUATION: With a low ceiling height in the building, which did not allow for a traditional ERV to be installed alternate options needed to be considered to provide fresh air to the office spaces for optimal occupant comfort.

SOLUTION: 1 Nova C24 with Custom DX Coil

WHY: Low-Profile and Quick Turnaround
The project specifications were met and optimal comfort and indoor air quality is now being delivered to the building occupants.

Office Retrofit, Boston MA

Office Fit-Out

LOCATION: Danvers, MA

SITUATION: With a tight installation space, a low profile ventilation solution was required for this office fit-out project.

SOLUTION: 2 x Nova A16

WHY: No Space for Tradition
With Oxygen8's 16" low profile unit, fitting into the drop ceiling of the office space was a breeze. Traditional air handling units do not allow for such space savings.

Office Fit-Out, Danvers MA

Restaurant Retrofit

LOCATION: New York City, NY

SITUATION: To allow patrons to return to their indoor dining experience, this NYC restaurant needed to retrofit their existing ventilation system. Hidden behind a custom wine barrel wall, there were no vertical duct runs or rooftop equipment required for this project.

SOLUTION: 2 x Nova A16

WHY: Decentralized Dining
Using Oxygen8's split DOAS unit integrated with Daikin VRV technology, the restaurant is able to create a comfortable dining environment for their guests.

Restaurant Retrofit, NYC

Student Residence Retrofit

Our First Project!

LOCATION: Monashee, BC

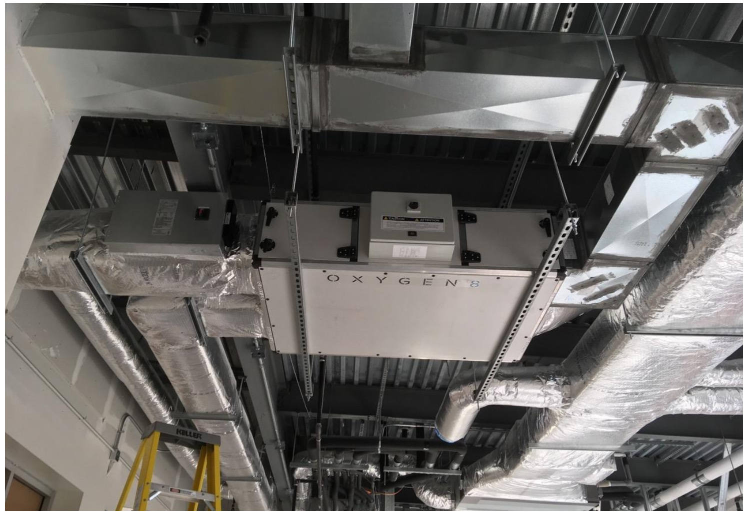
SITUATION: The 28-year old student residence housing 186 students had minimal ventilation, a sloped roof, concerns about COVID-19 and minimal space in their mechanical room.

SOLUTION: 4 x Oxygen8 Nova with Daikin VRV Integration

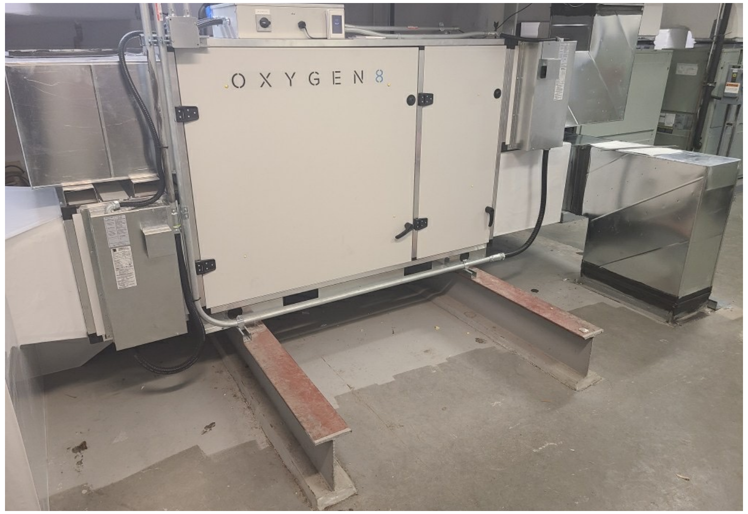
WHY: Investing In The Future
To mitigate risk of COVID-19 in the dorm rooms, air is delivered to each room at ideal conditions. The Oxygen8 Nova units are ceiling mounted in the mechanical rooms and decoupled DX coils in the attic are ducted to a DOAS connected to VRV condensing units.

