The Future of Healthy Efficient Buildings

VENTACITYSYSTEMS

Making Buildings Healthy – Efficient – Smarter

Chapter 1
High Performance Buildings

What is a "High Performance" Building?

High Performance Buildings

- Energy efficient
- Durable
- Resilient
- Healthy
- Comfortable

Energy Efficient

- Highly insulated
- Superior verified air-sealing
- Thermal bridges eliminated
- Low u-value windows
- Efficient heating & AC systems
- Heat Recovery Ventilation (HRV)

Durable

- Durable long-lasting materials
- High integrity water barrier
- Verified air-sealing
- Superior workmanship
- Quality control

Resiliant

- Designed to withstand flooding
- Drought tolerant
- Buffer temperature extremes in power outage
- Operable windows
- Daylighting

Healthy

- Exceptional indoor air quality
- Source control of pollutants
- No/low VOC materials
- Daylighting
- Humidity control
- Noise reduction
- High water quality

Comfortable

- Exceptional indoor air quality
- Temperature zones and control
- Window surface temperature
- Daylighting
- Humidity control
- Noise reduction
- Aesthetic

High Performance Rating Systems

- Passive House
- LEED
- Living Building Challenge
- Well Building Standard

Side Benefits of High Performance Buildings

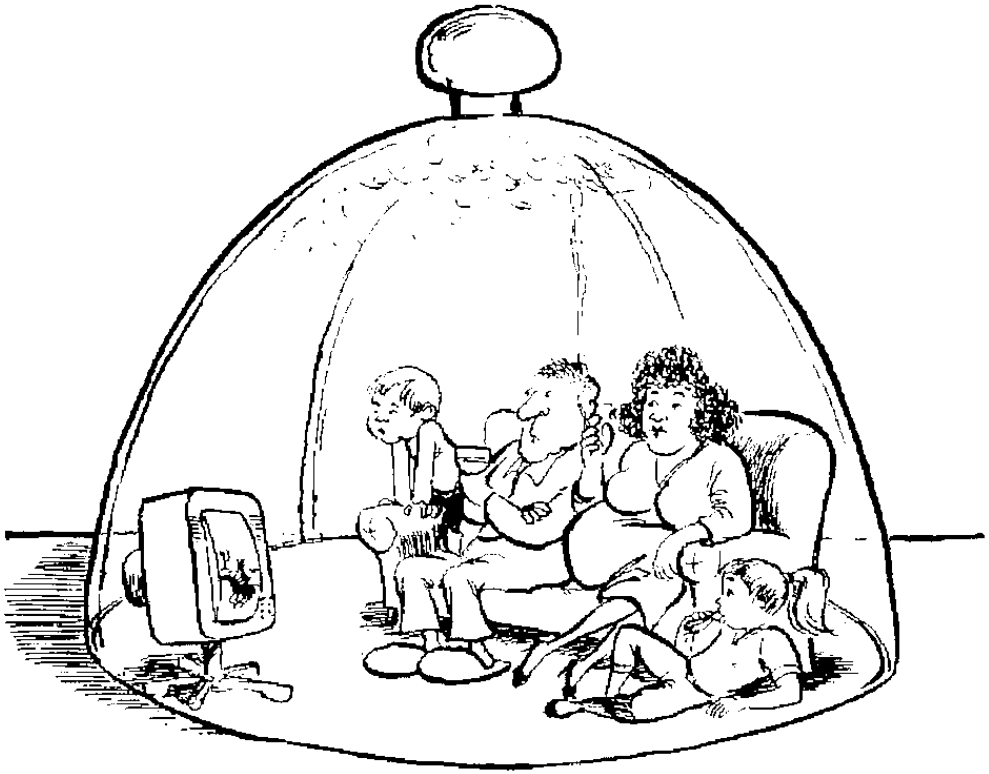
- Happy occupants
- Higher productivity
- Higher rent and/or lower vacancy rate
- Increased building value
- Hedged energy costs

Chapter 2
Why Ventilation Matters

Why Ventilate? Air is Life

For breath is life, and if you breathe well you will live long on earth.
~Sanskrit Proverb

Why Ventilate?
Better Indoor Environment



- Air Humidity
- CO_2 Concentration
- VOC's
- Smells
- Allergens
- Temperature
- **Viruses/Germs!**

Why Ventilate?
Healthier Conditions

- Lawrence Berkeley National Laboratory study of California classrooms
- Increasing ventilation from 8 CFM/student to 15 CFM/student
- Reduced sickness related absenteeism by almost 4%

Why Ventilate?
Lower Risk of Virus Spread

Indoor Air 2003; 13: 237–245
www.blackwellpublishing.com/ina

INDOOR AIR
ISSN 0905-6947

Risk of indoor airborne infection transmission estimated from carbon dioxide concentration

Abstract The Wells–Riley equation, which is used to model the risk of indoor airborne transmission of infectious diseases such as tuberculosis, is sometimes problematic because it assumes steady-state conditions and requires measurement of outdoor air supply rates, which are frequently difficult to measure and often vary with time. We derive an alternative equation that avoids these problems by determining the fraction of inhaled air that has been exhaled previously by someone in the building (rebreathed fraction) using CO_2 concentration as a marker for exhaled-breath exposure. We also derive a non-steady-state version of the Wells–Riley equation which is especially useful in poorly ventilated environments when outdoor air supply rates can be assumed constant. Finally, we derive the relationship between the average number of secondary cases infected by each primary case in a building and exposure to exhaled breath and demonstrate that there is likely to be an achievable critical rebreathed fraction of indoor air below which airborne propagation of common respiratory infections and influenza will not occur.

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Key words: Carbon dioxide; Infectious disease risk modeling; Wells–Riley equation; Basic reproductive number; Communicable disease control; Respiratory tract infections; Indoor air pollution.

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Why Ventilate?
Lower Risk of Virus Spread

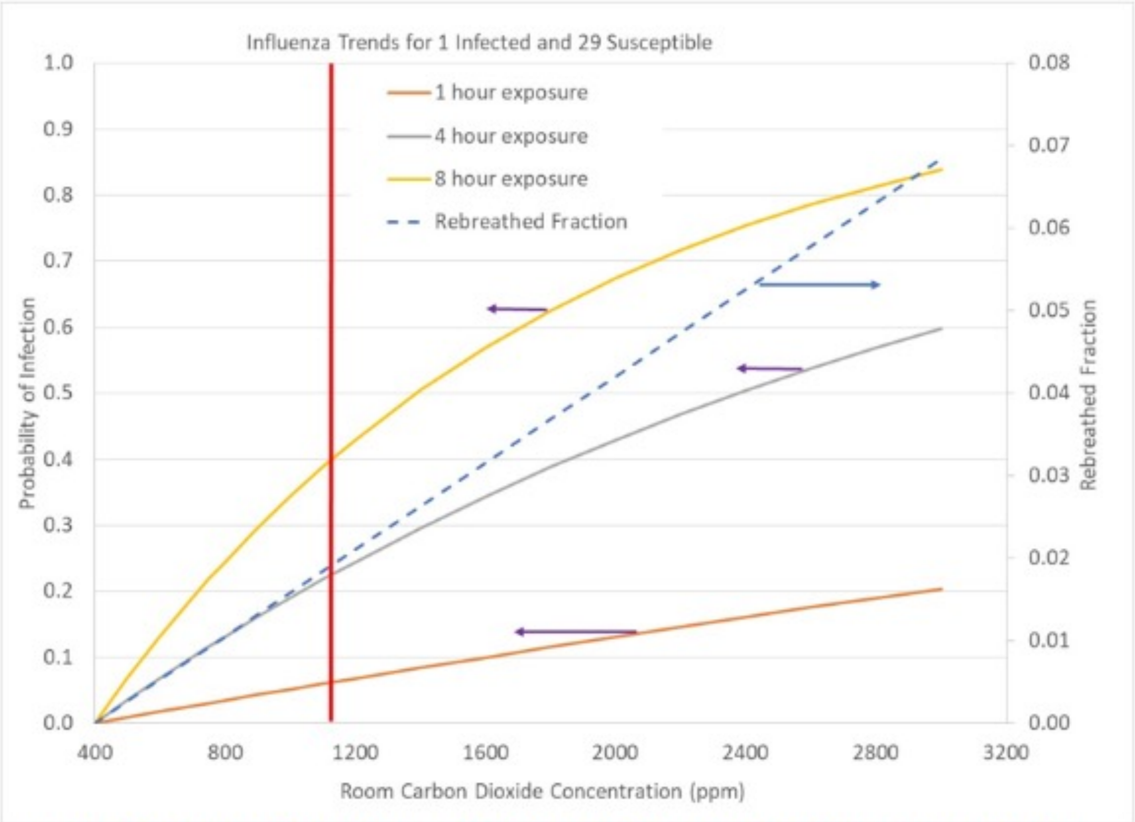


Figure 6 Probability of infection in a room with 1 infected person and 29 susceptible persons.

Evidence That Better Ventilation Provides Lower Risk For Viruses

CORONAVIRUS NEWS

Rethinking IAQ: Critical Advice from Harvard Healthy Buildings Guru

'Healthy Buildings' author Joe Allen offers insight about what the future may hold for building operations and maintenance.

APR 27, 2020

GAZETTE: Can you say more about how to specifically make a building a better barrier against the spread of coronavirus? Specifically hospitals, nursing homes, and grocery stores that are on the front lines right now.

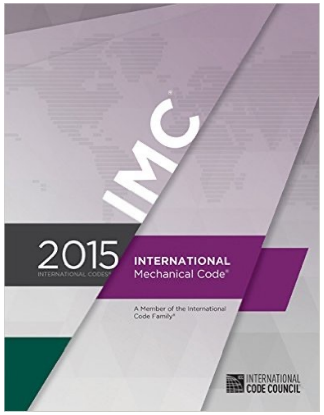
ALLEN: You want to try to get to 100 percent outdoor air being brought into your system with no recirculated air. If you don't have a central air system, you want to open up your windows as much as you can. You want to make sure that if you are recirculating air, that it's being filtered through upgraded filters. Typically you have a MERV 8 — MERV is a rating system for filters — and those capture less than 50 percent, it could be down to 20 percent of small particles. Filters like a MERV 13 get you closer to 80 or 90 percent, or HEPA filters capture 99.97 percent of particles, so upgraded filters can be effective.

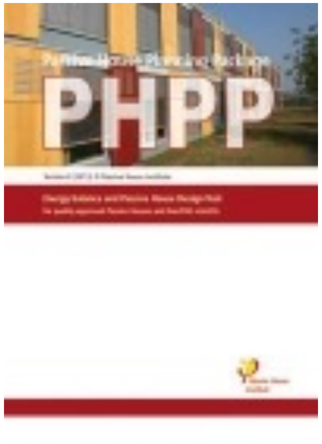
Why Ventilate?
Better Performance

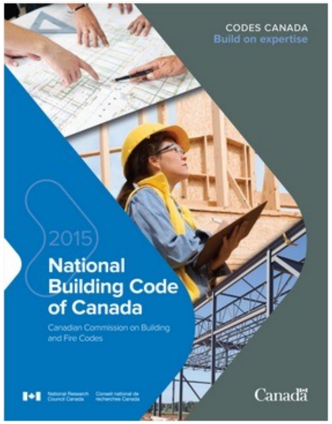
- Harvard/Syracuse study of cognitive function in office workers:
- Green days 61% better
- Green+ days 101% better
- Most effected categories were ***crisis response***, ***information usage***, and ***strategy***

Chapter 3: Ventilation Requirements

How Much Ventilation is Needed?



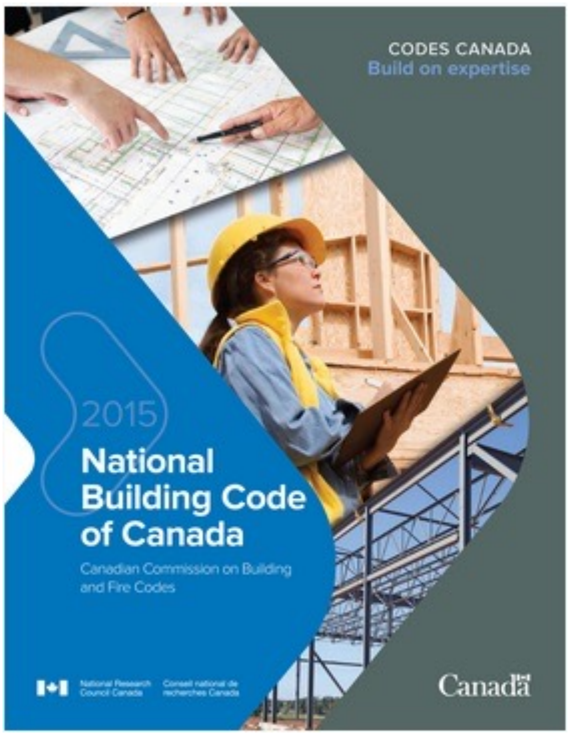


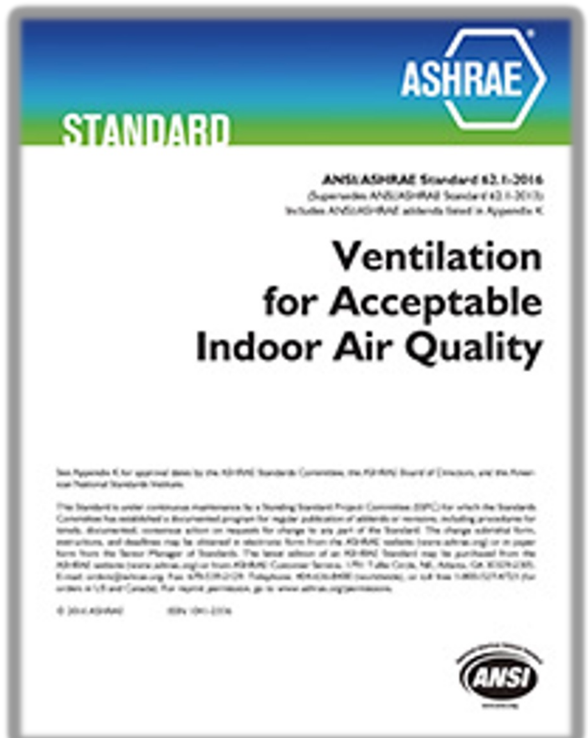


- International Mechanical Code (IMC)
- ASHRAE 62.1
- Passive House
- National Building Code of Canada

How much Ventilation is needed? 2015 National Building Code of Canada

[T]he rates at which outdoor air is supplied in *buildings* by ventilation systems shall be not less than the rates required by *ANSI/ASHRAE 62, "Ventilation for Acceptable Indoor Air Quality"*





- National Building Code of Canada
- References ASHRAE 62.1 for flow rates

How Much Ventilation is Needed? ASHRAE Standard 62.1 2016

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone
(Table 6.2.2.1 shall be used in conjunction with the accompanying notes.)

	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a			Default Values: Occupant Density (see Note 4)	Default Values: Combined Outdoor Air Rate (see Note 5)		
Occupancy Category	cfm/person	L/s·person	cfm/ft²	L/s·m²	Notes	#/1000 ft² or #/100 m²	cfm/person	L/s·person	Air Class
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Dayroom	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Daycare sickroom	10	5	0.18	0.9		25	17	8.6	3
Classrooms (ages 5–8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3	H	65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3	H	150	8	4.0	1
Art classroom	10	5	0.18	0.9		20	19	9.5	2
Science laboratories	10	5	0.18	0.9		25	17	8.6	2
University/college laboratories	10	5	0.18	0.9		25	17	8.6	2
Wood/metal shop	10	5	0.18	0.9		20	19	9.5	2
Computer lab	10	5	0.12	0.6		25	15	7.4	1

TABLE 6.5 Minimum Exhaust Rates

Occupancy Category	Exhaust Rate, cfm/unit	Exhaust Rate, cfm/ft²	Notes	Exhaust Rate, L/s·unit	Exhaust Rate, L/s·m²	Air Class
Arenas	—	0.50	B	—	—	1
Art classrooms	—	0.70		—	3.5	2
Auto repair rooms	—	1.50	A	—	7.5	2
Barber shops	—	0.50		—	2.5	2
Beauty and nail salons	—	0.60		—	3.0	2
Cells with toilet	—	1.00		—	5.0	2
Copy, printing rooms	—	0.50		—	2.5	2
Darkrooms	—	1.00		—	5.0	2
Educational science laboratories	—	1.00		—	5.0	2
Janitor closets, trash rooms, recycling	—	1.00		—	5.0	3
Kitchenettes	—	0.30		—	1.5	2
Kitchens—commercial	—	0.70		—	3.5	2
Locker rooms for athletic, industrial, and health care facilities	—	0.50		—	2.5	2
All other locker rooms	—	0.25		—	1.25	2
Shower rooms	20/50		G,I	10/25		2
Paint spray booths	—	—	F	—	—	4
Parking garages	—	0.75	C	—	3.7	2
Pet shops (animal areas)	—	0.90		—	4.5	2
Refrigerating machinery rooms	—	—	F	—	—	3
Residential kitchens	50/100	—	G	25/50	—	2
Soiled laundry storage rooms	—	1.00	F	—	5.0	3
Storage rooms, chemical	—	1.50	F	—	7.5	4
Toilets—private	25/50	—	E, H	12.5/25	—	2
Toilets—public	50/70	—	D, H	25/35	—	2
Woodwork shop/classrooms	—	0.50		—	2.5	2

NOTES:
A Stands where engines are run shall have exhaust systems that directly connect to the engine exhaust and prevent escape of fumes.
B Where combustion equipment is intended to be used on the playing surface additional dilution ventilation, source control, or both shall be provided.
C Exhaust shall not be required where two or more sides comprise walls that are at least 50% open to the outside.
D Rate is per water closet, urinal, or both. Provide the higher rate where periods of heavy use are expected to occur. The lower rate shall be permitted to be used otherwise.
E Rate is for a toilet room intended to be occupied by one person at a time. For continuous system operation during hours of use, the lower rate shall be permitted to be used. Otherwise the higher rate shall be used.
F See other applicable standards for exhaust rate.
G For continuous system operation, the lower rate shall be permitted to be used. Otherwise the higher rate shall be used.
H Exhaust air that has been cleaned to meet Class 1 criteria from Section 5.16.1 shall be permitted to be recirculated.
I Rate is per showerhead.

- Table 6.2.2.1 Minimum Ventilation Rates in Breathing Zone
- Table 6.5 Minimum Exhaust Rates

How Much Ventilation is Needed?

ASHRAE Standard 62.1 – Table 6.2.2.1

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone
(Table 6.2.2.1 shall be used in conjunction with the accompanying notes.)

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- People Outdoor Air Rate
- Area Outdoor Air Rate
- Default Occupancy
- Air Class

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

Zone Airflow = (People Rate x Number People) + (Area Rate x Area)

How Much Ventilation is Needed?

TABLE 6.2.2.2 Zone Air Distribution Effectiveness

Air Distribution Configuration	E_z
Ceiling supply of cool air	1.0
Ceiling supply of warm air and floor return	1.0
Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return	0.8
Ceiling supply of warm air less than 15°F (8°C) above space temperature and ceiling return provided that the 150 fpm (0.8 m/s) supply air jet reaches to within 4.5 ft (1.4 m) of floor level (See Note 6)	1.0
Floor supply of cool air and ceiling return, provided that the vertical throw is greater than 50 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) or more above the floor	1.0
Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification, or underfloor air distribution systems where the vertical throw is less than or equal to 50 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) above the floor	1.2
Floor supply of warm air and floor return	1.0
Floor supply of warm air and ceiling return	0.7
Makeup supply drawn in on the opposite side of the room from the exhaust, return, or both.	0.8
Makeup supply drawn in near to the exhaust, return, or both locations.	0.5

$V_{oz} = V_{bz}/0.8 = 1.25V_{bz}$

25% Increase!

$V_{oz} = V_{bz}/E_z$

$$\text{Outdoor Airflow} = \frac{\text{Zone Airflow}}{\text{Effectiveness}}$$

- Zone Air Distribution Effectiveness
- Amount of outdoor airflow depends upon distribution configuration
- Cool air supply by DOAS system minimizes amount of outside air required

How Much Ventilation is Needed?

TABLE 6.5 Minimum Exhaust Rates

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Beauty and nail salons	—	0.60		—	3.0	2
Cells with toilet	—	1.00		—	5.0	2
Copy, printing rooms	—	0.50		—	2.5	2
Darkrooms	—	1.00		—	5.0	2
Educational science laboratories	—	1.00		—	5.0	2
Janitor closets, trash rooms, recycling	—	1.00		—	5.0	3
Residential kitchens	50/100	—	G	25/50	—	2
Soiled laundry storage rooms	—	1.00	F	—	5.0	3
Storage rooms, chemical	—	1.50	F	—	7.5	4
Toilets—private	25/50	—	E, H	12.5/25	—	2
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Woodwork shop/classrooms	—	0.50		—	2.5	2

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I Rate is per showerhead.

- Exhaust Rate per Unit
- Exhaust Rate per Area
- Air Class
- Private Toilets: single toilet
- Public Toilets: multiple toilets

How Much Ventilation is Needed?

Passive House Institute

Passive House Non-Residential Air Flow Rate Guidelines			
	Rate [CFM/P]	Rate [CMH/P]	Note
Schools	9 to 12	15 to 20	CO_2 limit between 1200 -1500 PPM
Office	18	30	
Gymnasium	36	60	Demand control recommended

Passive House Institute

- Very little prescriptive rates available
- Generally follow code/ASHRAE requirements.
- Demand control whenever feasible to minimize airflow to meet occupancy

How Much Ventilation is Needed?

Passive House Institute

2,400 sq ft Home

2,400’ x 8’ ceiling height = 19,200 cubic feet

19,200/60 = 320

320 x 0.3 = 96 cfm

Passive House Institute

- Residential Rate = 0.3 ACH
- Generally follow code/ASHRAE requirements.
- Demand control whenever feasible to minimize airflow to meet occupancy

How Much Ventilation is Needed?

Other High-Performance Standards

LEED
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

LIVING BUILDING CHALLENGE

INTERNATIONAL WELL BUILDING INSTITUTE™

- All these standards reference ASHRAE 62.1
- LEED and Well Building Standard offer points for 30% higher airflow than ASHRAE 62.1

World Health Organization

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Transmission of SARS-CoV-2: implications for infection prevention precautions

Scientific Brief

9 July 2020

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Airborne transmission

Airborne transmission is defined as the spread of an infectious agent caused by the dissemination of droplet nuclei (aerosols) that remain infectious when suspended in air over long distances and time.(11) Airborne transmission of SARS-CoV-2 can occur during medical procedures that generate aerosols ("aerosol generating procedures").(12) WHO, together with the scientific community, has been actively discussing and evaluating whether SARS-CoV-2 may also spread through aerosols in the absence of aerosol generating procedures, particularly in indoor settings with poor ventilation.

Experts Weigh In

The New York Times

Opinion

Your Building Can Make You Sick or Keep You Well

Proper ventilation, filtration and humidity reduce the spread of pathogens like the new coronavirus.

By Joseph G. Allen

Dr. Allen is director of the Healthy Buildings program at Harvard T.H. Chan School of Public Health.