Student Residence Retrofit, UBC

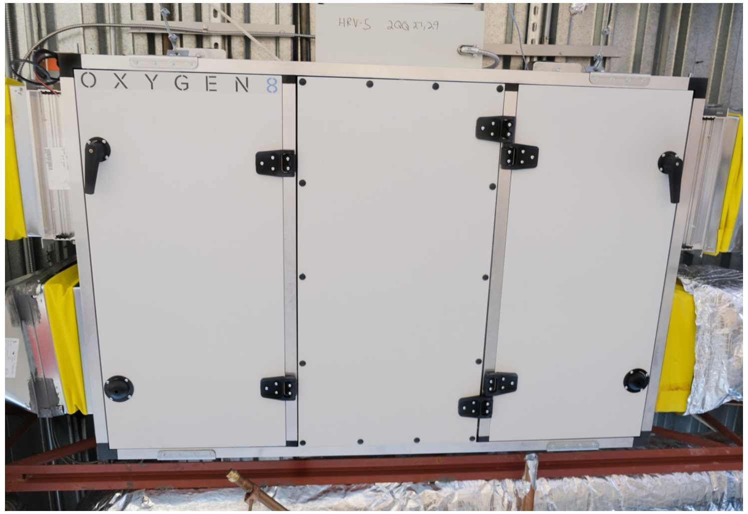
School Applications



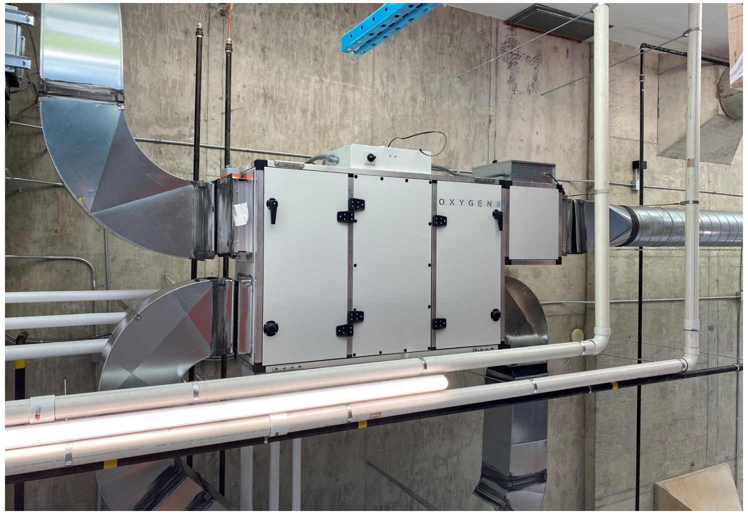
Office Applications




Health and Senior Care Applications



Retail, Dining and Fitness Applications

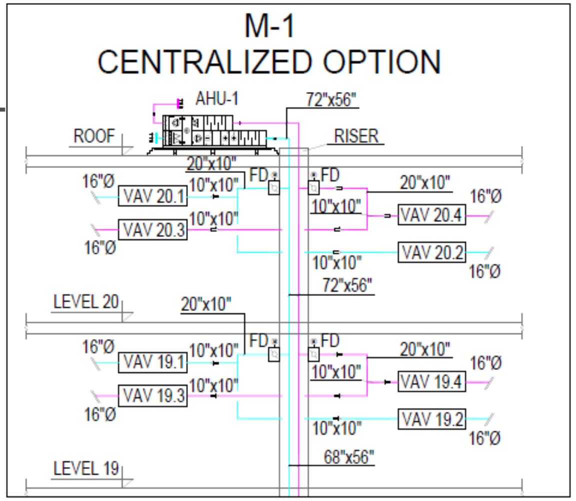


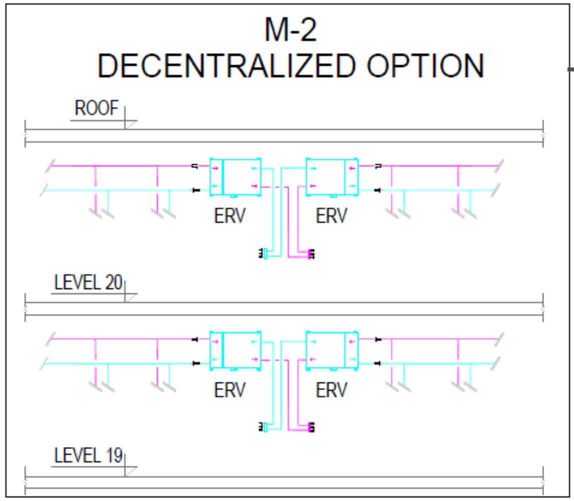
Cost Study

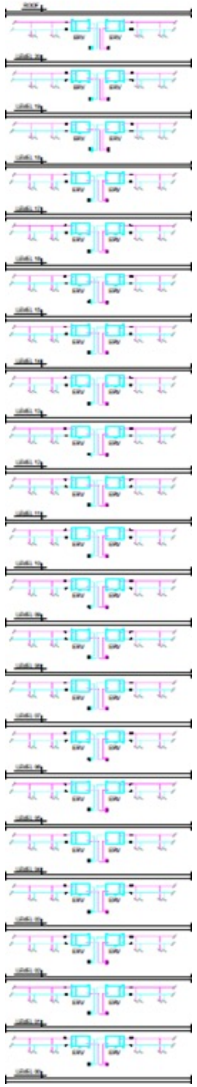
20-Floor Office Building

- **M-1: Centralized**
  AHU mounted on roof

- **M-2: Decentralized**
  Floor-by-floor ERVs



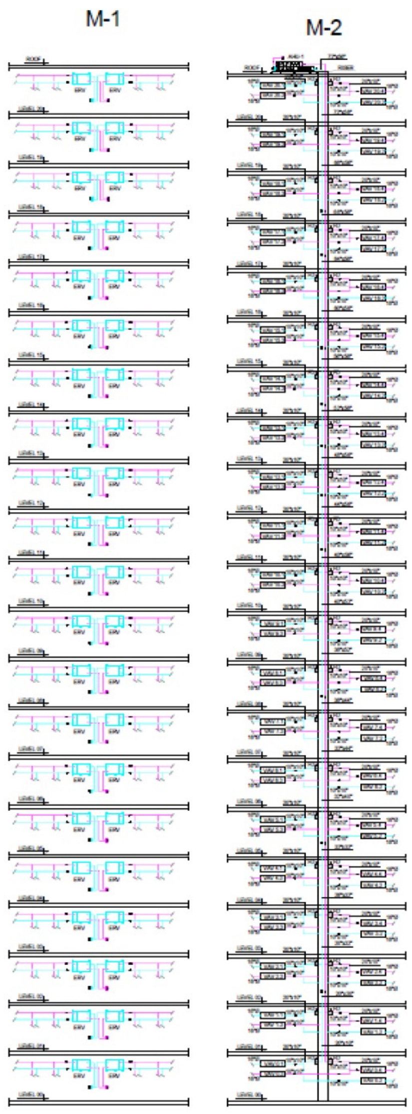




Decentralized Ventilation Cost Study

Study By Zenon Management

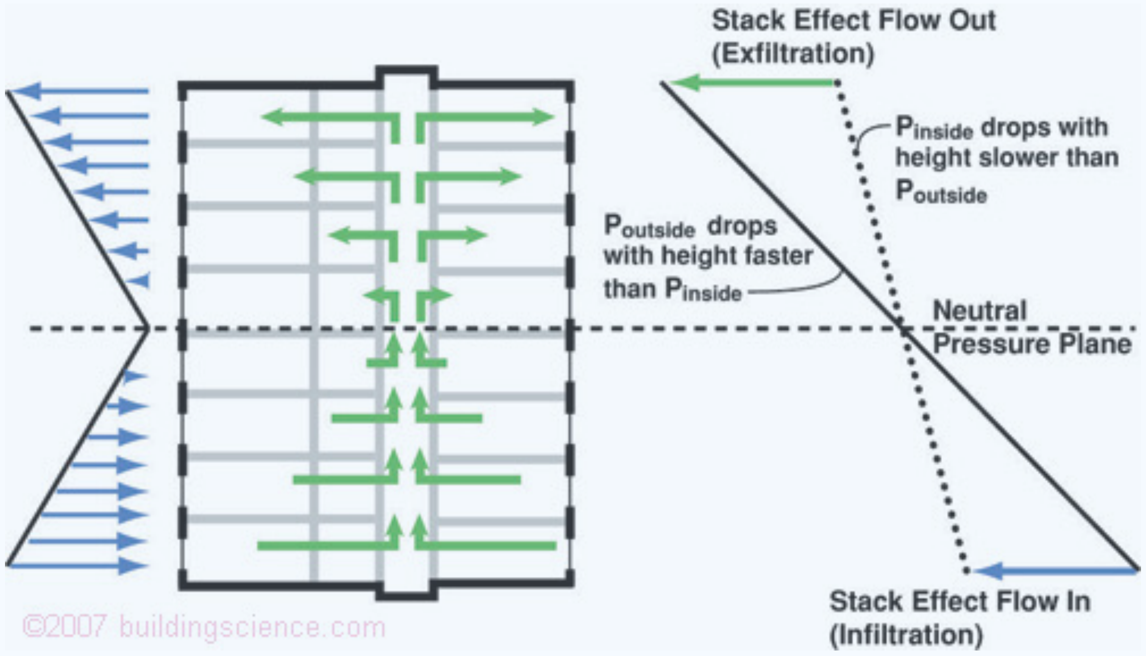
- Performed a financial analysis looking at Decentral (M1) vs Central (M2) ventila
- Analysis looked at 1. Leasable Floor Area, 2. Ductwork and Equipment Costs, 3. Maintenance, 4. Redundancy, 5. Air Quality