March 4, 2020

Forty-Six Years Later…….

In 1974, a young girl with measles went to school in upstate New York. Even though 97 percent of her fellow students had been vaccinated, 28 ended up contracting the disease. The infected students were spread out across 14 classrooms, but the young girl, the index patient, spent time only in her own classroom. The culprit? A ventilation system operating in recirculating mode that sucked in the viral particles from her classroom and spread them around the school.

Buildings, as this historical example highlights, are highly efficient at spreading disease.

Mounting Evidence

Back to the present, the most high-profile evidence of the power of buildings to spread the coronavirus is from a cruise ship — essentially a floating building. Of the 3,000 or so passengers and crew members onboard the quarantined Diamond Princess, at least 700 are known to have contracted the new coronavirus, a rate of infection that is significantly higher than that in Wuhan, China, where the disease was first found.

Schools!

It is widely known, after multiple studies across North America, Europe and beyond, that schools have poor IAQ and health.

Impacts include learning impairment, reduced cognitive function and increased illness and absence.

PPS says it will comply after state clarifies air quality recommendations

Aimee Green - The Oregonian/OregonLive

In a sweeping about-face, Oregon's largest school district on Friday said it will "strive" to increase a key measure of air quality to bare minimum levels long-trumpeted by a wide swath of experts nationwide.

Portland Public Schools' announcement comes after an investigation by The Oregonian/OregonLive in May found nearly 500 classrooms with subpar ventilation rates that experts said could increase the risk of airborne-disease transmission as well as lower the ability of students to learn in stuffy classrooms with stale air.

The district's announcement also comes on the heels of clarified guidance from the Oregon Health Authority, brought about by questions raised by The Oregonian/OregonLive this month. On Thursday, the health authority told school officials it "recommends a range of 3-6 air changes per hour" along with other efforts to improve indoor air quality.

The Solution

Here's what we should be doing. First, bringing in more outdoor air in buildings with heating and ventilation systems (or opening windows in buildings that don't) helps dilute airborne contaminants, making infection less likely. For years, we have been doing the opposite: sealing our windows shut and recirculating air. The result are schools and office buildings that are chronically underventilated. This not only gives a boost to disease transmission, including common scourges like the norovirus or the common flu, but also significantly impairs cognitive function.

A study published just last year found that ensuring even minimum levels of outdoor air ventilation reduced influenza transmission as much as having 50 percent to 60 percent of the people in a building vaccinated.

Avoid Re-Circulation, But If You Must….

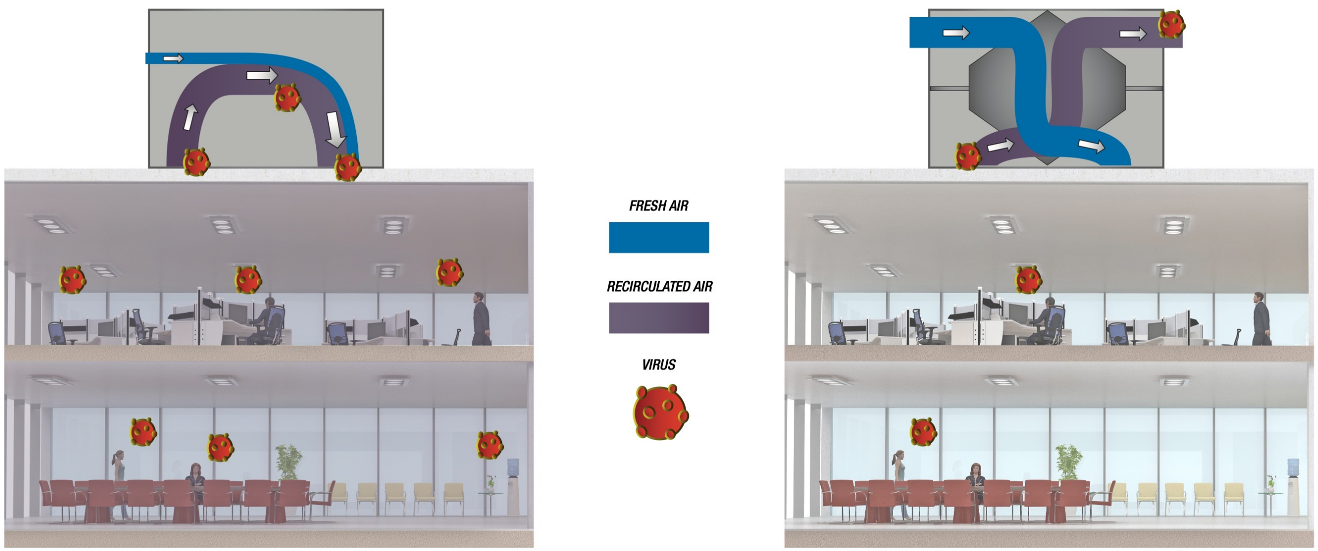
Buildings typically recirculate some air, which has been shown to lead to higher risk of infection during outbreaks, as contaminated air in one area is circulated to other parts of the building (as it did in the school with measles). When it's very cold or very hot, the air coming out of the vent in a school classroom or office may be completely recirculated. That's a recipe for disaster.

If air absolutely has to be recirculated, you can minimize cross-contamination by enhancing the level of filtration. Most buildings use low-grade filters that may capture less than 20 percent of viral particles. Most hospitals, though, use a filter with what's known as a MERV rating of 13 or higher. And for good reason — they can capture more than 80 percent of airborne viral particles.

DOAS IS BETTER

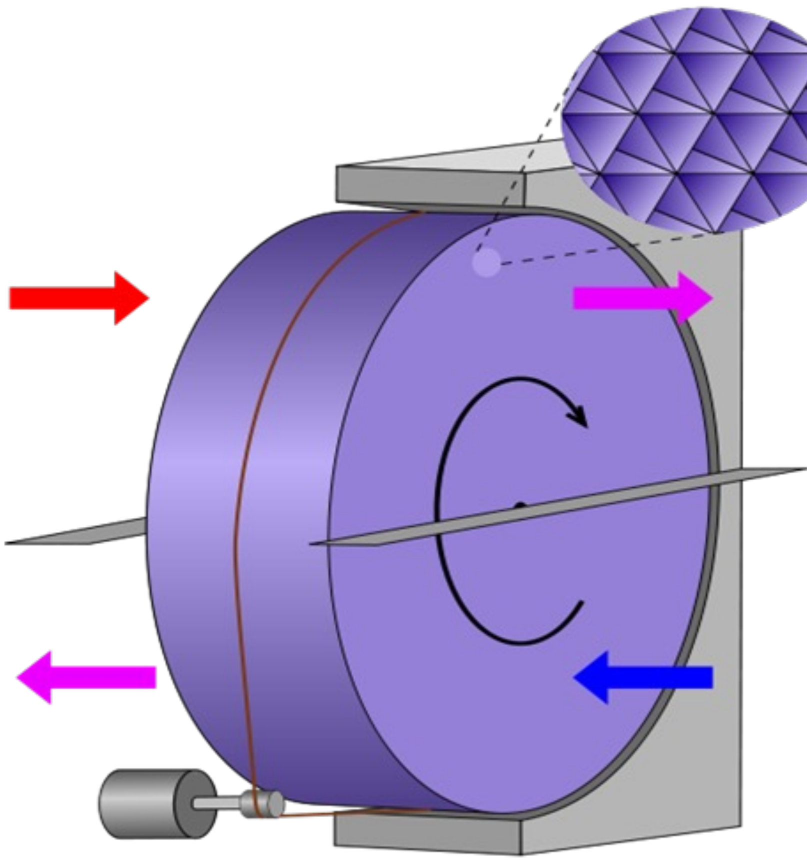
DOAS IS BETTER

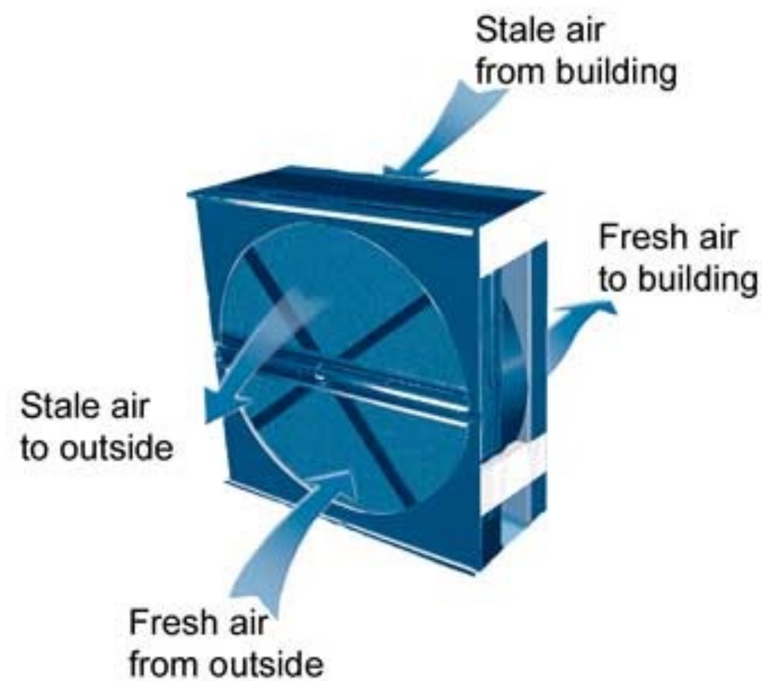
VENTACITYSYSTEMS
Making Buildings Healthy · Efficient · Smarter



Chapter 4:
What's In The Box?

Enthalpy Wheel ERV





Ventilation in the Age of COVID-19

CIBSE JOURNAL

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Preventing Covid-19 spreading in buildings

In response to the coronavirus pandemic, REHVA experts have published a guidance document on how to operate and use building services to minimise the spread of Covid-19. Alex Smith provides a summary of their findings

Posted in March 2020

Increase air supply and exhaust ventilation

The general advice is to supply as much outside air as possible. Expanded operation times are recommended for buildings with mechanical ventilation. Consider keeping the ventilation on 24/7 with lower ventilation rates when people are absent.

If employee numbers reduce, do not place remaining staff in smaller areas.
Exhaust ventilation systems of toilets should always be left on 24/7, and relatively negative pressure must be maintained in the room air to help avoid faecal-oral transmission.

Ventilation in the Age of COVID-19

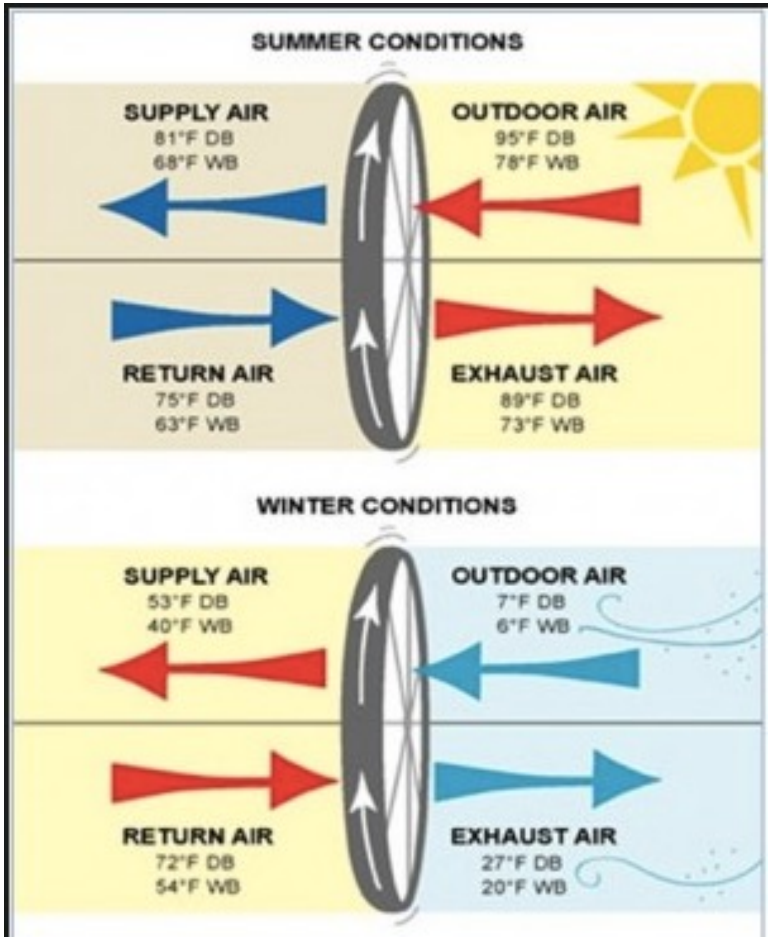
Safe use of heat-recovery devices

Virus particles in extract air can re-enter the building. Heat-recovery devices may carry over the virus attached to particles from the exhaust airside to the supply airside via leaks. In rotary heat exchangers (including enthalpy wheels) particles deposit on the return airside of the heat exchanger surface, after which they might be resuspended when the heat exchanger turns to the supply airside.

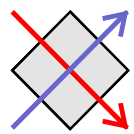
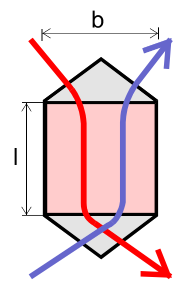
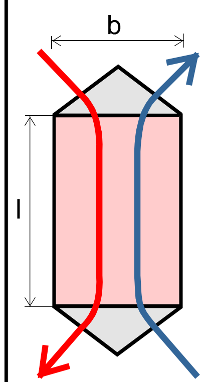
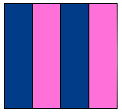
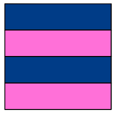
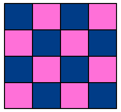
Based on current evidence, REHVA recommends turning off rotary heat exchangers temporarily during SARS-CoV-2 episodes. Its document goes on to state: if leaks are suspected in the heat-recovery sections, pressure adjustment or bypassing can be an option to avoid a situation where higher pressure on the extract side causes air leakages to the supply side.

Transmission via heat-recovery devices is not an issue when a HVAC system is equipped with a twin-coil ('run around' coil) or other heat-recovery device that guarantees air separation between return and supply side.

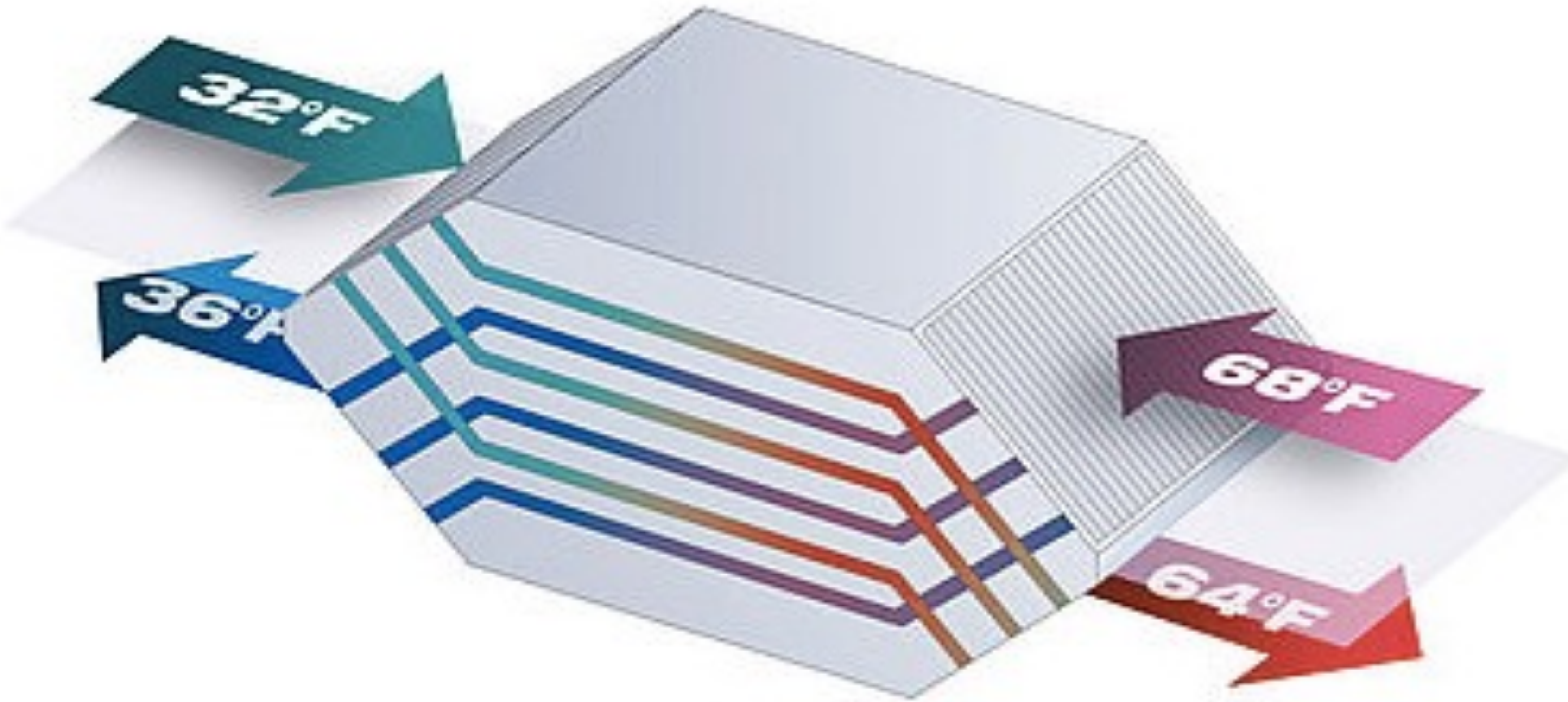
Enthalpy Wheel ERV



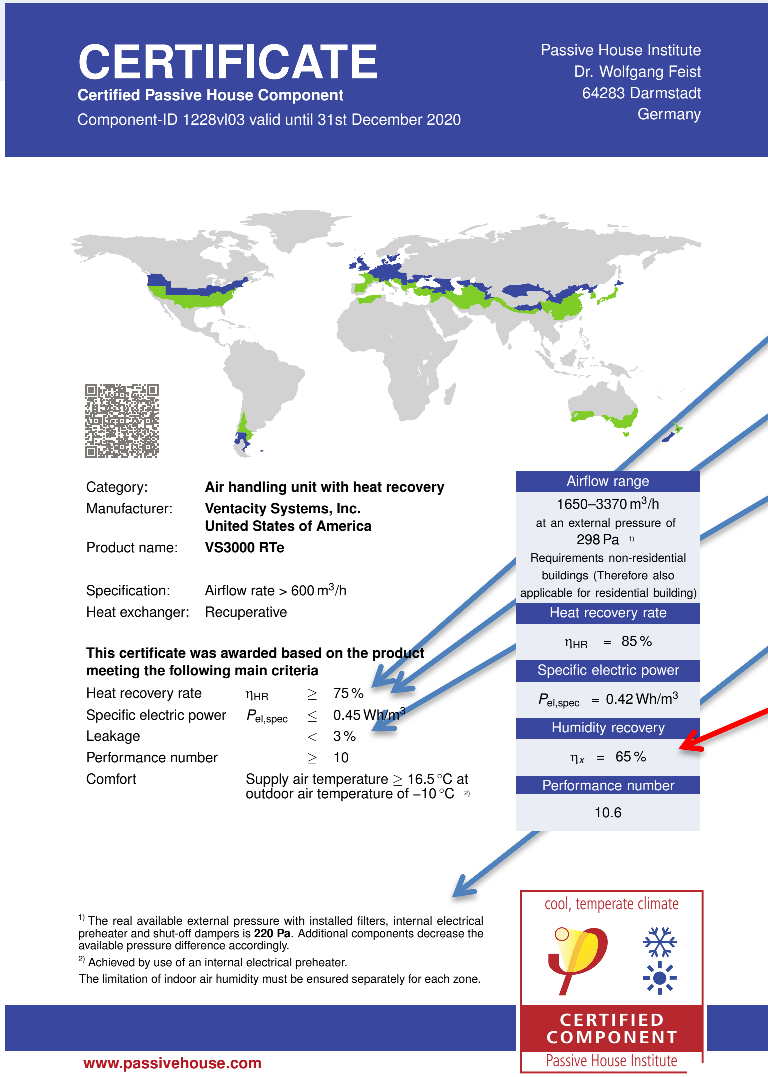
Options for H/ERV Cores

Schematic diagram				cross flow counter flow
	cross flow heat exchanger	cross counter flow heat exchanger	counter flow heat exchanger	
heat exchanger surface [m²] [ft²]	4 – 10 0,4 – 0,9	6 – 14 0,6 – 1,3	17 – 60 1,6 – 5,6	
flow profile				
heat recovery [%] effective like in PHPP	50 – 70	70 – 80	85 – 99 (92)	

Very High Efficiency Counter-Flow Heat Exchanger



Passive House Efficiency



CERTIFICATE

Certified Passive House Component

Component-ID 1228vl03 valid until 31st December 2020

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
Germany

Category:	**Air handling unit with heat recovery**
Manufacturer:	**Ventacity Systems, Inc.** **United States of America**
Product name:	**VS3000 RTe**
Specification:	Airflow rate > 600 m^3/h
Heat exchanger:	Recuperative

This certificate was awarded based on the product meeting the following main criteria

Heat recovery rate	η_{HR}	≥	75 %
Specific electric power	$P_{el,spec}$	≤	0.45 Wh/m^3
Leakage		<	3 %
Performance number		≥	10
Comfort	Supply air temperature ≥ 16.5 °C at outdoor air temperature of –10 °C [2]		

Airflow range
1650–3370 m^3/h at an external pressure of 298 Pa [1] Requirements non-residential buildings (Therefore also applicable for residential building)
Heat recovery rate
η_{HR} = 85 %
Specific electric power
$P_{el,spec}$ = 0.42 Wh/m^3
Humidity recovery
η_x = 65 %
Performance number
10.6

[1] The real available external pressure with installed filters, internal electrical preheater and shut-off dampers is **220 Pa**. Additional components decrease the available pressure difference accordingly.

[2] Achieved by use of an internal electrical preheater.

The limitation of indoor air humidity must be ensured separately for each zone.

cool, temperate climate

CERTIFIED COMPONENT

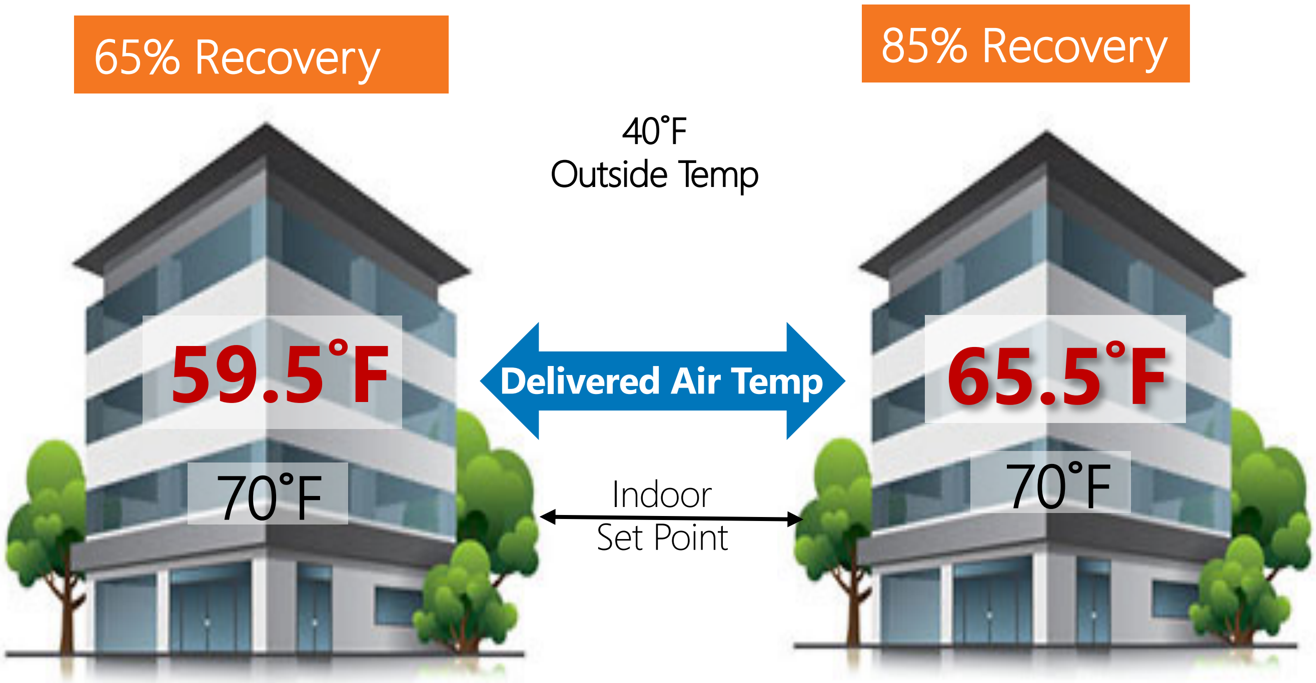
Passive House Institute

www.passivehouse.com

- **NET RECOVERY EFFICIENCY**
- **POWER EFFICIENCY**
- **CROSS-FLOW TRANSFER/ CONTAMINATIOIN**
- **SOUND LEVEL**
- **IF IT IS AN ERV – *HUMIDITY RECOVERY***

Chapter 4: What's In The Box?

Efficiency Means Comfort



Efficiency Means Comfort

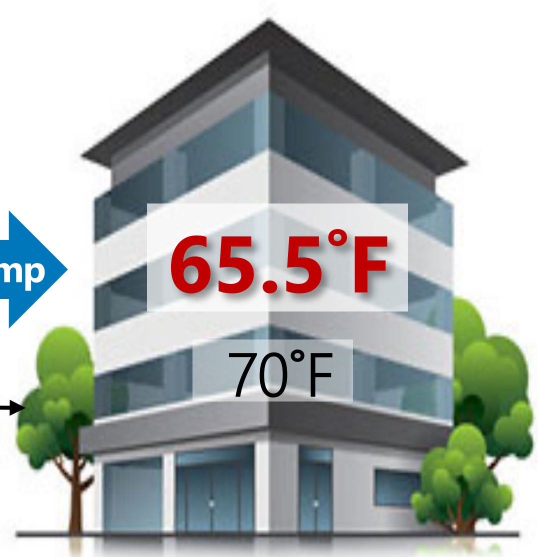
65% Recovery

85% Recovery

40˚F
Outside Temp

Delivered Air Temp

Indoor
Set Point



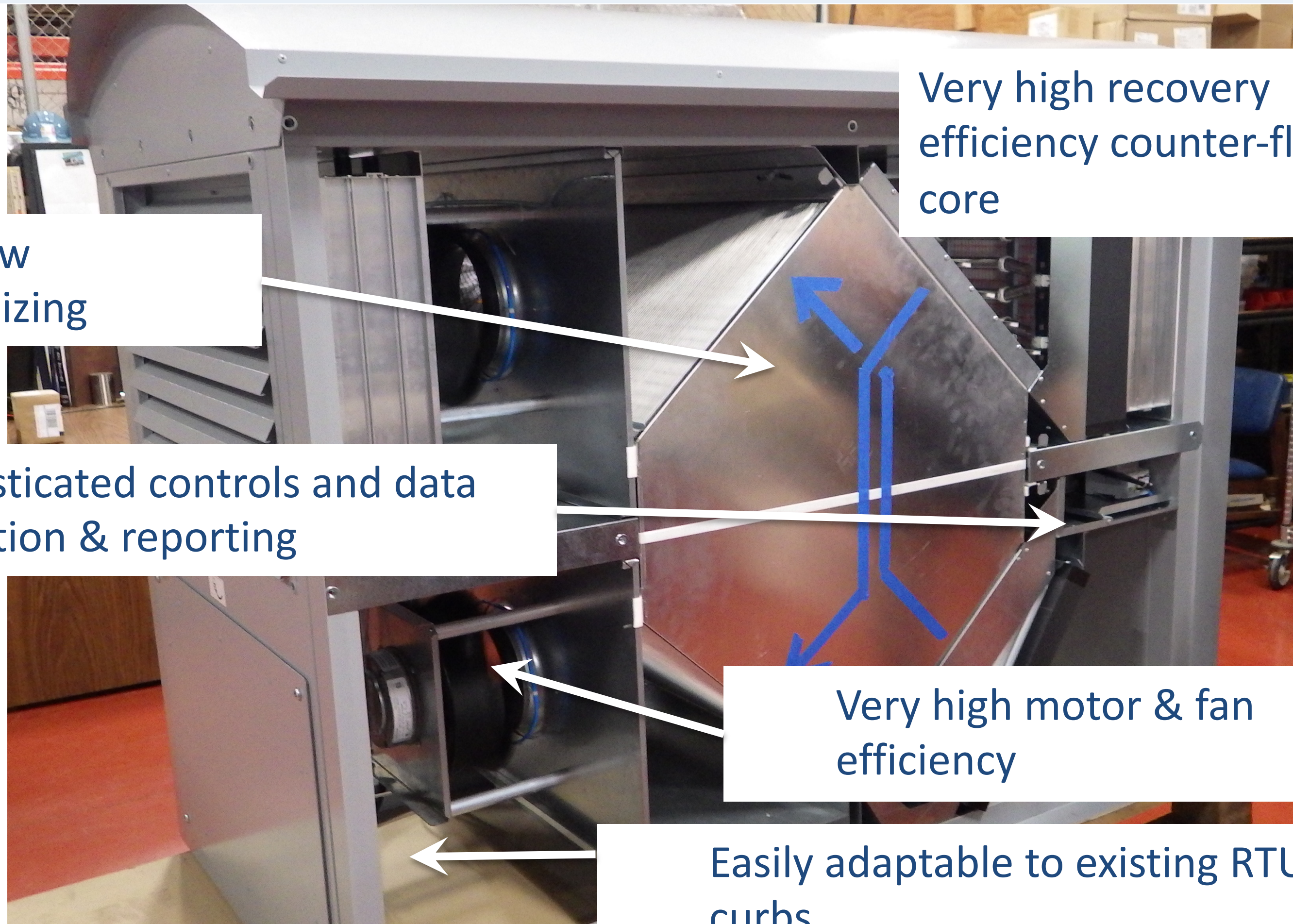
5,667 BTU/Hour

Fresh Air Contribution to Heating Load

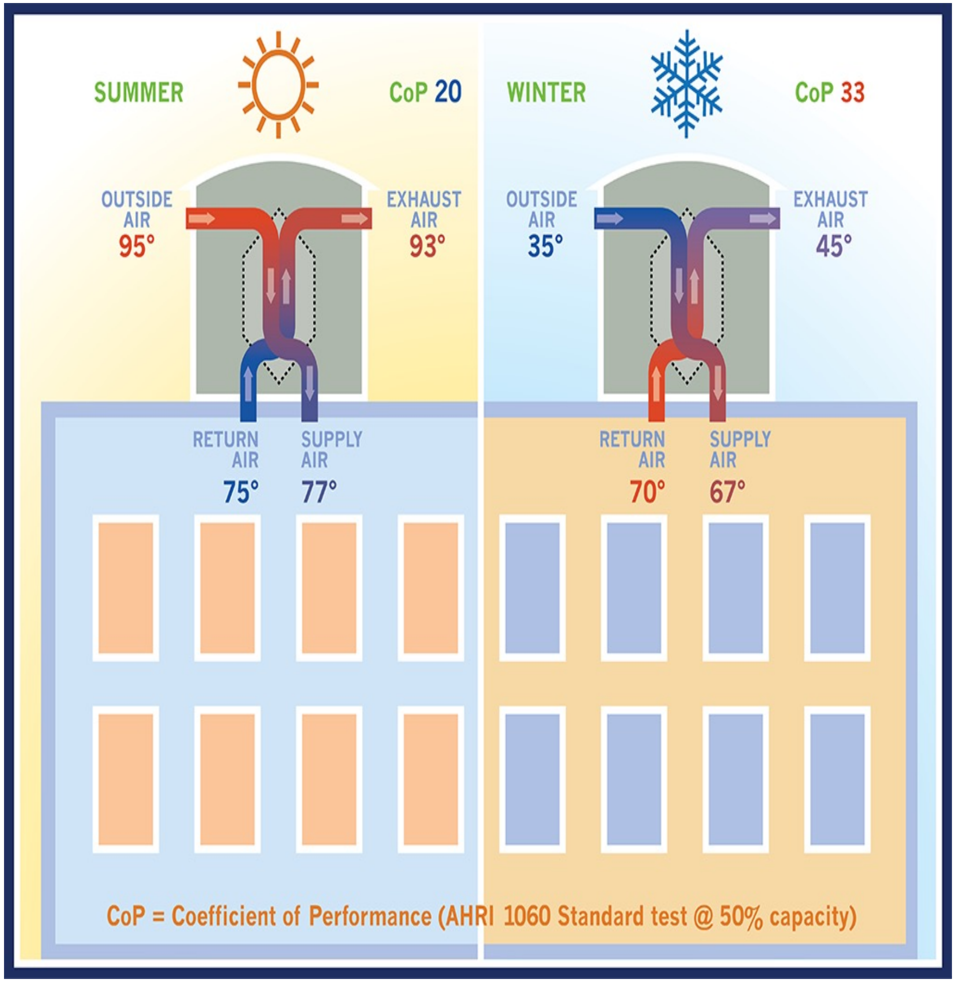
2,430 BTU/Hour

Assume 500 cfm

The Ventilator Technology



Efficiency, Efficiency, Efficiency!



NET EFFICIENCY MATTERS!

- BUILDING LOAD REDUCTION
- HIGH COMFORT LEVEL
- NO NEED TO REHEAT
- SIMPLER CONTROLS
- HIGH RETURN (COP)

SIGNIFICANT ROI

Ventacity Comparison: North Beach Elementary

ERV-1 @ 3000CFM, 1"W.C.

Assumption	Parameter	Competitor	Ventacity
	Fan Power (W)	6114	3421
	Delivered (SA) Temperature Deg F	53.4	57.8
	Heat Recovered (W)	30785	34956
	Heat Recovered (BTU/h)	104976	119200
•	Hours per day	*10*	*10*
•	Days per month	25	25
•	Months per year	9	9
	Heat Recovered per month (kW.h)	7696	8739
	Heat Recovered per year (kW.h)	69266	78651
	HRV/ERV CoP	**5.0**	**10.2**
	Heat Load from fresh HRV/ERV air (W)	15772	11613
	Heat Load from fresh HRV/ERV air (BTU/h)	53784	39600
•	heat Pump CoP (heating)	1	1
	Heat pump power to heat HRV/ERV SA (W)	15772	11613
	Power: Heat Pump Plus fan (W)	21886	15034
•	Electrical rate $/kWh	0.15	0.15
	Monthly electric bill HRV/ERV Power plus Power to heat fresh air. $	$ 821	$ 564
	Annual electic bill to heat fresh air $	$ 7,387	$ 5,074

Savings Per Unit	$	**2,313**
Savings for 6 Units	$	**13,876.37**
Savings for 6 Units over 10 Years	$	**138,763.75**

- BIGGER VOLUMES EQUALS BIGGER SAVINGS
- SCHOOL USED TEN YEAR BOND – SAVINGS MORE THAN COVERED INCREASED COST OF PROJECT OVER LIFE OF LOAN
- COP IS ***DOUBLE*** THAT OF CONVENTIONAL ERVS

Two key conversion performance drivers

HVAC whole-system COP

At average heating conditions in one floor of a New York highrise:				
ERV recovery efficiency:		70	85	0
Ventilation rate:	cfm	1,000	1,000	1,000
ERV fan power:	W	600	390	510
Heating hours per year:	hrs	3,650	3,650	3,650
OAT:	F	35	35	35
IAT:	F	70	70	70
delta T:	F	35	35	35
Energy recovered:	Btu/hr	26,460	32,130	0
Energy not recovered:	Btu/hr	11,340	5,670	37,800
Vent. fraction of total load	%	19.4	10.8	44.6
Fan energy used:	Btu/hr	2,047	1,331	1,740
Heating COP:		0.75	3.00	0.75
Ventilation Gas Energy use :	therms	355		1,183
Ventilation Fan Energy use:	kWh	3,154	10,283	3,066
At average conditions:				
Ventilation System COP:		12.9	24.1	na
Whole System COP:		3.1	5.3	0.75
(Assuming envelopel heating load of 3.9 tons)				

Designing for “off”

Heat Exchanger Core Efficiency – VS1000 RT

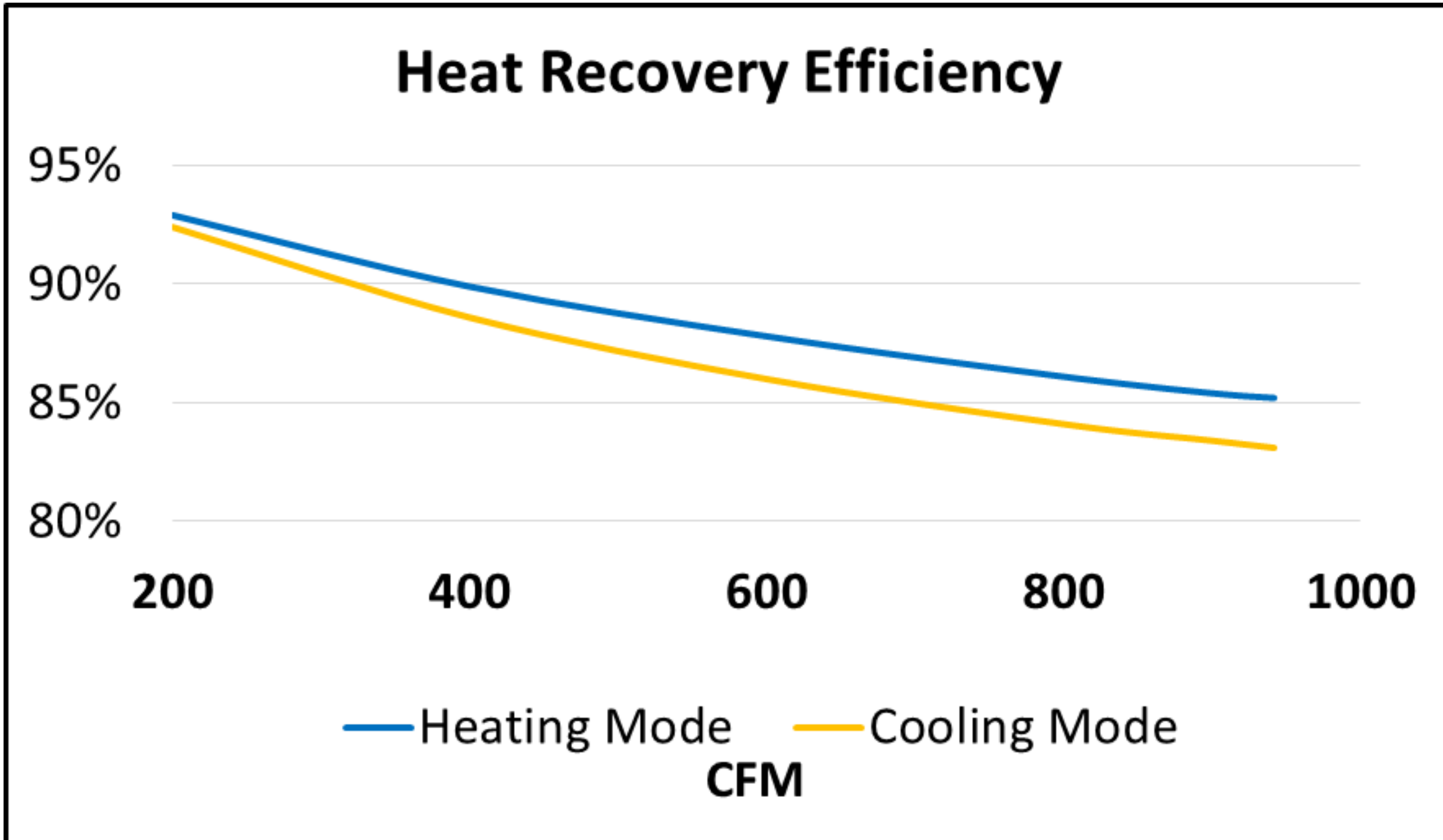
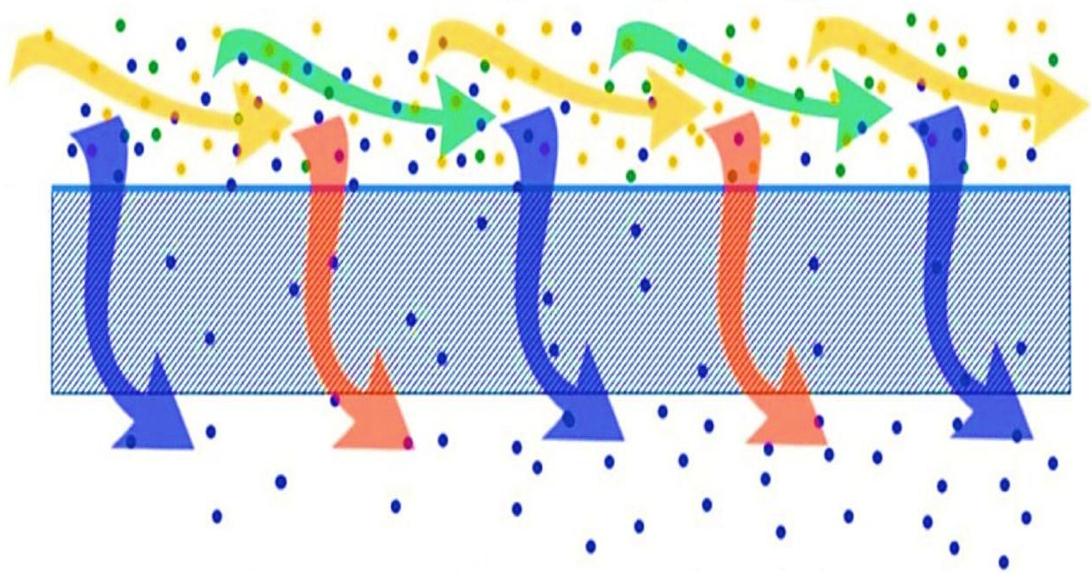


Plate Exchanger with Enthalpy Recovery



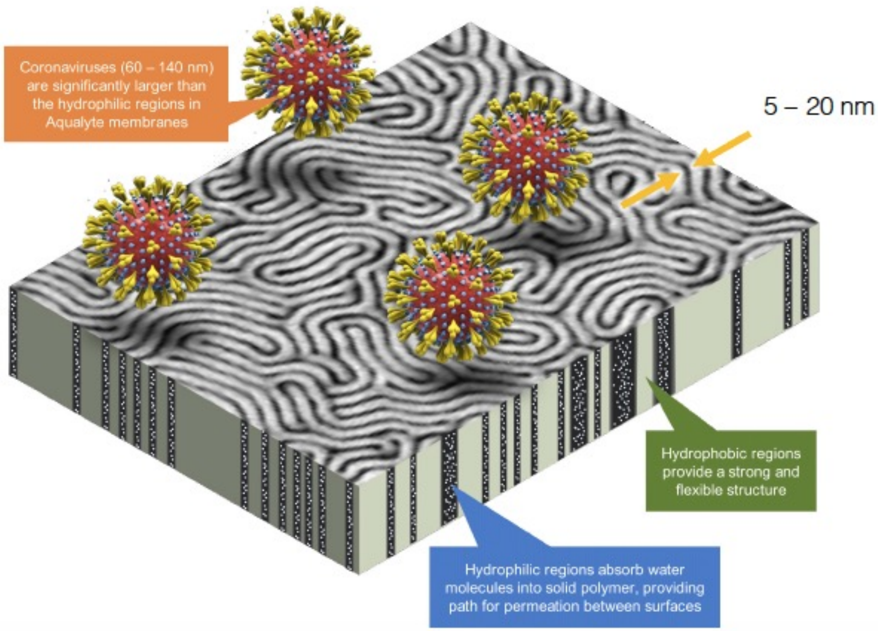
- water vapor
- heat
- odors
- gases, contaminants

Plate Exchanger with Enthalpy Recovery

2. Diffusion through the membrane

Enthalpy exchangers are produced of widely varying materials. In Asia and North America, cellulose paper is often used. These enthalpy exchangers are usually very cheap, but as they are very sensitive to water, it is very hard to get a hygiene certification for these models. It is also challenging to get hygiene certifications for porous plastic foils.

The multilayer membrane developed by Polybloc and its partners allows water molecules to transfer without using porous foils.



Should you use an HRV or an ERV?

Tight, well-built buildings in cold and mixed climates need dry outside air in the wintertime to mitigate the interior latent loads. Otherwise moisture related problems could occur.