	M1 (Floor by Floor)	M2 (Rooftop)
Total Construction Costs	**$1.54M**	**$1.49M**
Incremental Revenue (@$50/ft2)	$150K/yr=**$7.5M over 50 yrs** 2,000ft2 chases+1,000ft2 roof	--
Maintenance Costs	$4,000/yr= **$200,000 over 50 yrs**	--
Air Quality	√	√-Potential for stack effect
Redundancy	√- 24 units	1 unit

*https://oxygen8.ca/wp-content/uploads/2021/03/Cent-vs-Decent-White-Paper.pdf

Designing for Decentralized Ventilation



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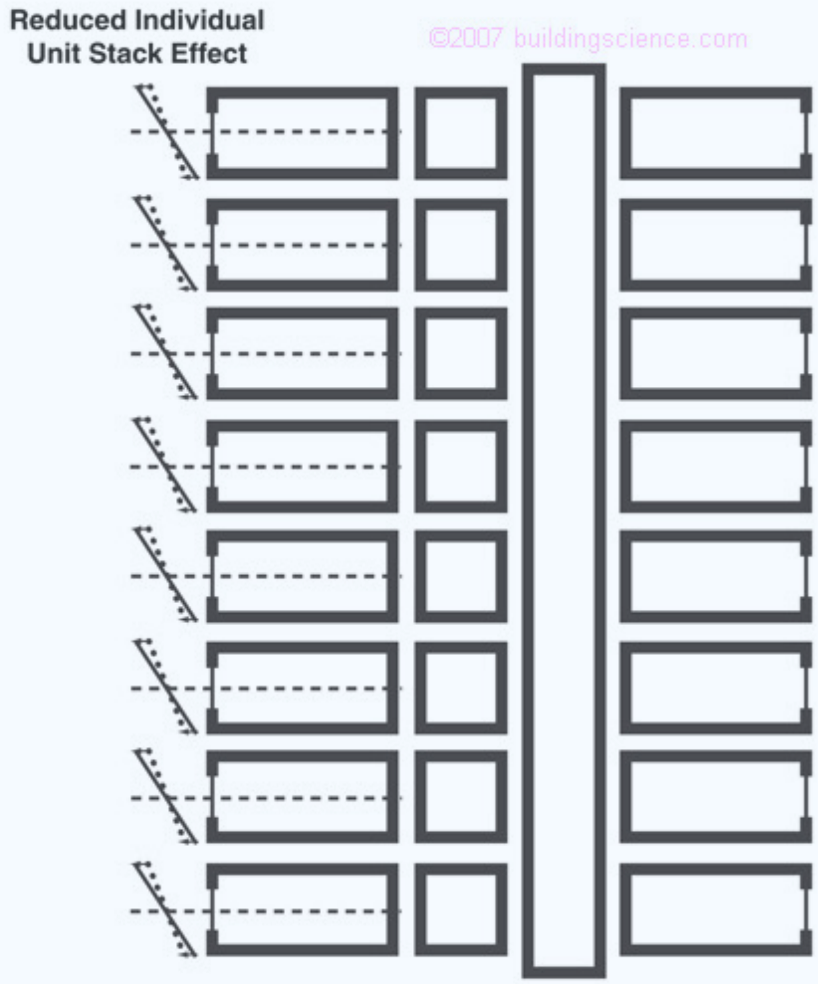
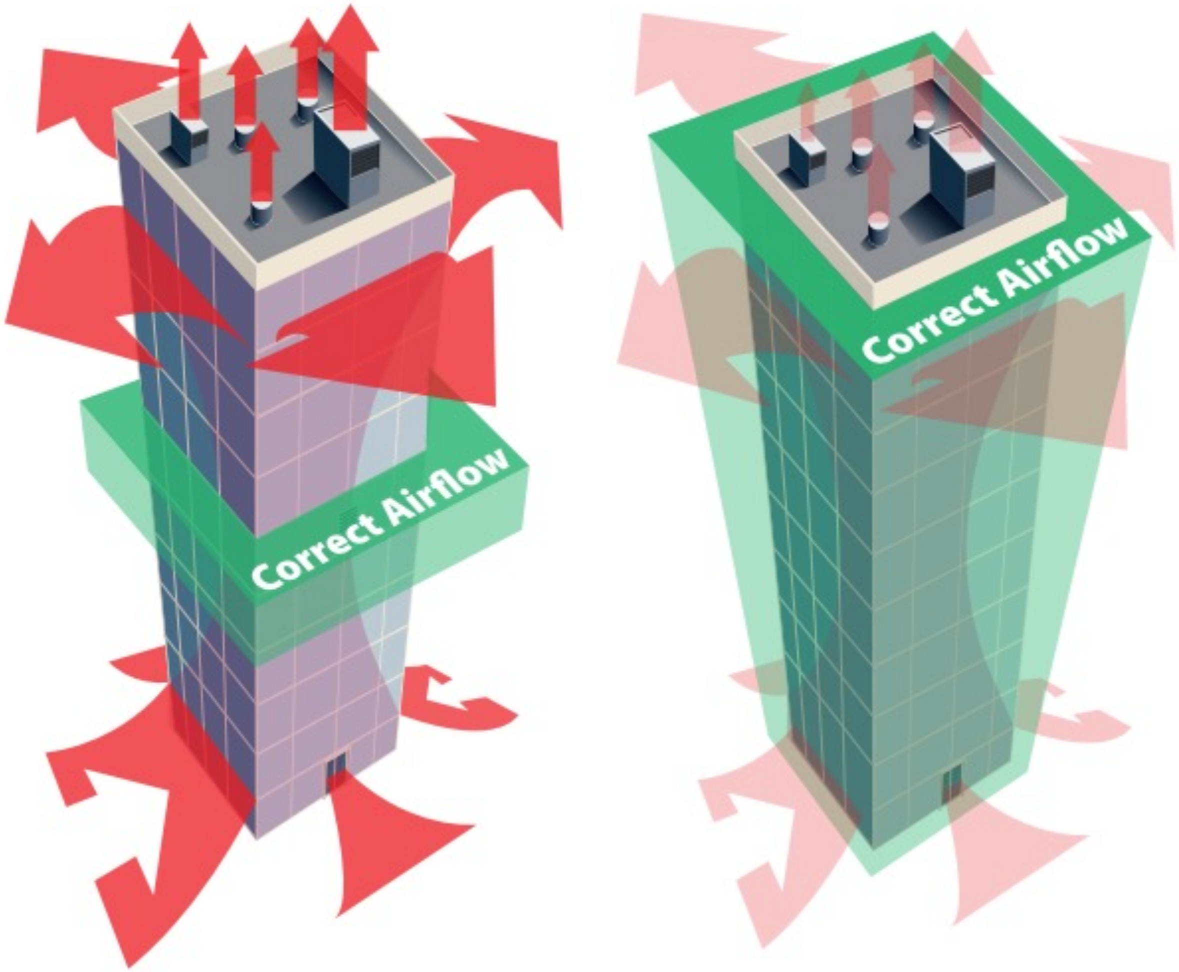