THE EFFECT OF ENTHALPY RECOVERY VENTILATION ON THE RESIDENTIAL INDOOR CLIMATE

Bart Cremers

Zehnder Group Nederland
Lingenstraat 2
8028 PM Zwolle, The Netherlands
bart.cremers@zehndergroup.com

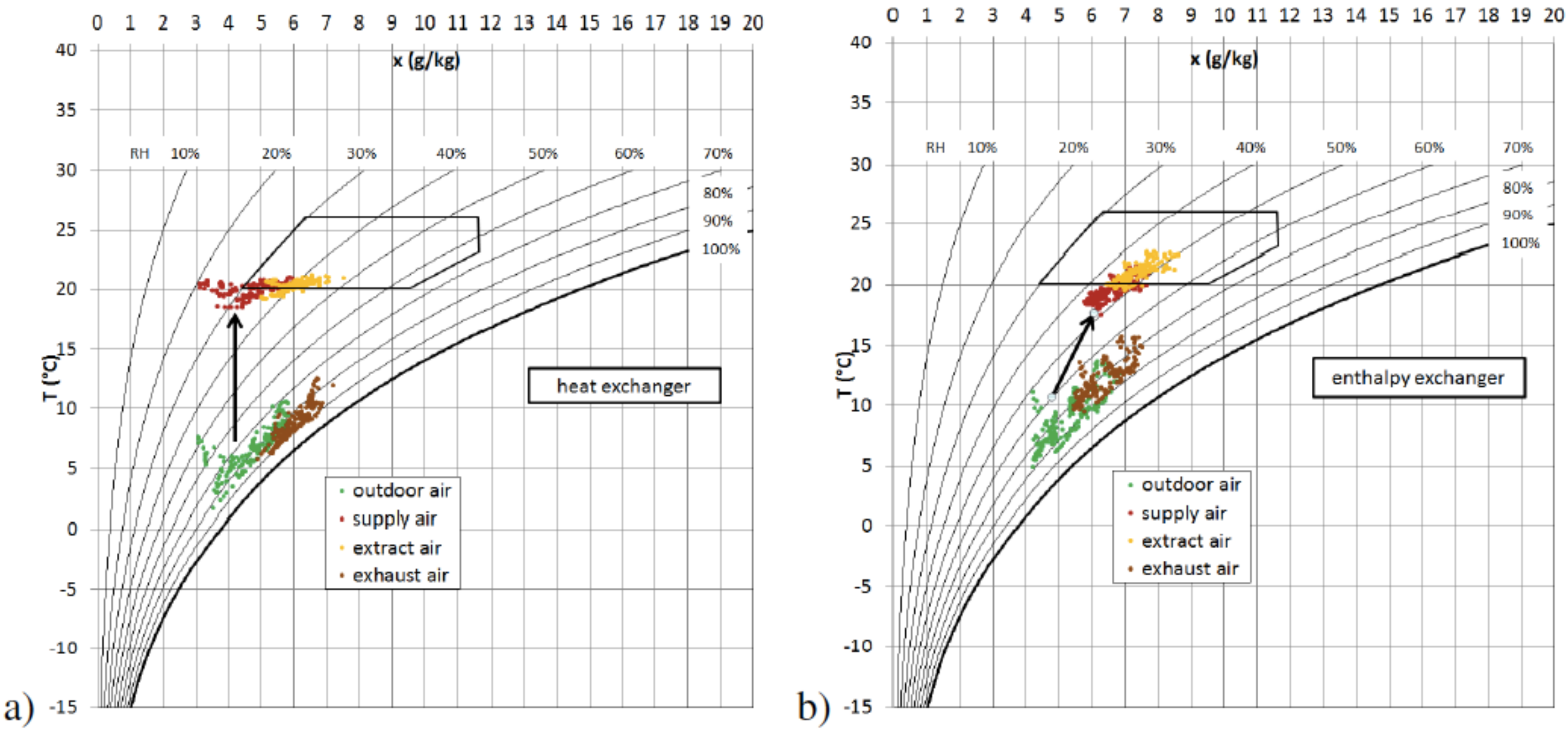
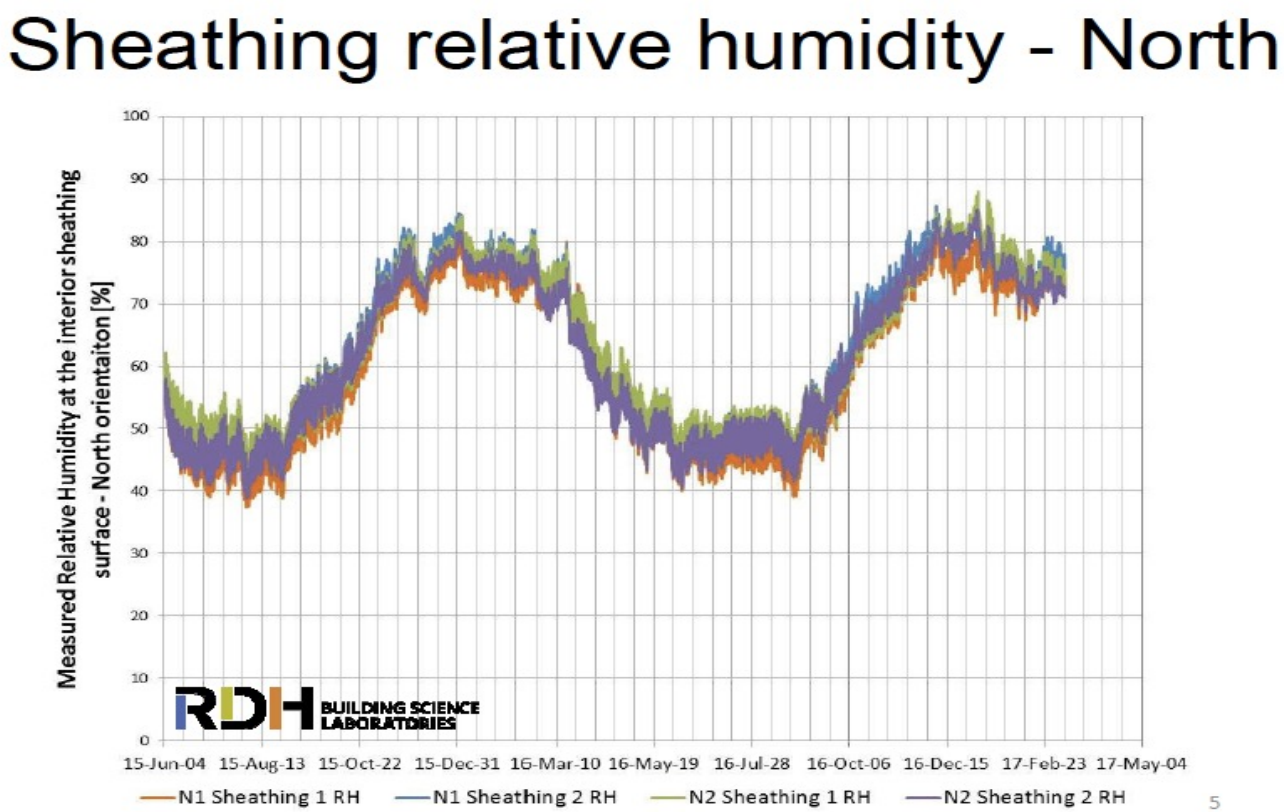
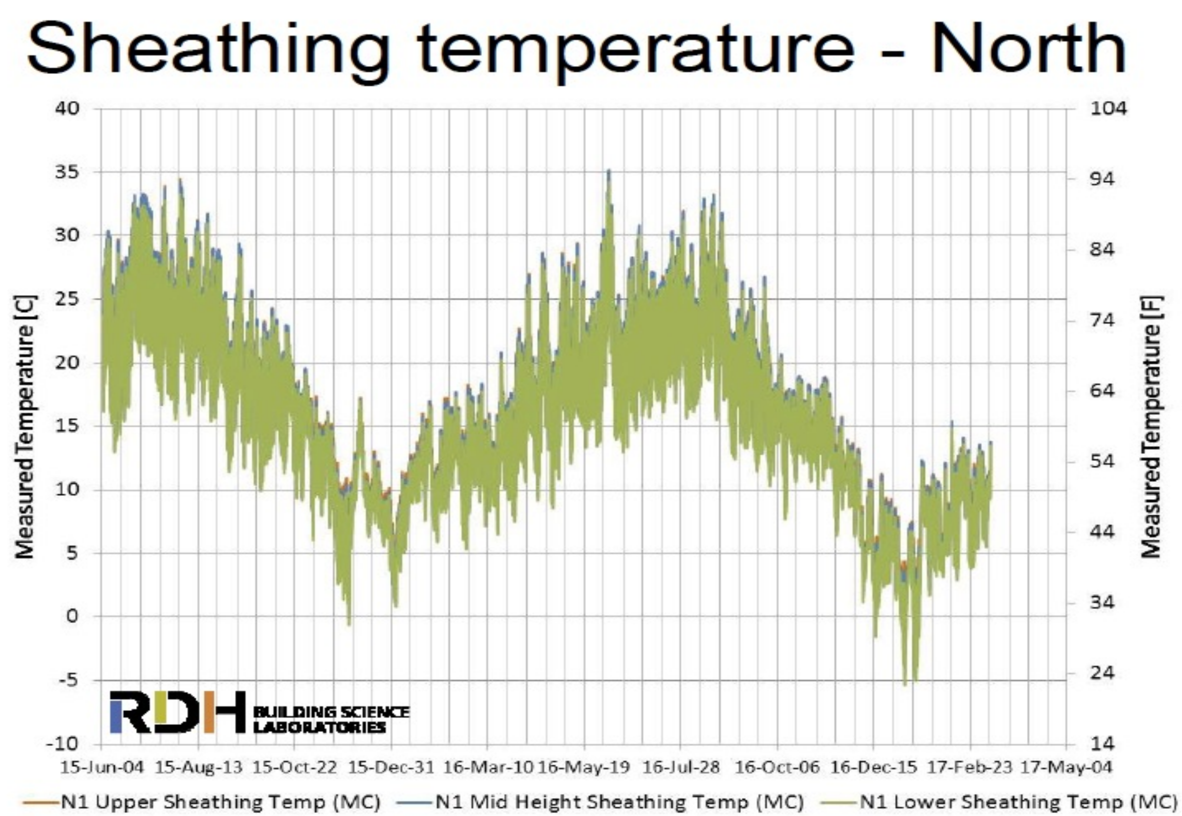


Figure 3: The effect of a heat exchanger (a) and an enthalpy exchanger (b) on the supply air and the indoor air.

Should you use an HRV or an ERV?



Should you use an HRV or an ERV?



Should you use an HRV or an ERV?

VENTACITY SYSTEMS
ALWAYS HEALTHY • ALWAYS EFFICIENT

Project Information

Project Name:	Example Project Name
City:	Portland
State/Province:	OR
Org Name:	Customer Co, Inc.
Org Contact Name:	John Doe
Org Contact Phone:	800-555-1212
Org Contact Email:	john@buildingowner.com
Created By:	You
Created On:	1/1/2020

Project Conditions

Summer Conditions Cooling

Outside DBT	91.4	°F	
Outside WBT	67.3	°F	
or Outside RH		%	28.0
Design Inside DBT	73.0	°F	
Design Inside WBT		°F	
or Design Inside RH	50.0	%	50.0

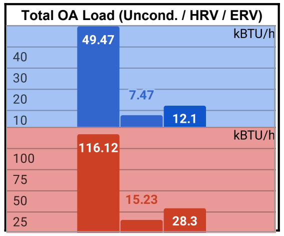
Winter Conditions Heating

Outside DBT	25.2	°F	
Outside WBT	23	°F	
or Outside RH		%	72.4
Design Inside DBT	70	°F	
Design Inside WBT			
or Design Inside RH	50	%	50.0

Quick Selector

Ventacity HRV / ERV

Ventacity Model	**VS3000**	
Altitude	**100**	ft
Supply Flow	**2400**	CFM
Exhaust Flow	**2400**	CFM



	HRV	ERV	REDUX
Cooling	-42.00	-37.4	kBTU/h
Heating	-100.89	-87.8	kBTU/h

Unconditioned OA Cooling Load

Supply DBT	91.4	°F
Supply WBT	67.3	°F
Supply RH	28.0	%
Total Load	49.47	kBTU/h
Sensible Load	47.69	kBTU/h
Latent Load	1.78	kBTU/h

HRV OA Cooling Load

Supply DBT	75.2	°F
Supply WBT	61.9	°F
Supply RH	47.2	%
Efficiency (S)	87.9	%
Total Load	7.47	kBTU/h
Sensible Load	5.76	kBTU/h
Latent Load	1.71	kBTU/h

ERV OA Cooling Load

Supply DBT	77.4	°F
Supply WBT	62.5	°F
Supply RH	43.5	%
Efficiency (S)	76.1	%
Efficiency (L)	57.2	%
Total Load	12.1	kBTU/h
Sensible Load	11.4	kBTU/h
Latent Load	0.7	kBTU/h

Unconditioned OA Heating Load

Supply DBT	25.2	°F
Supply WBT	23.0	
Supply RH	72.4	%
Total Load (Sensible)	116.12	kBTU/h

HRV OA Heating Load

Supply DBT	64.1	°F
Supply WBT	45.1	°F
Supply RH	16.3	%
Efficiency (S)	86.9	%
Total Load (Sensible)	15.23	kBTU/h

Warning: Condensation (1)

ERV OA Heating Load

Supply DBT	59.1	°F
Supply WBT	50.3	°F
Supply RH	54.1	%
Efficiency (S)	75.6	%
Efficiency (L)	64.6	%
Total Load (Sensible)	28.3	kBTU/h

Post-Heating/Cooling, Humidity Control With DX Coil

VENTACITYSYSTEMS
Making Buildings Healthy – Efficient – Smarter

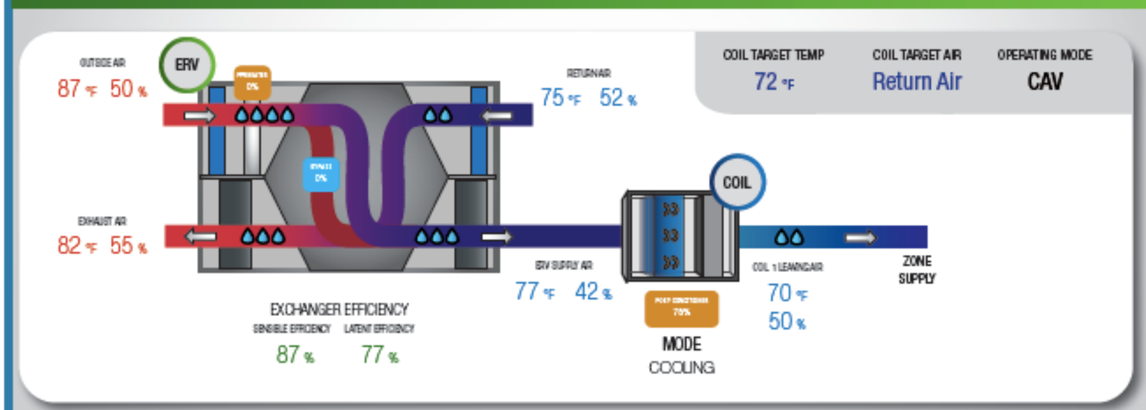
VS DX KIT
Specification & Installation

DX COIL & ECO CONTROLLER
FOR ERV/HRV POST-CONDITIONING

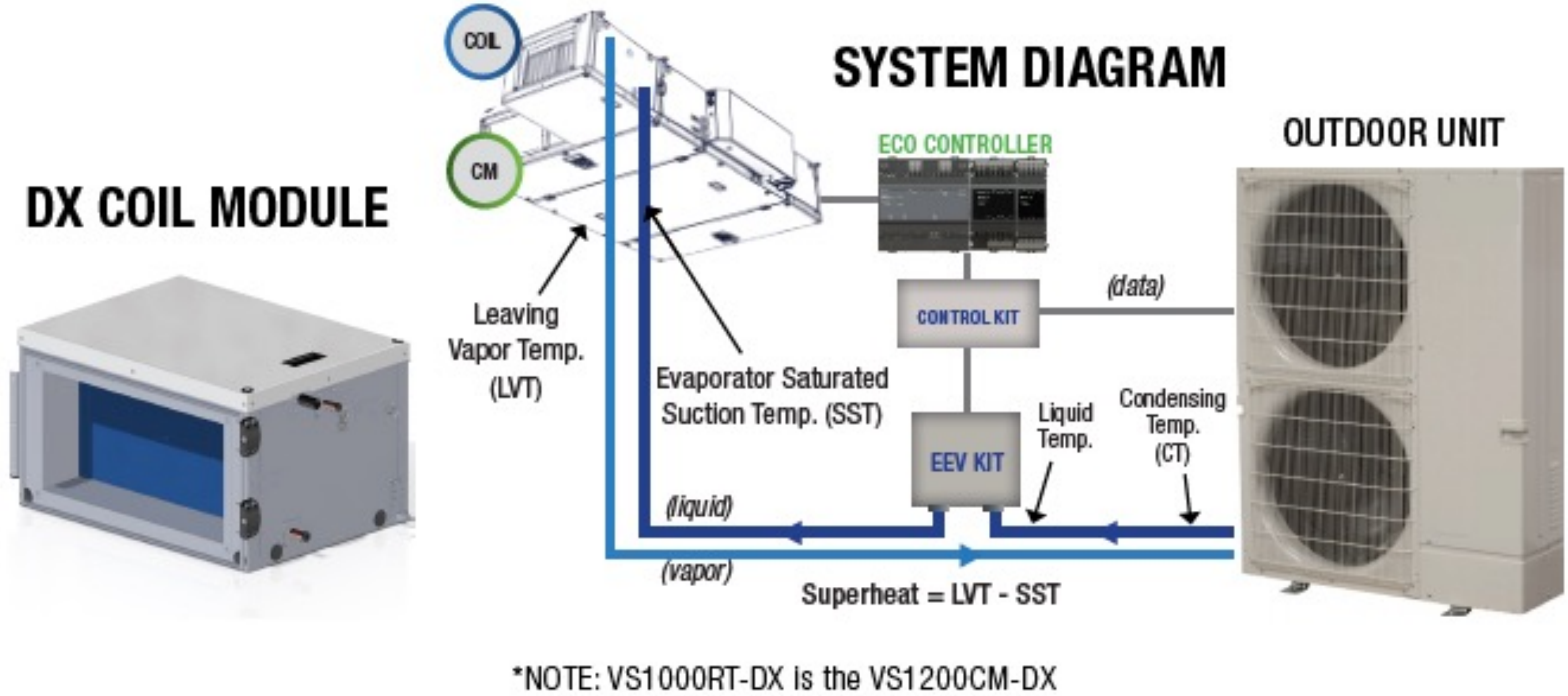
VENTACITY SYSTEMS provides a suite of DX Coil Modules for the following ERV and HRV ventilators:
VS1200CM, VS900CM, VS400CM, VS250CM, VS1000RT*, and VS3000RT.

- DX coils are compatible with VRF systems.
- ECO Controller: Energy Conserving Orchestration. Used for added features (see following pages).