No vertical shafts. No stack effect!

Indoor Air Quality



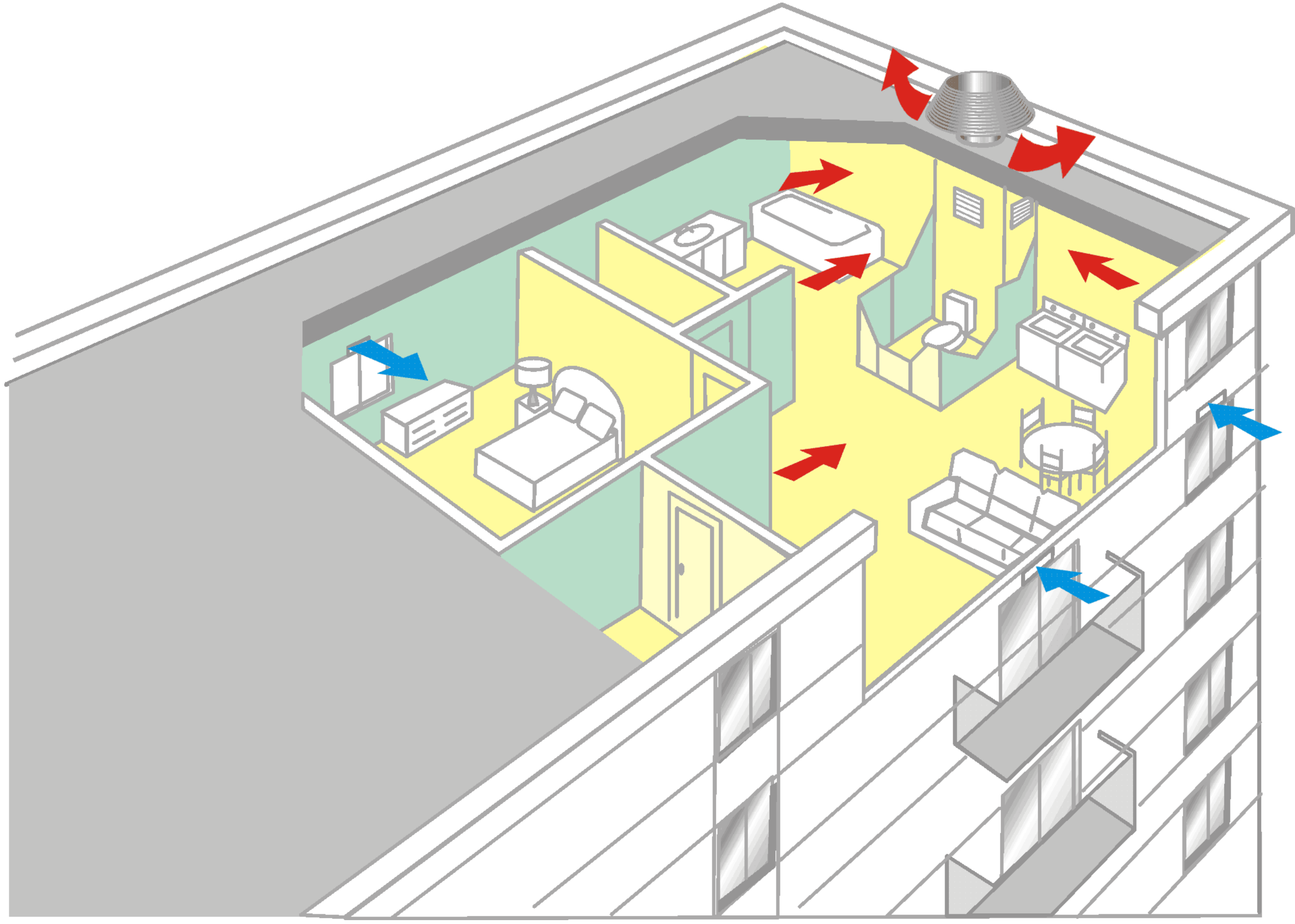
Maintain Control

- Simplified balancing
- Maintains correct airflow year-round
- Equipment malfunction in one unit has no impact on other units

Passive Makeup Air