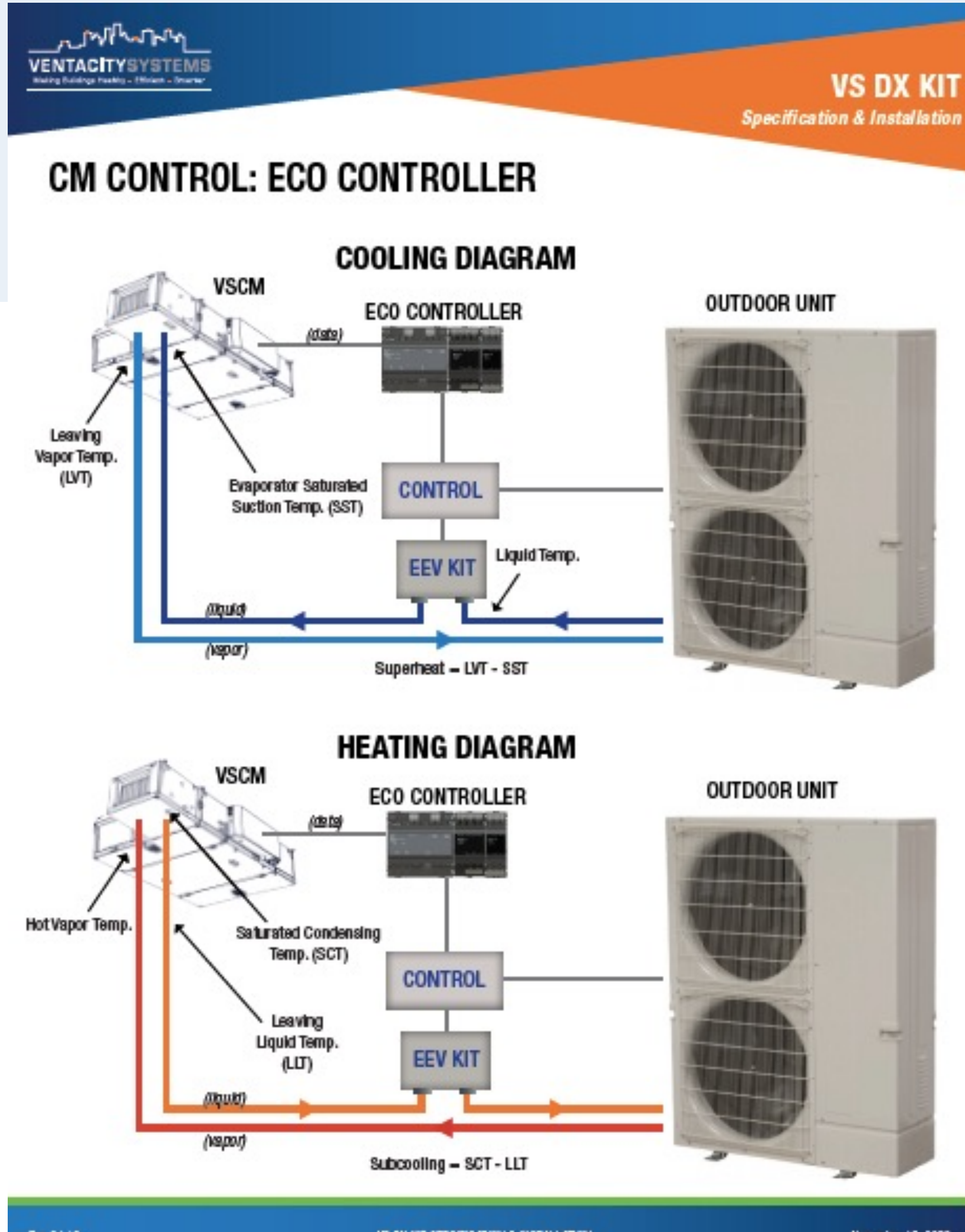
EXAMPLE: ERV & DX COIL



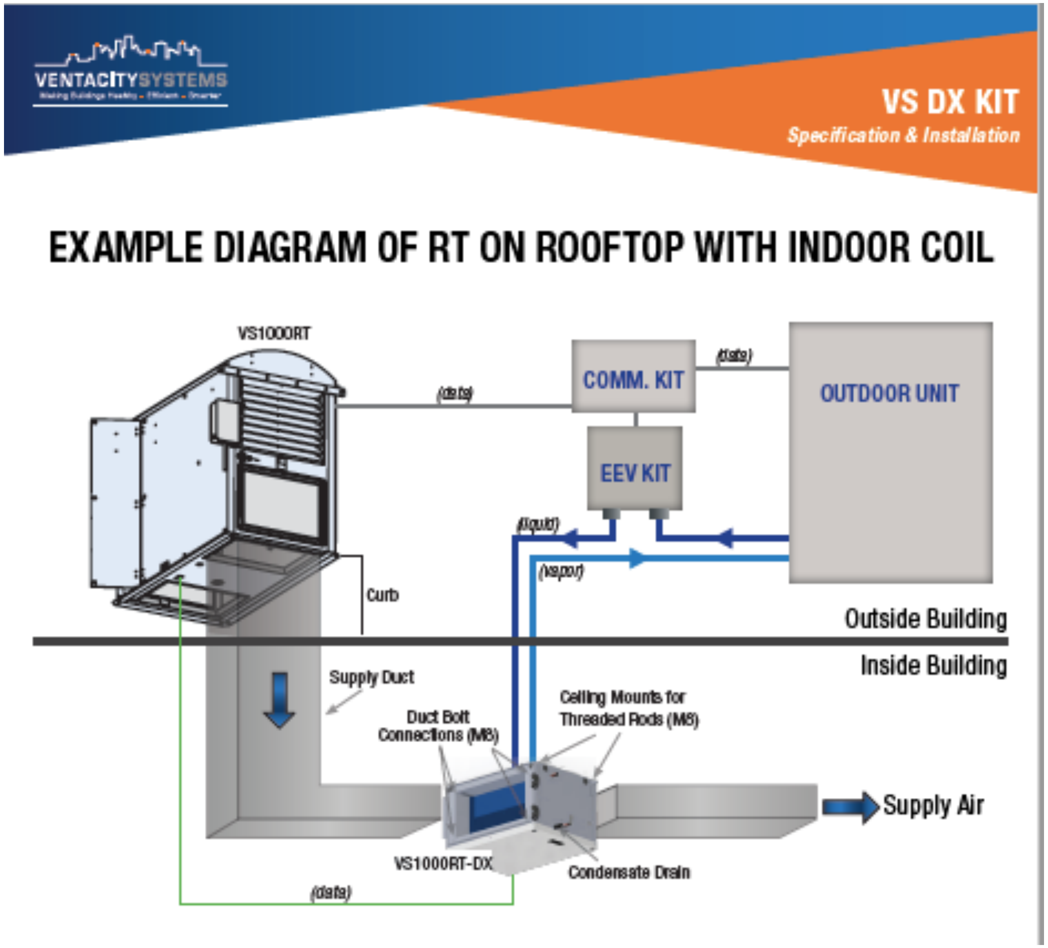
Controls are Key



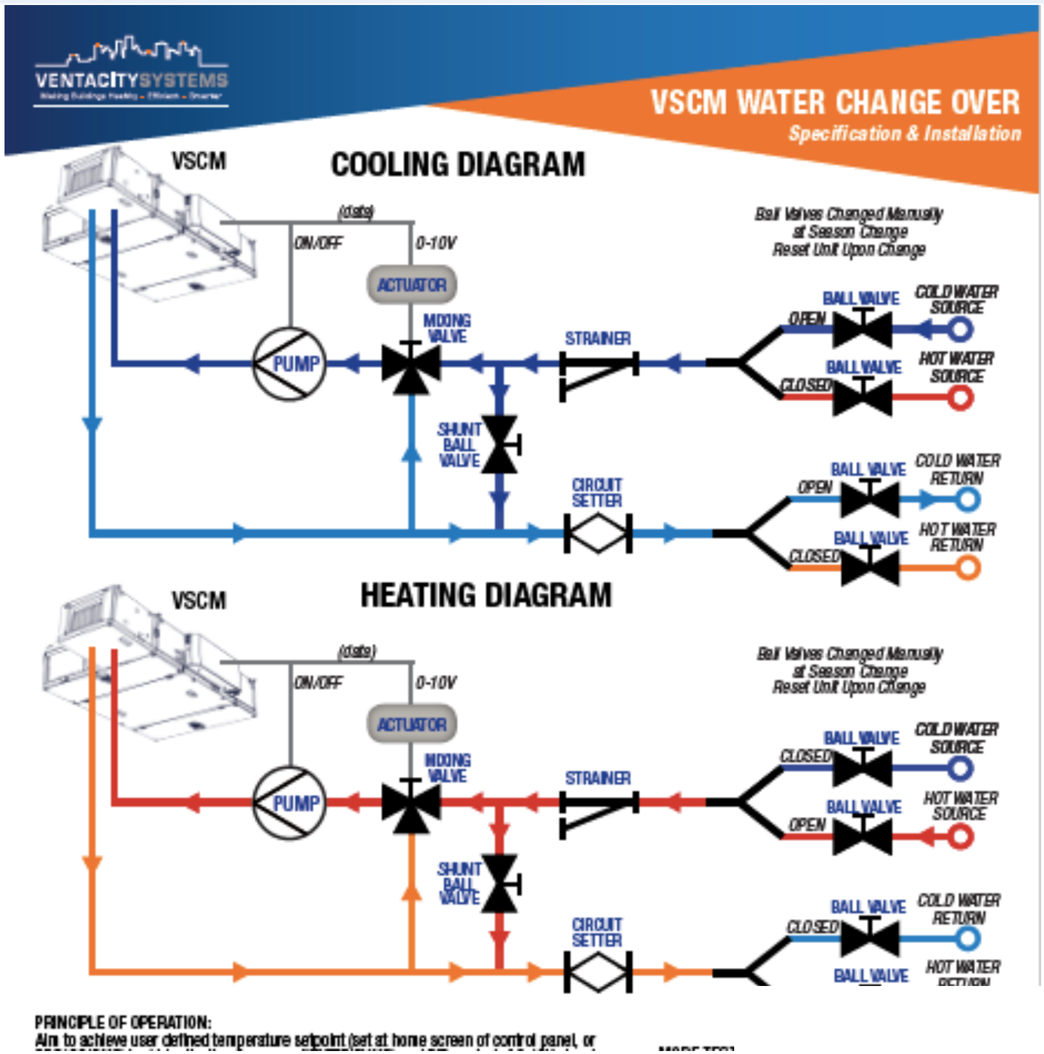
Heating, Cooling, Humidity Control



Rooftop Installation with DX Coil Installed On Inside Ducting

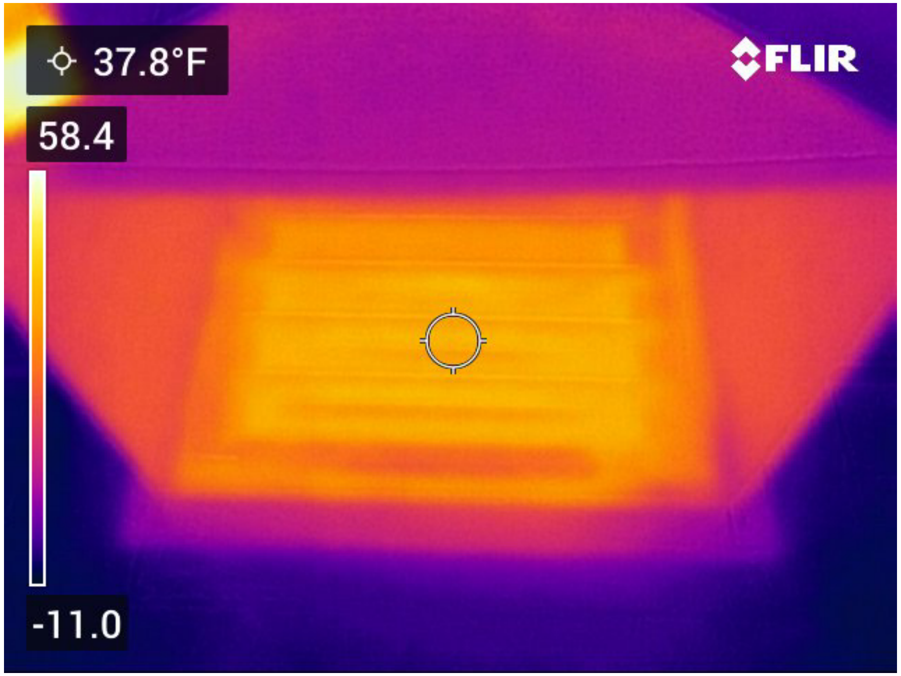


Hydronic Changeover Coil Option

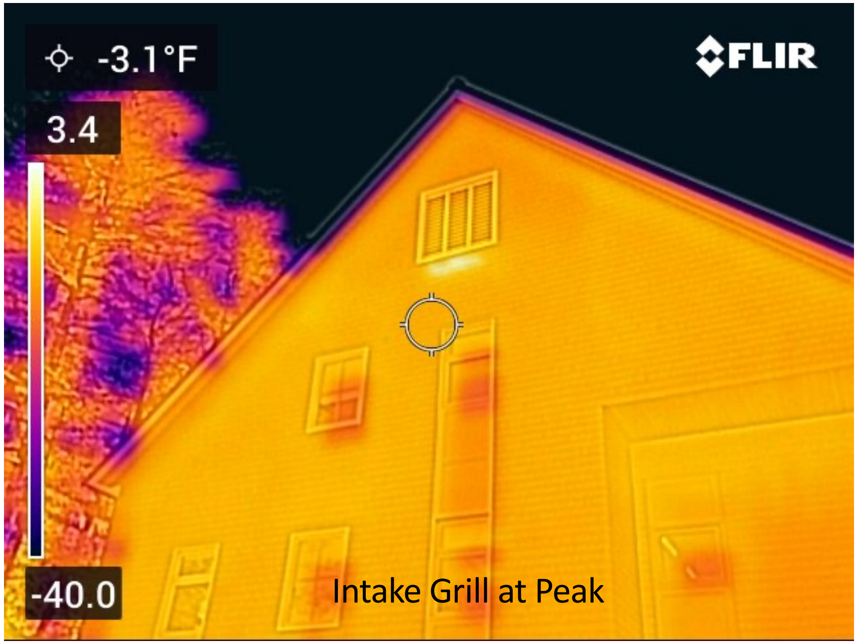


Exhaust Side Matters

Exhaust Side Matters



Exhaust Side Matters

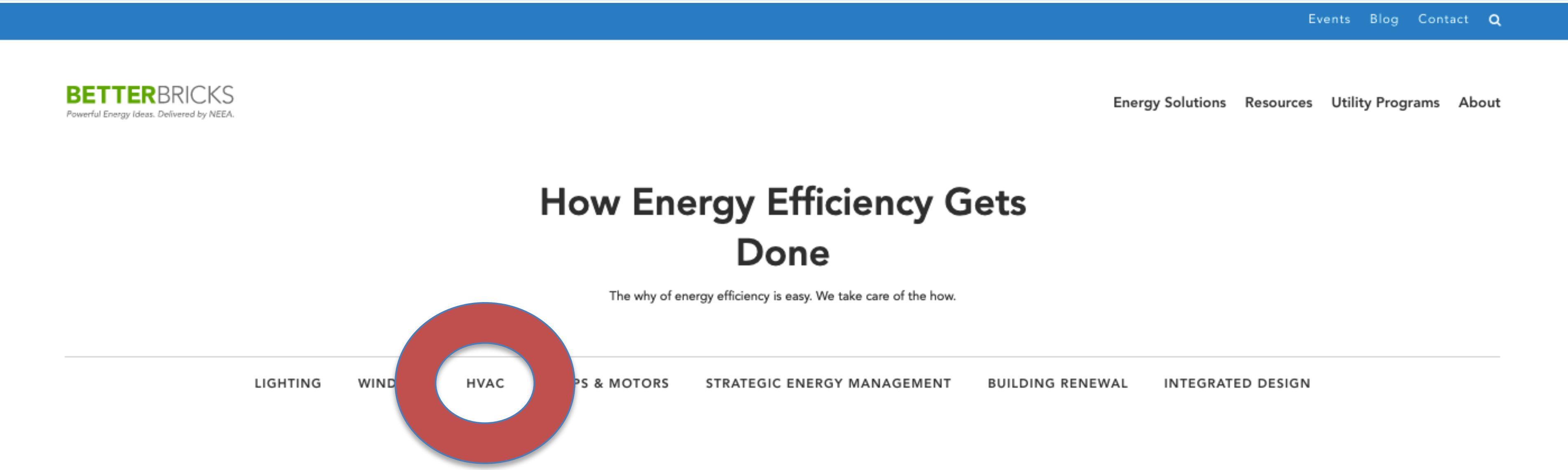


Intake Grill at Peak

Exhaust Grill at Peak

Chapter 5: VHE DOAS Program

Better Bricks/NEEA VHE DOAS



Better Bricks/NEEA VHE DOAS

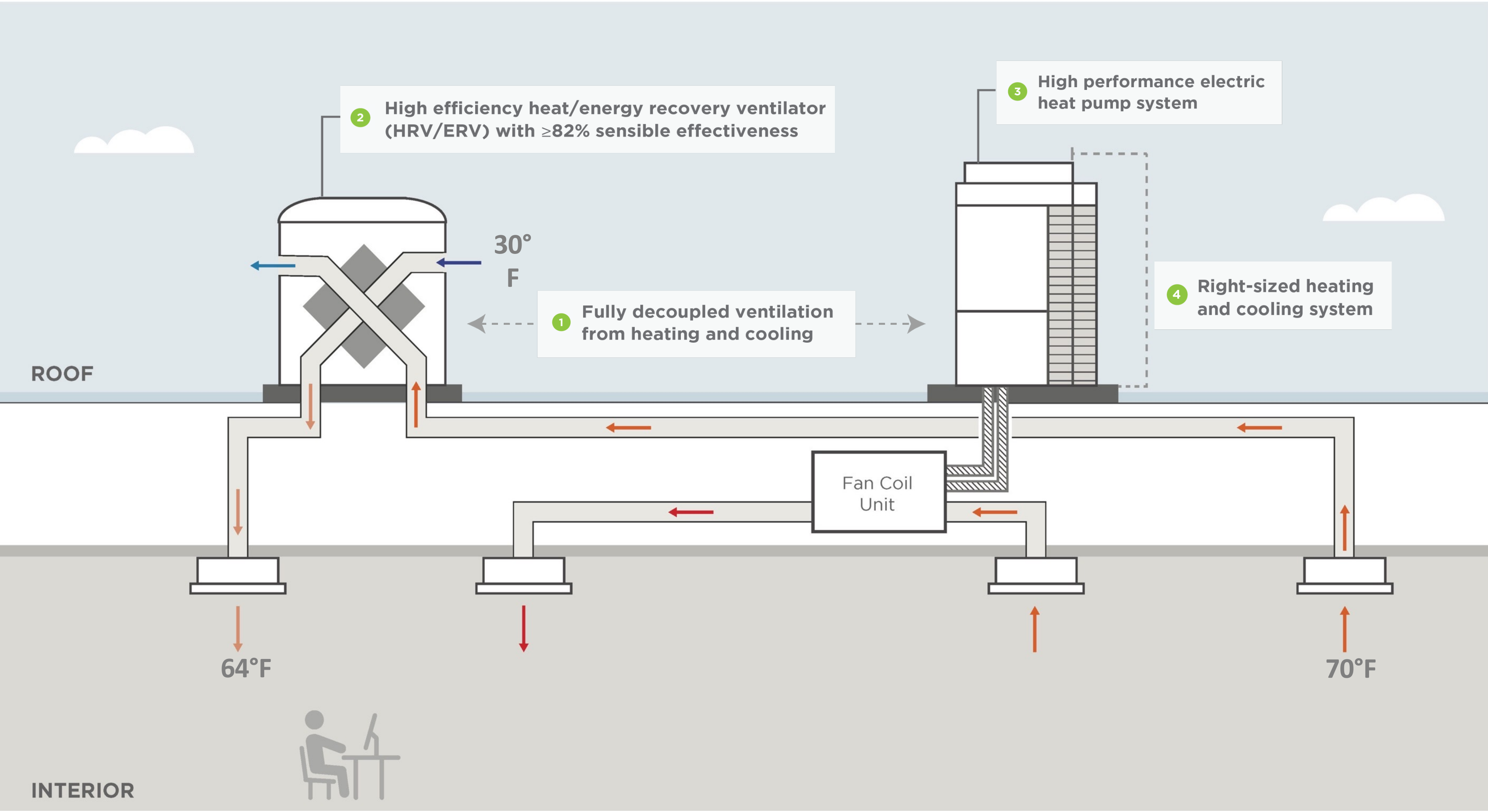
HVAC +1 Tags

[Video] Very High Efficiency DOAS: How It Works and Why It Matters

In commercial buildings across the U.S., outdated or inefficient HVAC systems waste a staggering amount of energy and money, while also creating unhealthy and uncomfortable indoor environments. However, research and field studies have proven there's an optimal approach to HVAC design that can significantly improve indoor air quality and occupant health, comfort and productivity, while maximizing energy-cost savings. Learn how this optimized, high-performance approach to HVAC combines high-efficiency equipment with design best practices to make widespread commercial HVAC deficiencies a thing of the past.

Resources

- **Established Model**
- **Multiple Case Studies**
- **Specification**
- **Proven Results**


High efficiency heat/energy recovery ventilator (HRV/ERV) with ≥82% sensible effectiveness
High performance electric heat pump system
30° F
Fully decoupled ventilation from heating and cooling
Right-sized heating and cooling system
ROOF
Fan Coil Unit
64°F
70°F
INTERIOR

Better Bricks/NEEA VHE DOAS

Events Blog Contact

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Powerful Energy Ideas. Delivered by NEEA.

Energy Solutions Resources Utility Programs About

Share

A Proven Approach to High-Performance HVAC Improves Efficiency, Health and Comfort

SELL SHEETS

Very high efficiency dedicated outside air systems (very high efficiency DOAS) pair the highest performance HVAC equipment with key design principles to provide cleaner and safer indoor air, enhance indoor comfort, and reduce commercial building HVAC energy use. This approach has been demonstrated to reduce HVAC energy use by an average of 69% when compared to a code-minimum version of the existing equipment (often a packaged rooftop unit).

Very high efficiency DOAS consists of the following key elements:

1. **A high efficiency HRV/ERV** that features 82% or greater sensible effectiveness.
2. **High-performance heating and cooling system** that meets ENERGY STAR® performance standards.
3. **Ventilation fully separated** from heating and cooling.
4. **Right-sized** heating and cooling equipment.

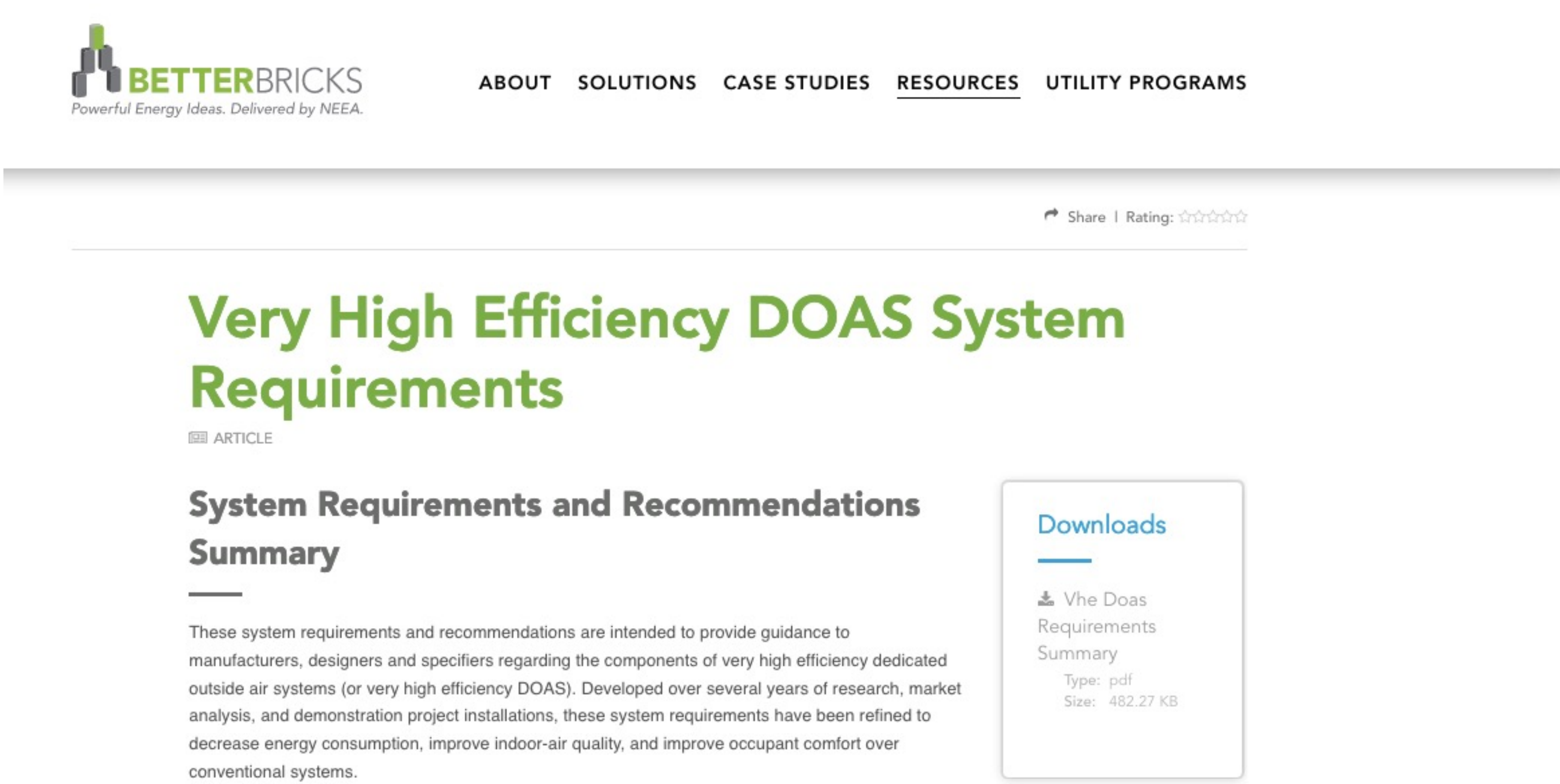
To learn more about very high efficiency DOAS, including through case studies, research, and technical guides, visit: https://betterbricks.com/solut...

Downloads

Very High Efficiency DOAS Fact Sheet
Type: pdf
Size: 477.83 KB

PROGRAM SPECIFICATION

https://betterbricks.com/resources/very-high-efficiency-doas-system-requirements



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ABOUT SOLUTIONS CASE STUDIES RESOURCES UTILITY PROGRAMS

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Very High Efficiency DOAS System Requirements

ARTICLE

System Requirements and Recommendations Summary

These system requirements and recommendations are intended to provide guidance to manufacturers, designers and specifiers regarding the components of very high efficiency dedicated outside air systems (or very high efficiency DOAS). Developed over several years of research, market analysis, and demonstration project installations, these system requirements have been refined to decrease energy consumption, improve indoor-air quality, and improve occupant comfort over conventional systems.

Downloads

Vhe Doas Requirements Summary
Type: pdf
Size: 482.27 KB

PROGRAM SPECIFICATION

Table 1: Minimum Equipment Performance [learn more]	
Heat Recovery Ventilation [learn more]	
1.	Minimum efficiency: Passive House Institute[1] (PHI) certified, or minimum 82% Sensible Effectiveness[2] of heat exchanger (HX) at Air-Conditioning, Heating & Refrigeration Institute (AHRI) Standard 1060 winter conditions at 75% of rated flow[3] verified by independent third-party testing[4].
2.	Minimum fan efficacy: PHI-certified, or minimum 1.4 cubic feet per minimum per Watt (cfm/Watt) at 0.5" water gauge (w.g.) external static pressure (ESP) at 75% of rated full airflow[5].

VHE DOAS - The Basics

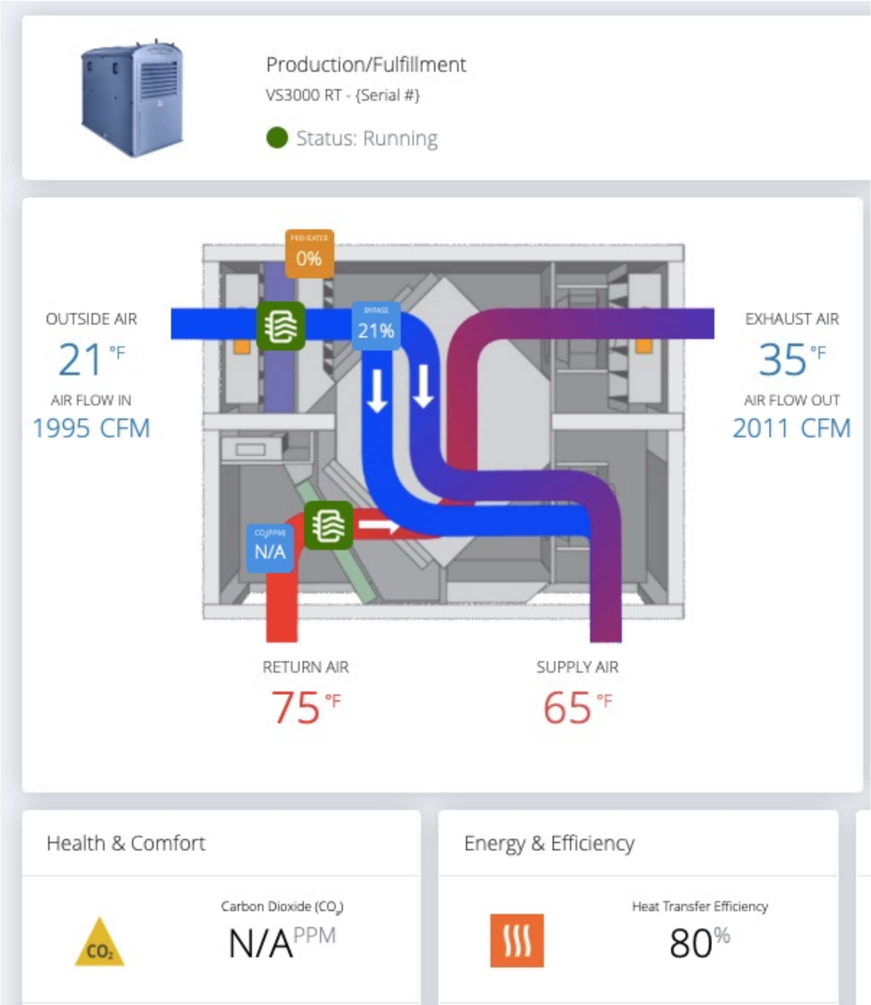
The VHE Concept - Heating and Cooling

- Very high efficiency heat pump-based heating and cooling.
- System significantly downsized due to the removal of most of the ventilation load.
- Design simplicity and minimizing indoor fan/coil units greatly improves economics and reliability, reduces refrigerant volumes and piping losses (parasitic losses).

Critical System Elements

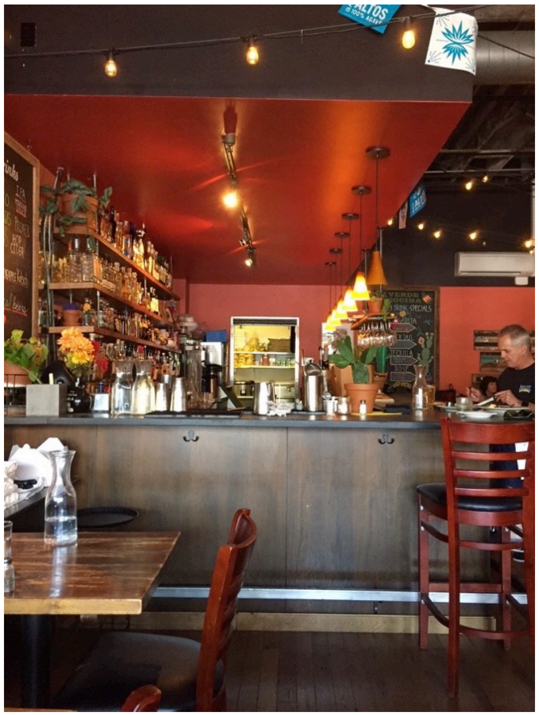
- Use heating/cooling systems with high part-load efficiency and minimize parasitic losses.
- Good ducting design
- Use systems with very low fan power.
- Design for “off.”

Controls are important



Chapter 5: VHE DOAS Program

Pilot Projects

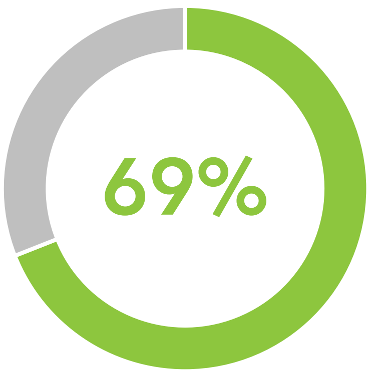


Chapter 5: VHE DOAS Program

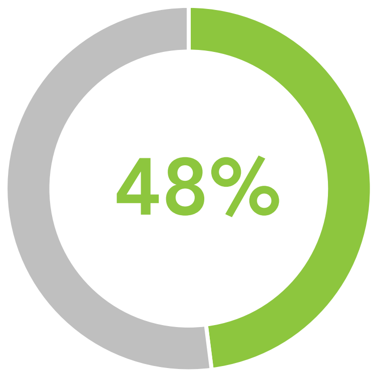
NEEA pilot project results are fairly consistent:

- In office occupancies:
  - 50 – 75% HVAC energy savings (ending HVAC EUI 11 kBtu/sq ft, ±3)
  - 20 – 40% cooling demand reduction
  - 30 – 60% whole-building energy savings
  - Very high indoor air quality
  - Excellent indoor comfort
  - Lower maintenance costs
  - Radical system simplification
  - Simple but sophisticated, inexpensive controls
  - No building improvements required (but in many cases they would be a good idea – e.g., glazing/secondary glazing)
  - Wide variation in building base loads (6-35 kBtu/sq ft)

A proven approach to high-performance HVAC



HVAC ENERGY SAVINGS*



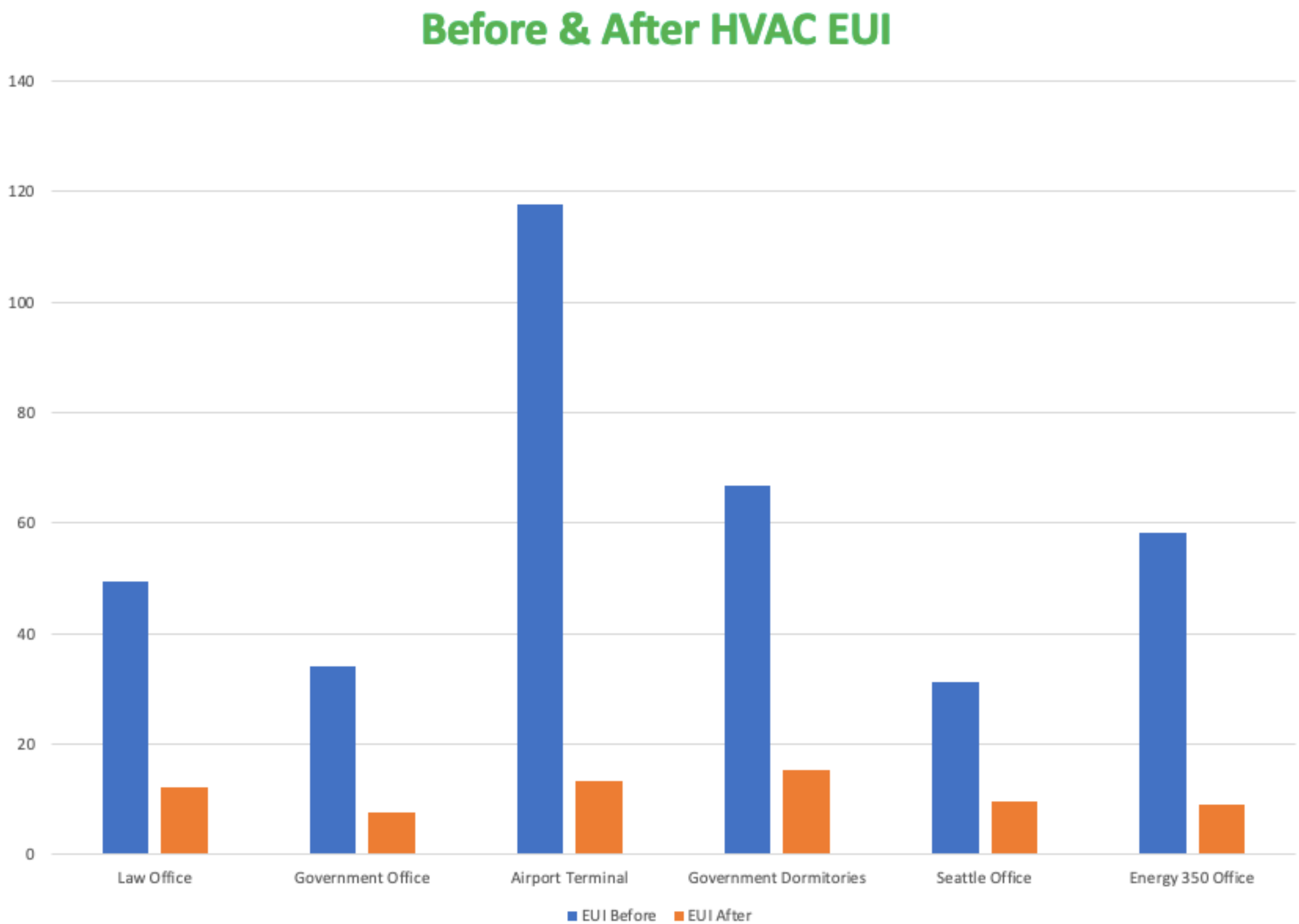
WHOLE-BUILDING ENERGY SAVINGS*

12 pilots using the very high efficiency DOAS approach

in small-to-medium commercial buildings across the NW proved significant average energy savings—based on if the building had started with standard code-minimum equipment.

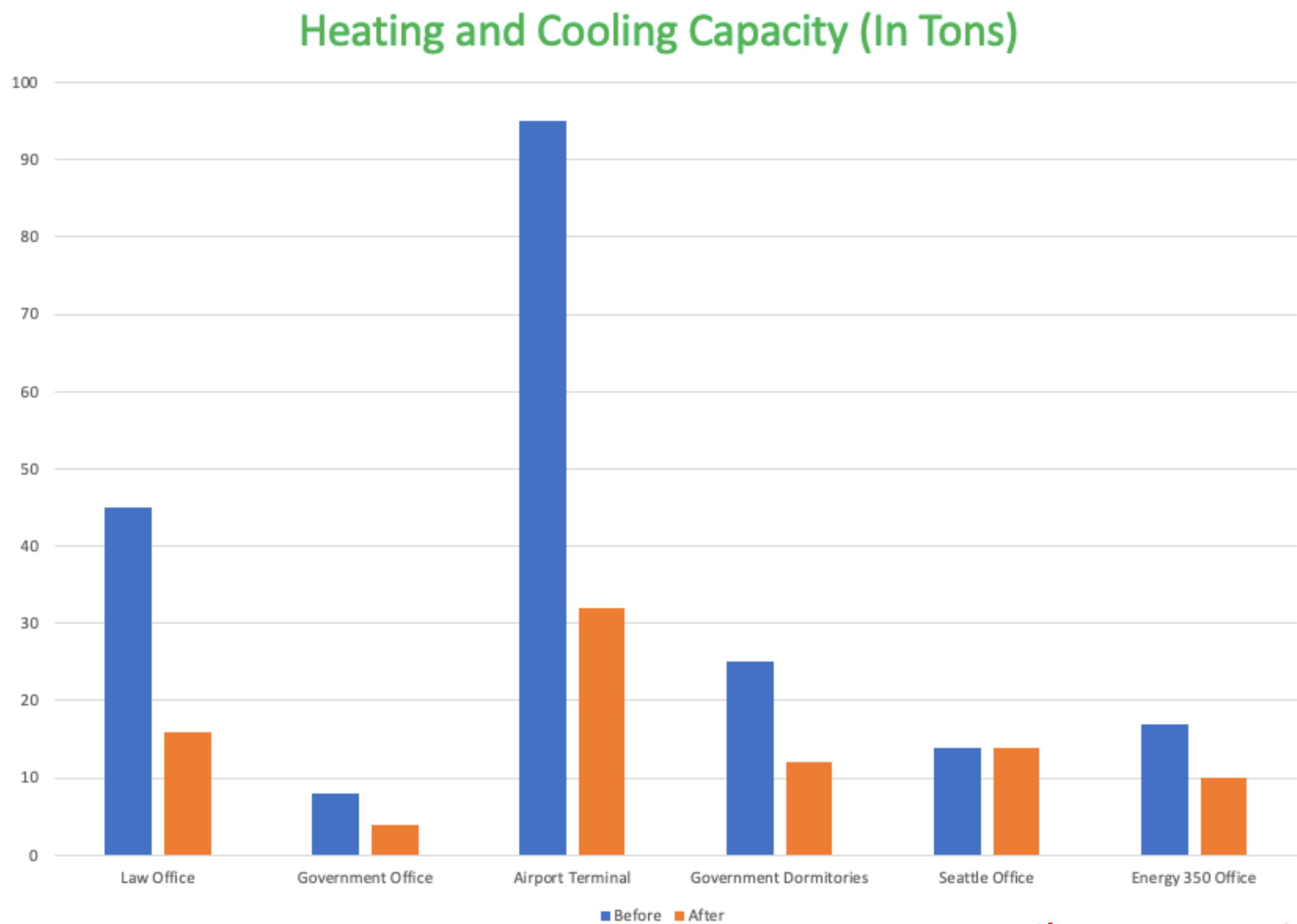
**When compared to a code-minimum version of the existing equipment (often a packaged rooftop unit)*

HVAC EUI Results

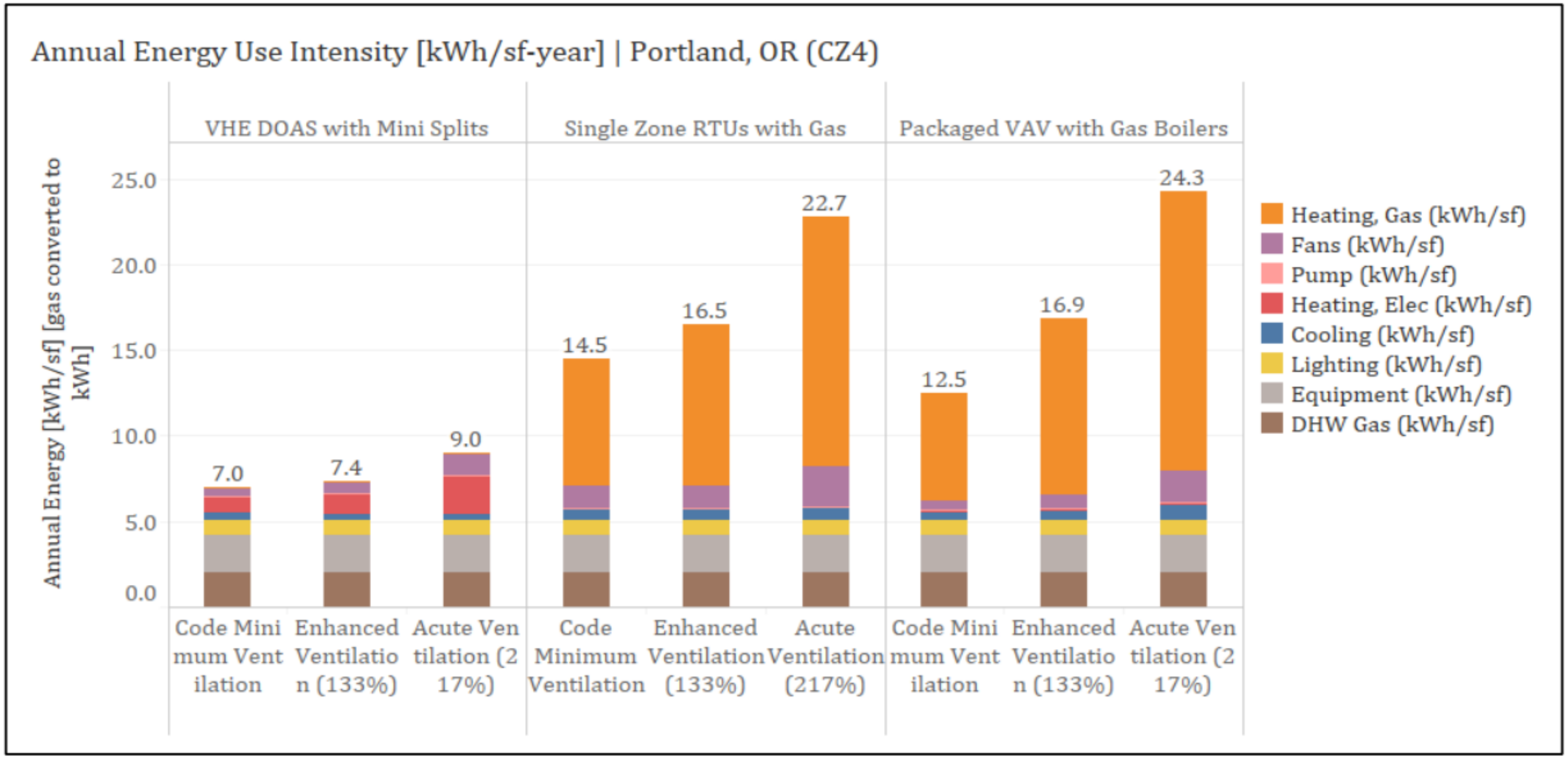


Chapter 5: VHE DOAS Program

HVAC Capacity Reductions



Increased Ventilation and Energy Cost



[Source: BetterBricks | Covid-19 Risk Reduction Strategies and HVAC System Energy Impact]()

Other results

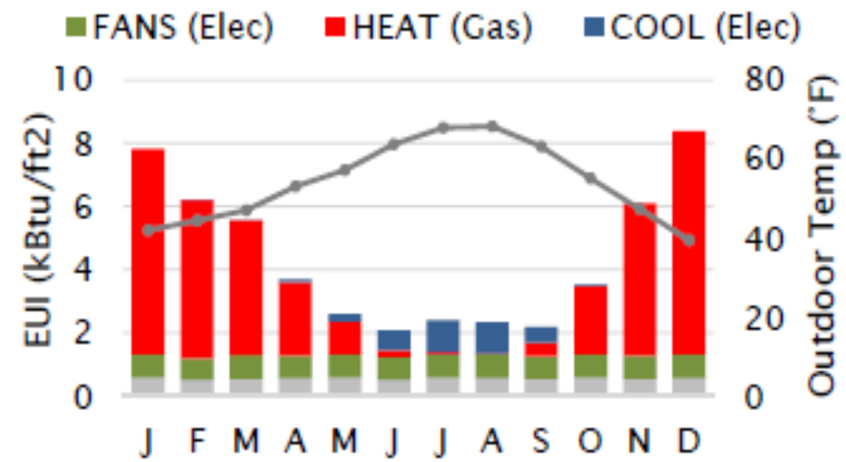
Project	Floor Area (sq ft)	Installed System Capacity (tons)	Conditioned Floor Area / Ton (sq ft / ton)	Number of System Zones	Conditioned Floor Area per Zone (sq ft / zone)	Project Cost	Project Cost per Square Foot
Law Office	11,615	16	**726**	8	**1,452**	$181,256	**$15.61**
Pizza Restaurant	1,730	9	**192**	4	**433**	$37,400	**$21.62**
Government District Office 1	3,770	8	**471**	2	**1,885**	$43,238	**$11.47**
Utility District Office	5,681	8	**710**	8	**710**	$125,528	**$22.10**
Airport Terminal Building	26,200	32	**819**	37	**708**	$928,500	**$35.44**
Government Dormitories (4)	~11,000, (each building)	16	**688**	5	**2,200**	$106,000	**$9.64**
Seattle Office	6,100	14	**422**	12	**508**	$99,500	**$16.83**
Restaurant	1,147	3	**382**	3	**382**	$35,550	**$30.99**

Law Office

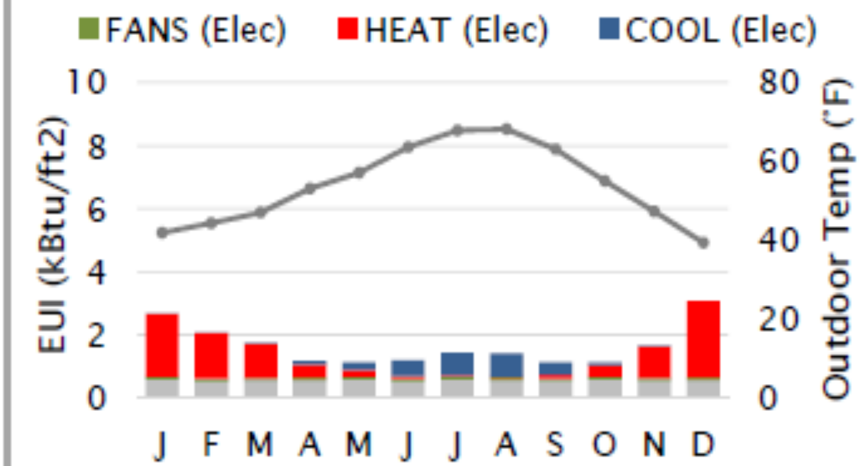
- 1907, 2nd floor suite, 11,615 sq ft, 12" brick walls, 900 sq ft glazing (new), R-38 ceiling insulation (new), LED lighting (new)
- Remove - 35 tons cooling, 45 tons gas heating in nine RTUs (332 sq ft/ton)
- Install - Four Ventacity VS 1000s, one 16-ton Mitsubishi VRF system (725 sq ft/ton)
- **Distributor proposal**: 41 indoor units (24 tons, or 500 sq ft/ton)
- **Final system**: eight 2-ton AHUs w/short ducting
- 2 VS 1000s for conference rooms, 2 for the rest
- Sound transmission was an issue