System Challenges

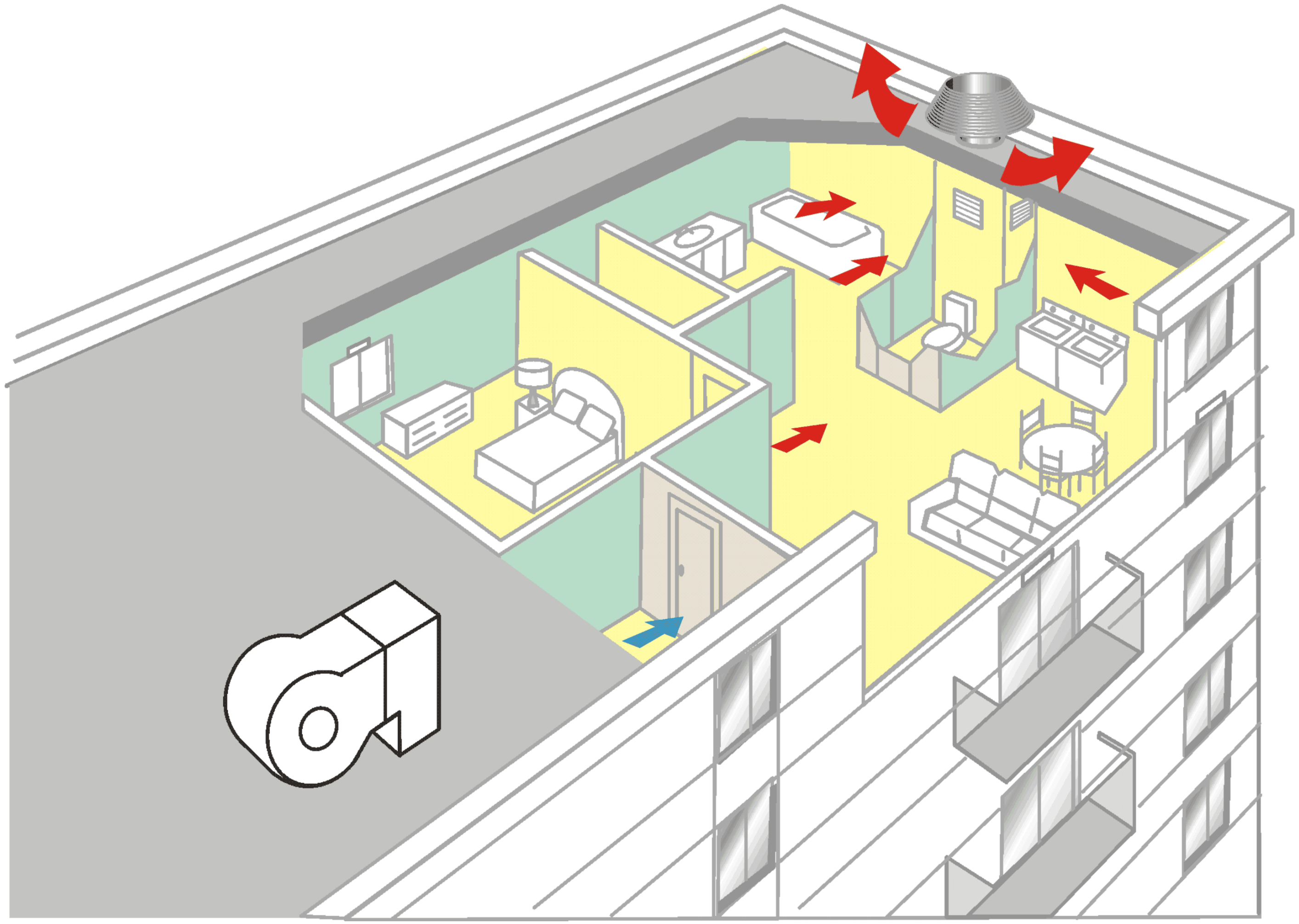
- Makeup Air through controlled passive openings "Trickle Vents" or leakage
- Relies on negative pressure from exhaust to draw in fresh air, which could come from anywhere
- **Undesirable in tall buildings**