Law Office - VRF Zoning

Law Office Results - Energy

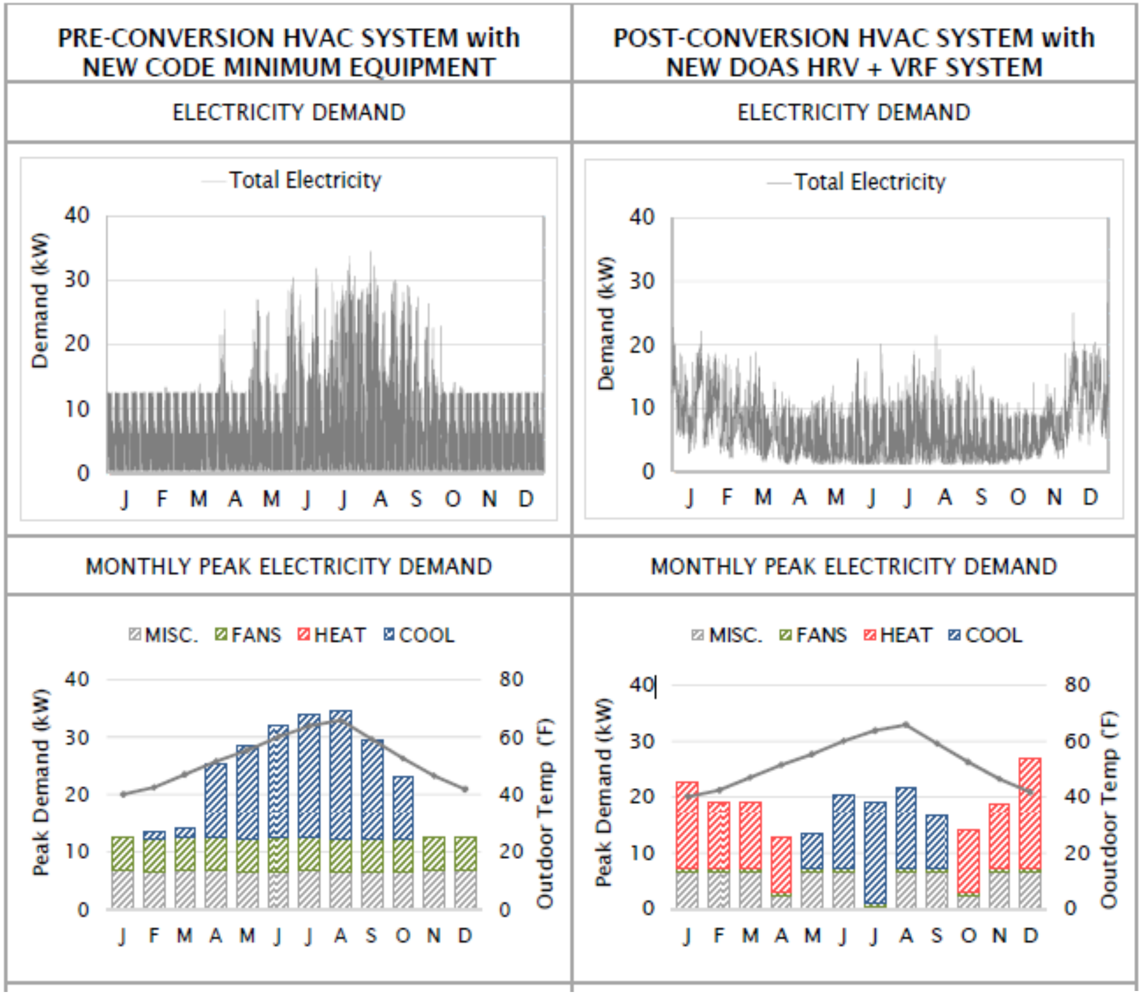


	ANNUAL EUI	---
Total:[2]	51.4 kBtu/ft²	---
Fans:	8.7 kBtu/ft²	---
Heating:	32.5 kBtu/ft²	---
Cooling:	3.4 kBtu/ft²	---
HVAC:	44.6 kBtu/ft²	---
Electricity:	18.9 kBtu/ft²	---
Gas:	32.5 kBtu/ft²	---



	ANNUAL EUI	ANNUAL SAVINGS
Total:	19.1 kBtu/ft²	32.3 kBtu/ft²
Fans:	1.0 kBtu/ft²	7.6 kBtu/ft²
Heating:	8.4 kBtu/ft²	24.1 kBtu/ft²
Cooling:	2.8 kBtu/ft²	0.6 kBtu/ft²
HVAC:	12.3 kBtu/ft²	32.3 kBtu/ft²
Electricity:	19.1 kBtu/ft²	-0.2 kBtu/ft²
Gas:	0.0 kBtu/ft²	32.5 kBtu/ft²

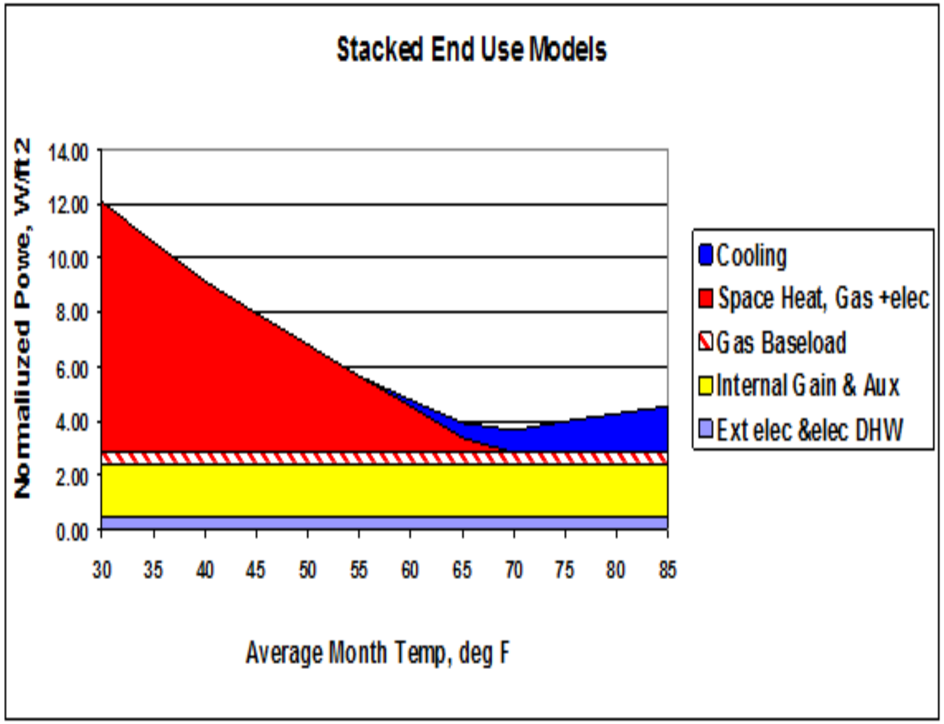
Law Office Results - Demand



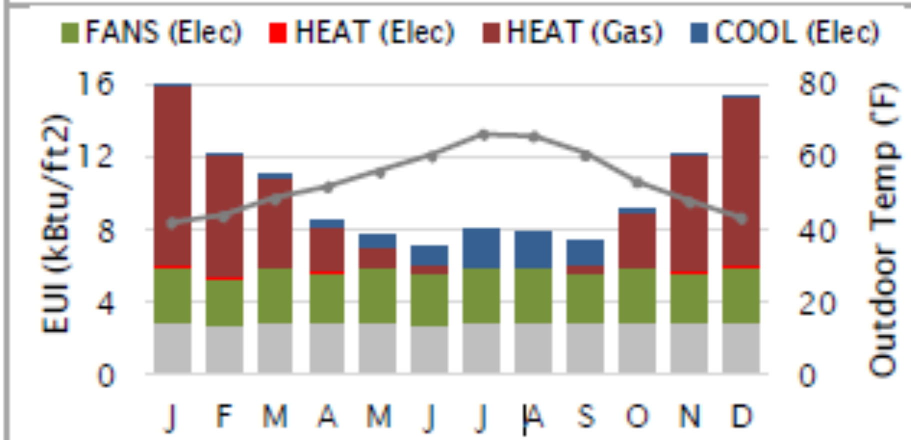
Airport Terminal Before & After

Airport Terminal Building

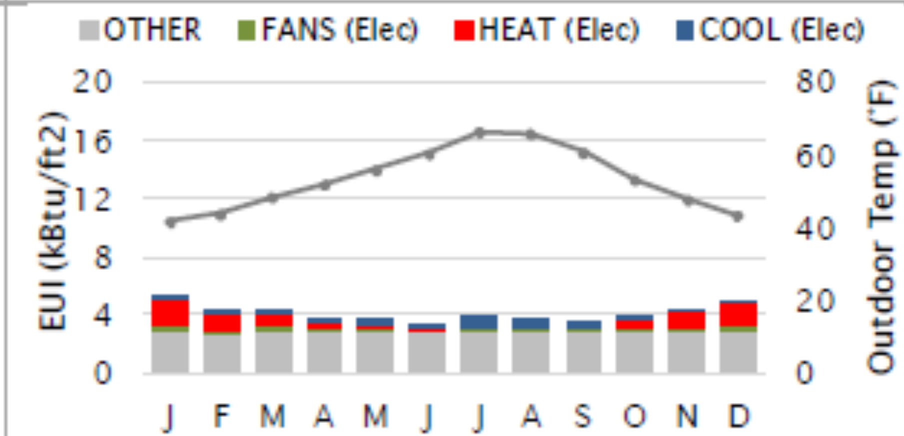
- 1930, 2-story, 25,200 sq ft, updated glazing & insulation
- Remove – Two 40-ton, one 15-ton dual-deck RTUs (265 sq ft/ton)
  - Lots of simultaneous heating & cooling
- Install - Three Ventacity VS 1000s; two 8-ton, one 10-ton, one 6-ton Mitsubishi VRF systems (788 sq ft/ton)
  - 37 indoor units



Airport Terminal Results - Energy



	ANNUAL EUI	---
Total:	122.0 kBtu/ft²	---
Fans:	33.9 kBtu/ft²	---
Heating:	45.5 kBtu/ft²	---
Cooling:	7.9 kBtu/ft²	---
HVAC:	87.3 kBtu/ft²	---
Electricity:	76.8 kBtu/ft²	---
Gas:	45.3 kBtu/ft²	---

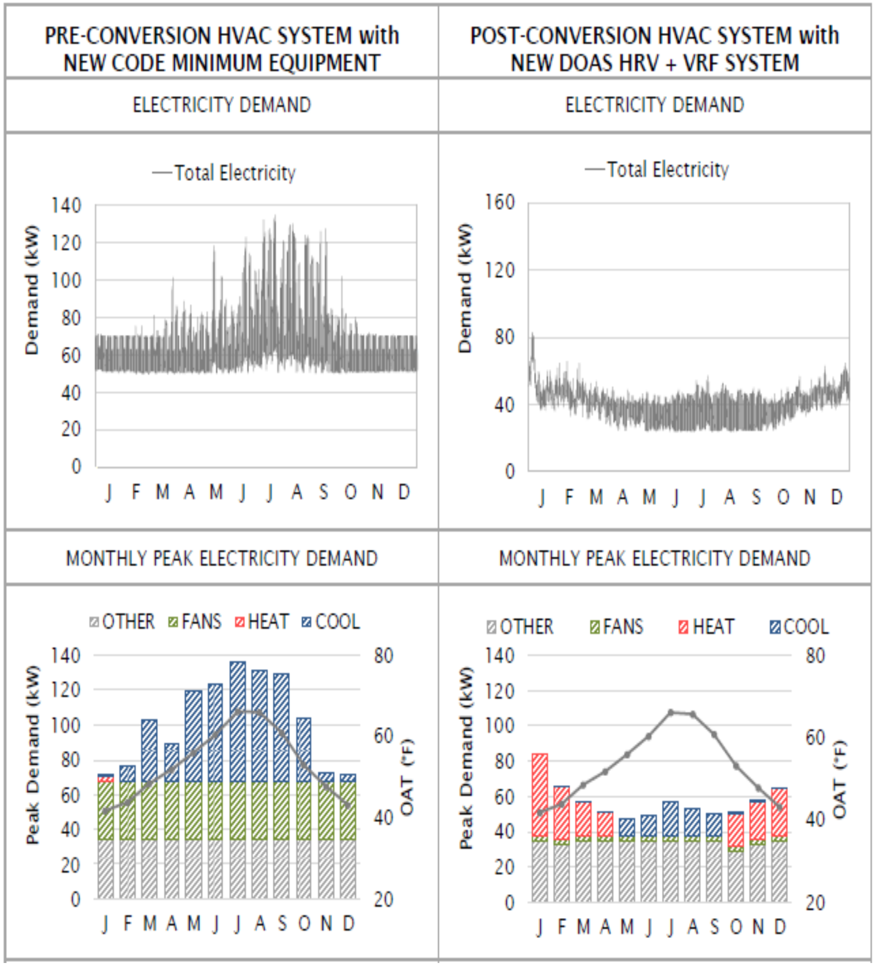


	ANNUAL EUI	ANNUAL SAVINGS
Total:	48.1 kBtu/ft²	73.9 kBtu/ft²
Fans:	2.8 kBtu/ft²	31.2 kBtu/ft²
Heating:	8.1 kBtu/ft²	37.3 kBtu/ft²
Cooling:	2.4 kBtu/ft²	5.5 kBtu/ft²
HVAC:	13.3 kBtu/ft²	73.9 kBtu/ft²
Electricity:	47.4 kBtu/ft²	29.4 kBtu/ft²
Gas:	0.7 kBtu/ft²	44.6 kBtu/ft²

1 Minor additive discrepancies are due to rounding.

Airport Terminal Results - Demand

- Peak January Demand (highest post-conversion month): ~72 kW to 83 kW (15% increase)
- Peak July Demand (highest pre-conversion month): ~138 kW to 58 kW (58% reduction)
- Overall, demand is essentially flattened, with average summer demand slightly lower than average winter demand.



Office in Portland, OR

BETTERBRICKS
Powerful Energy Ideas. Delivered by NEEA.

HVAC CASE STUDY

PORTLAND FIRM ENGINEERS THERMAL COMFORT AND HVAC EFFICIENCY

"Before this project, our thermal comfort and ventilation were limited. We had no reliable control of our building's air changes, and thermal comfort was difficult to achieve universally due to our single-zone systems. This project increased confidence in our building safety with added air changes and controllability and improved occupant comfort by adding several zones. I'm most impressed at how much system capacity we were able to remove and still maintain comfort through a few unprecedented weather events."

— *Josh Weissert,*
Principal Engineer, Energy 350

PROJECT OVERVIEW

BUILDING TYPE Office

YEAR BUILT 1943

PROJECT FLOOR AREA 7,569 sq. ft.

ENERGY UTILITY/PROGRAM Portland General Electric

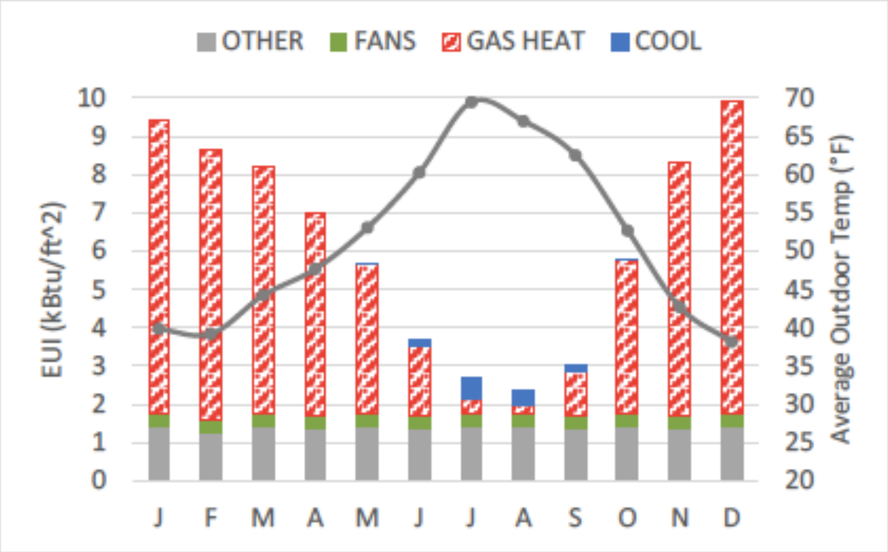
TOTAL PROJECT COST $13.94 per sq. ft.[1]

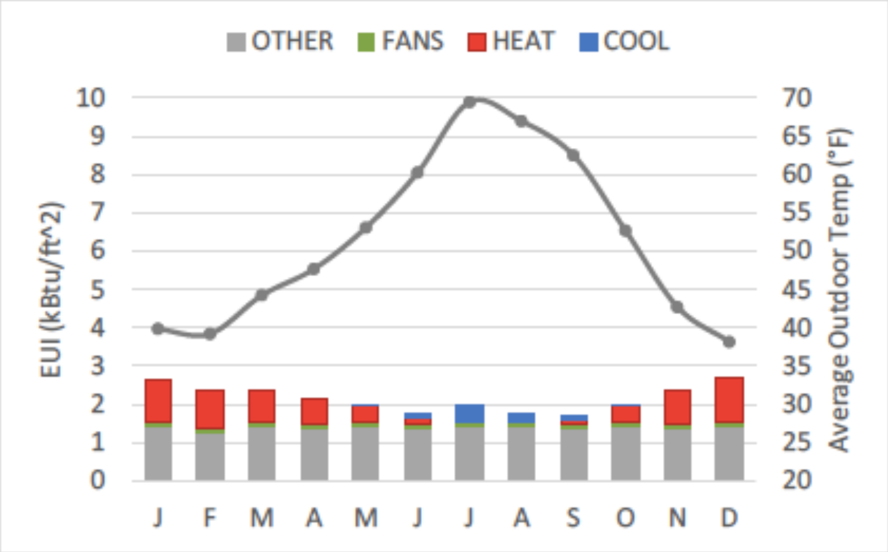
REDUCTION IN TOTAL BUILDING ENERGY USE 66%[2]

REDUCTION IN HVAC SYSTEM ENERGY USE 84%[2]

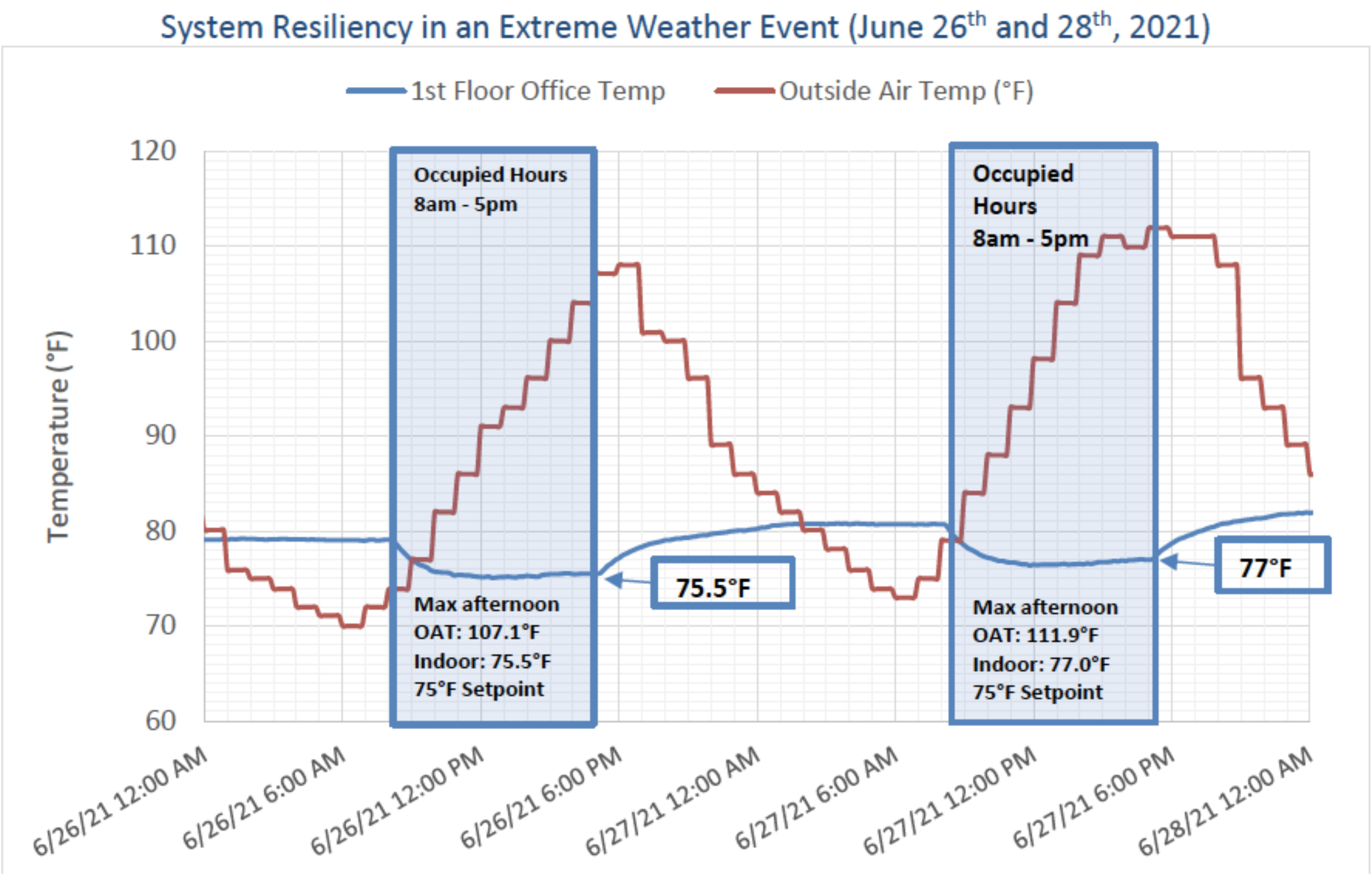
Office in Portland, OR

Pre-Conversion (As Modeled)	Post-Conversion (As Modeled)





Office in Portland, OR



Tarrytown Office Building

ELECTRIFICATION DONE RIGHT!

IMPROVED COMFORT

IMPROVED HEALTH

- LARGEST PROJECT to date

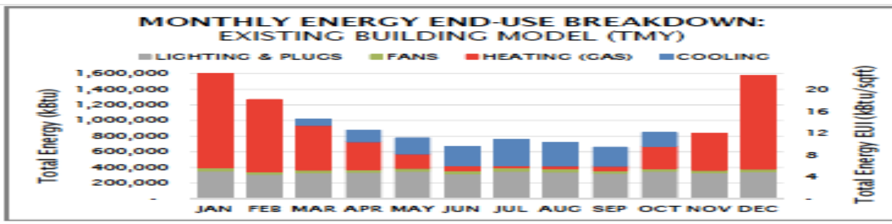


Figure 2.1
Monthly energy end-use breakdown for the Existing Building Model (TMY).

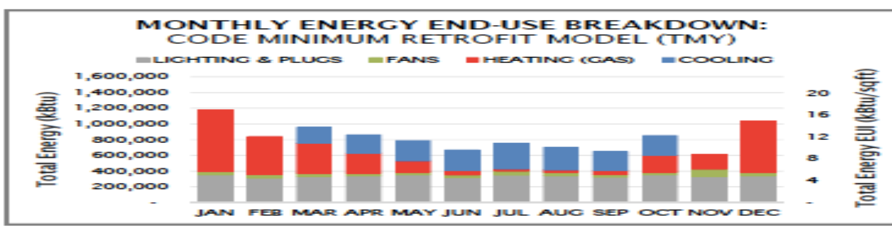


Figure 2.2
Monthly energy end-use breakdown for the Code Minimum Model (TMY).

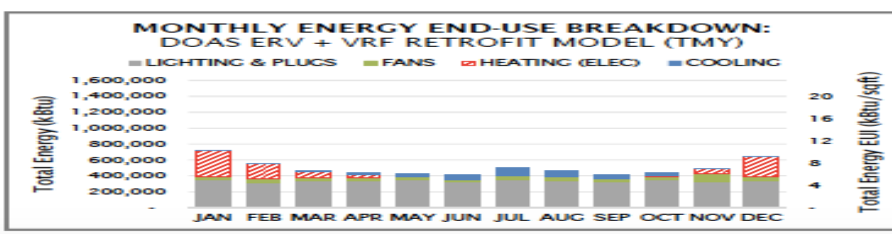


Figure 2.3
Monthly energy end-use breakdown for the DOAS ERV + VRF Model (TMY).