Corridor Supply

System Challenges

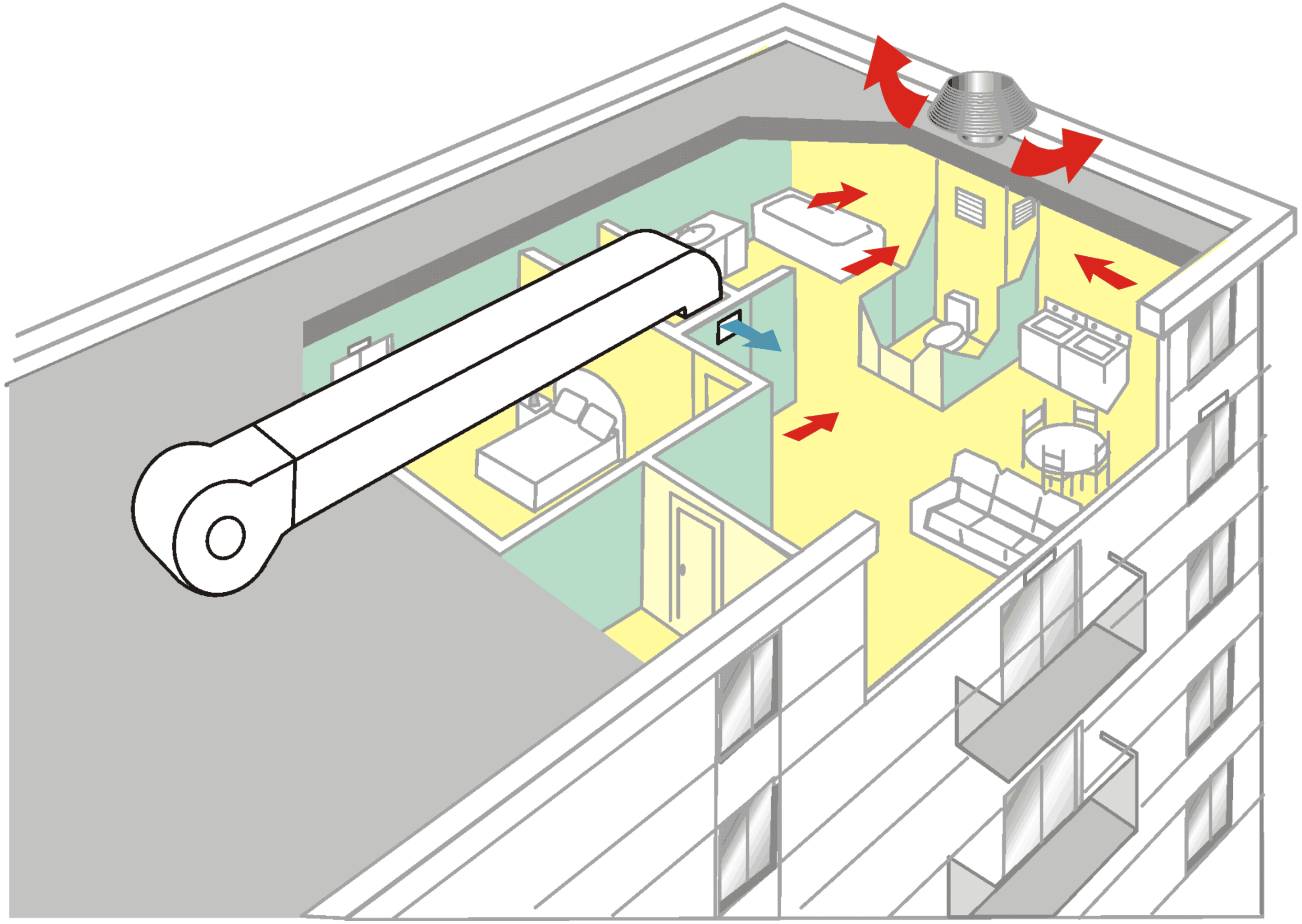
- Pressurized corridors is the most common design used in North America due to the simplicity and low-cost.
- Corridor fire barrier construction may now make this difficult.
- Nearly impossible to determine how much “fresh” air from corridor reaches each apartment.
- **Not code compliant.**



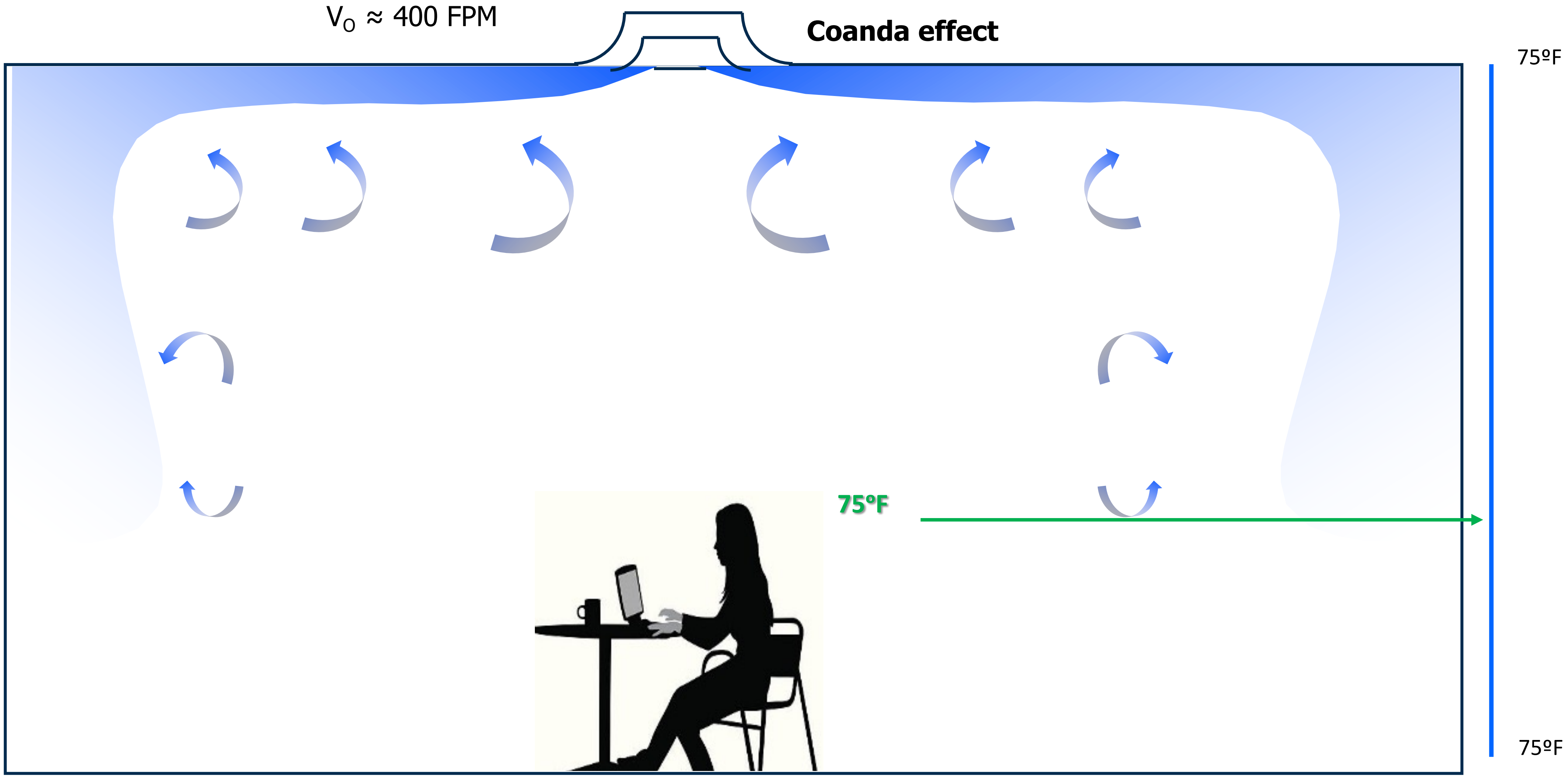
Central Ducted Ventilation

System Challenges

- The central system is ducted to each apartment.
- Increases in size and complexity of MUA system.
- Requires precise balancing of both supply and exhaust otherwise air will not spread evenly and some rooms will be over/under ventilated
- **Today's primary solution**



Mixed Air Systems



Thermal Displacement Ventilation