HUGE SAVINGS EXCEED THE MODEL

- 71,000 Sq ft
- 4 stories + partial basement
- Existing HVAC system based on dual-deck RTUs
- Lots of simultaneous heating & cooling
- Conversion completed (while occupied) in late 2019
- 2018 peak demand 519 kW (June)
- 2020 peak demand 366 kW (November)
- 2020 highest summer peak demand 208 kW (July)

MODELED AND ACTUAL PERFORMANCE

Annual *Savings*

	Modeled (TMY)	Actual (not TMY)
Electricity (kWh)	224,000	656,000
Natural Gas (therms)	38,800	52,650
Annual Energy Cost	$61,700	$213,920

Loads and Heating/Cooling Capacity

Project	Floor Area (sq ft)	Installed System Capacity (tons)	Conditioned Floor Area / Ton (sq ft / ton)
Law Office	11,615	16	**726**
Pizza Restaurant	1,730	9	**192**
Government District Office1	3,770	8	**471**
Utility District Office	5,681	8	**710**
Airport Terminal Building	26,200	32	**819**
Government Dormitories (4)	~11,000, (each building)	16	**688**
Seattle Office	6,100	14	**422**
Restaurant	1,147	3	**382**

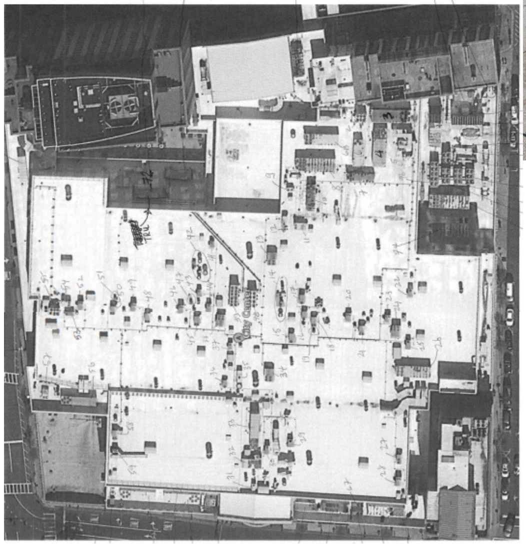
- PNW target for existing buildings : 750 sq ft / ton
- PNW target for new buildings : 1,000 sq ft / ton
- Chicago Target for existing Buildings: 550-600 sq ft / ton
- Chicago Target for new Buildings: 800-900 sq ft / ton

NYSERDA & COMED Projects

Forest Preserves of Cook County

Oak Park Temple and School

780 Third Ave, NY

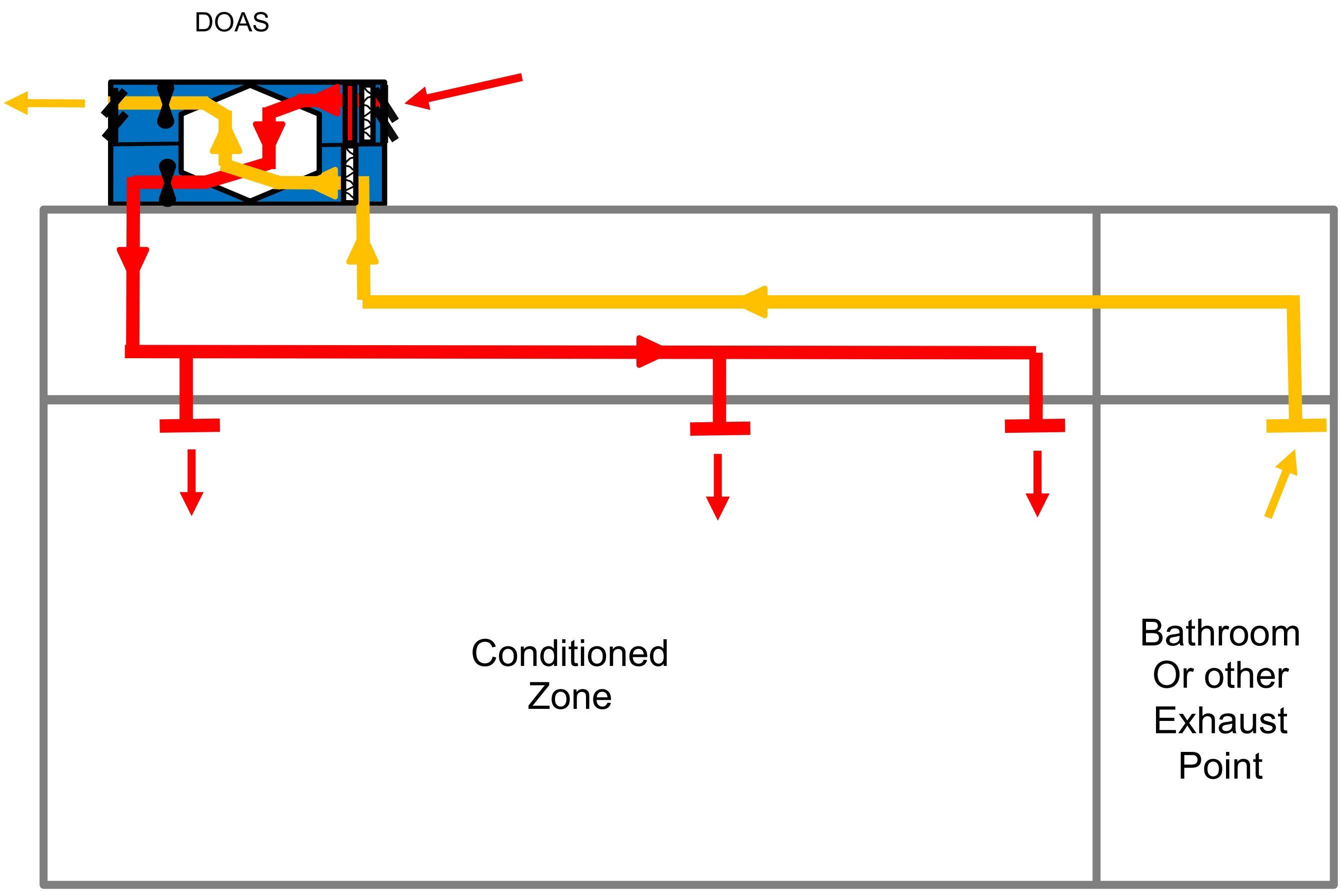


City Center Mall, White Plains, NY

Chapter 5: VHE DOAS Program

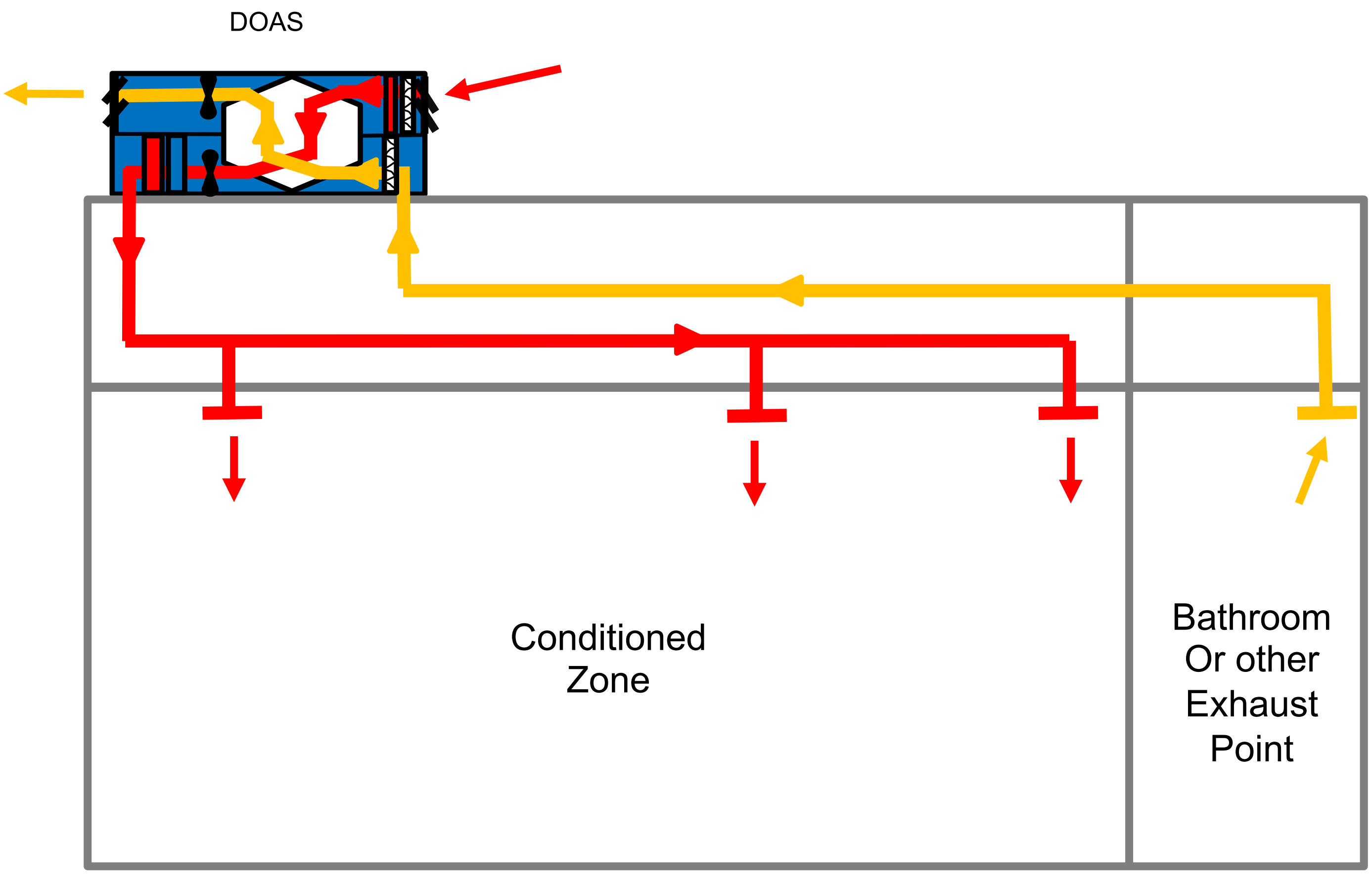
Chapter 6: DOAS (Dedicated Outdoor Air Systems)

Dedicated Outdoor Air Systems



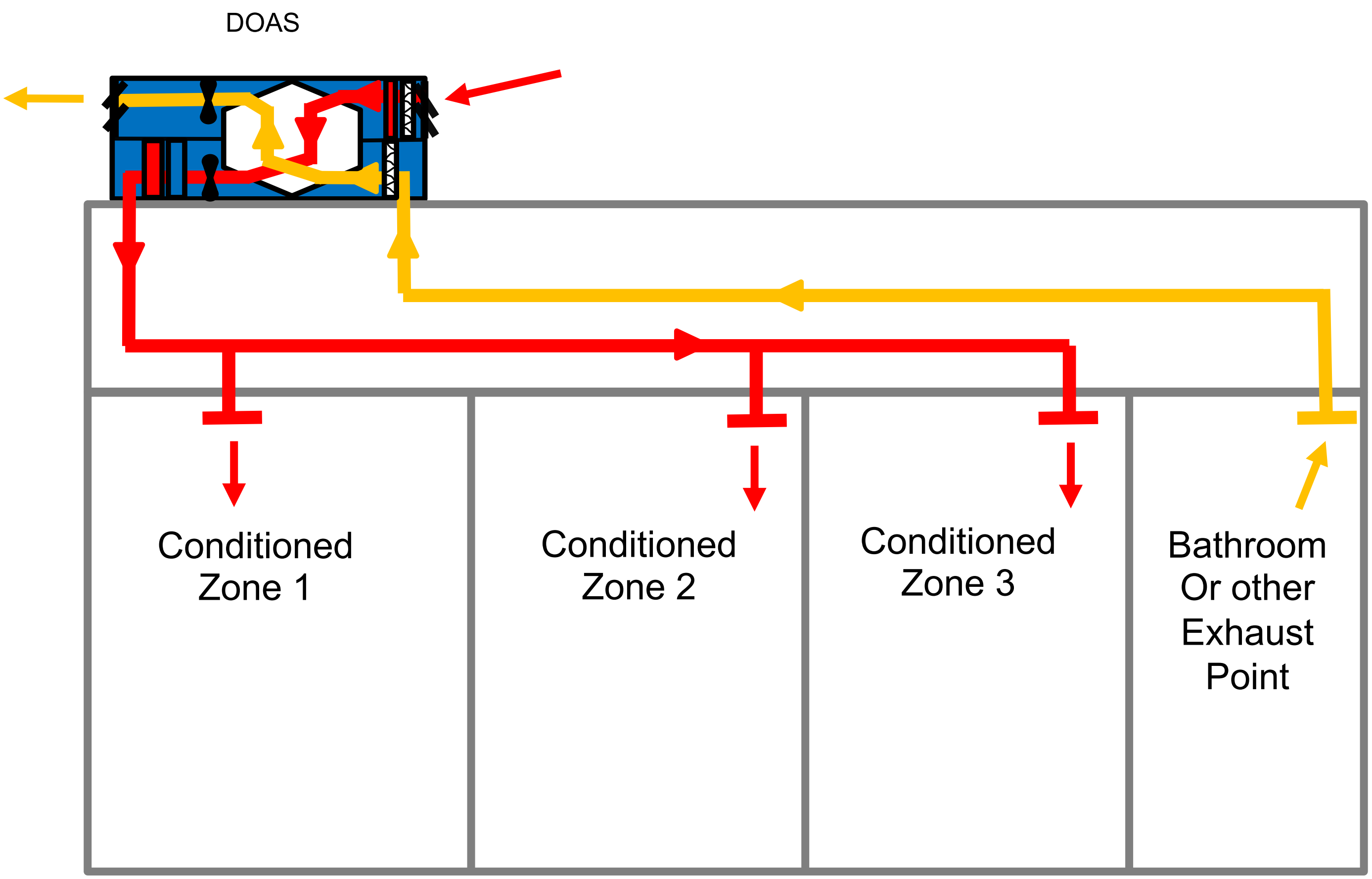
- DOAS ventilation is decoupled from the heating and cooling.
- Supply air is ducted independently to the conditioned zone(s).
- Exhaust air is ducted back to the DOAS H/ERV to recovery energy before exhausting.

Dedicated Outdoor Air Systems (DOAS) Post Conditioning Possibilities



- Post heat exchanger conditioning coils possible for additional tempering to further heat, cool and/or dehumidify OA airstream.
- Sometimes internal to DOAS unit or installed downstream separately.

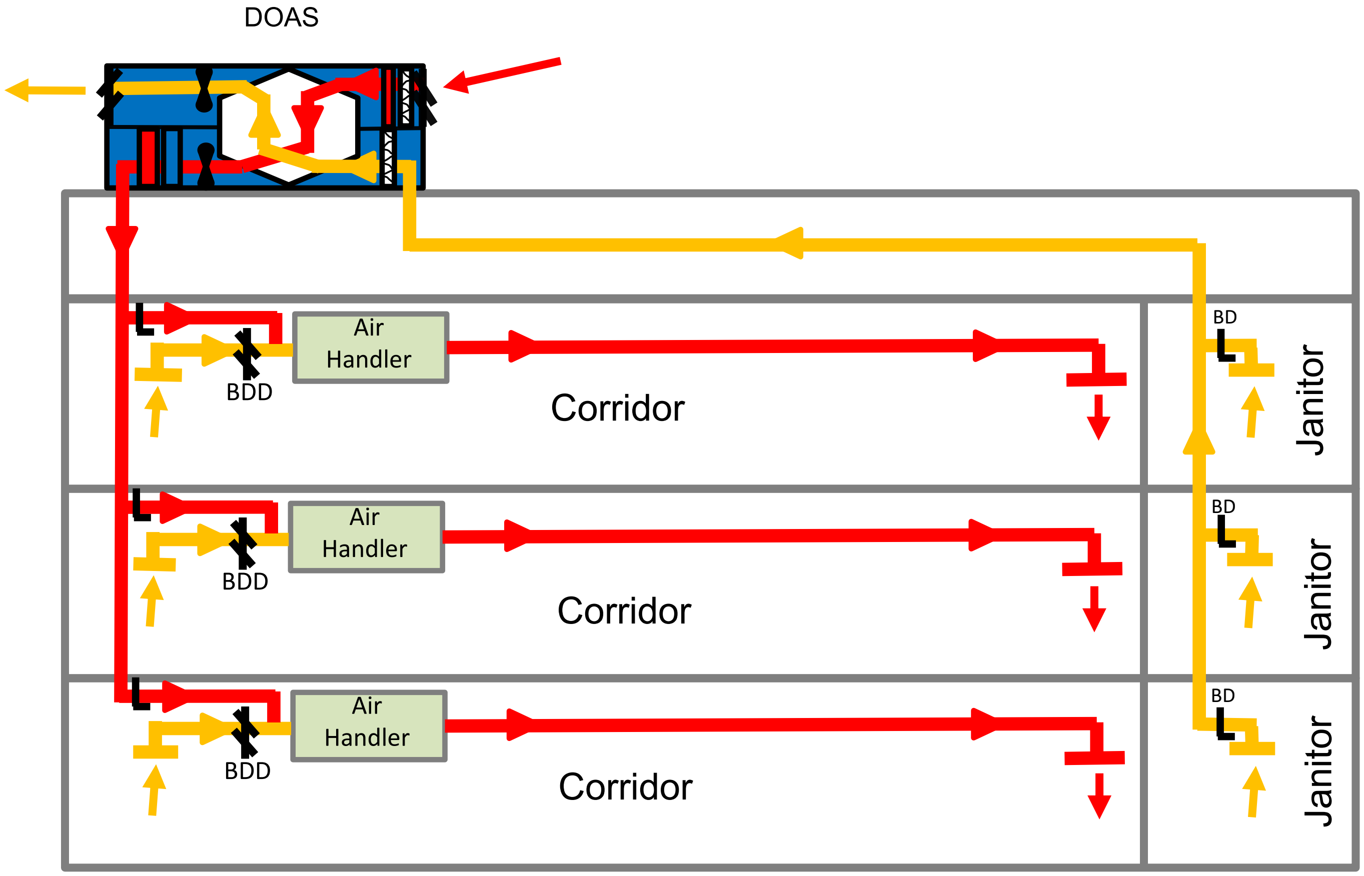
Dedicated Outdoor Air Systems (DOAS) Multiple Zones



- DOAS works better than traditional approach for multiple zone systems
- Supply air to zones, exhaust from bathrooms and other exhaust points.
- Balance flows to higher of the two design flows

Dedicated Outdoor Air Systems (DOAS)

Multiple Zones – Connecting to Air Handlers



- For simple zones it is possible to connect supply to zone air handlers.
- Include back-draft damper so air flows out the supply network.
- Preferably keep exhaust independent.

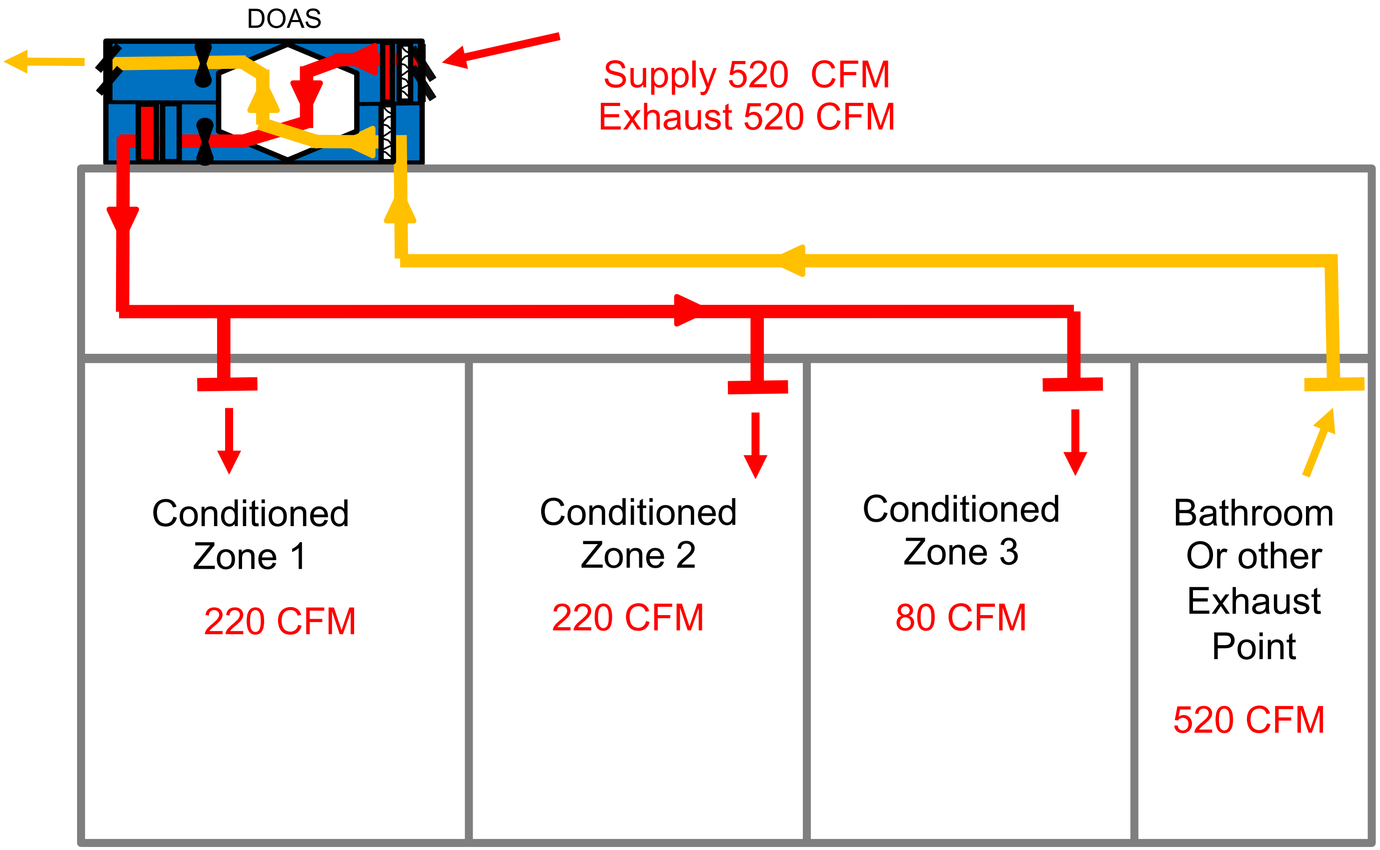
DOAS Control Strategies

Main Approaches:

- CAV – Constant Air Volume
- DCV – Demand Control Ventilation
- VAV – Variable Air Volume
- Economizer

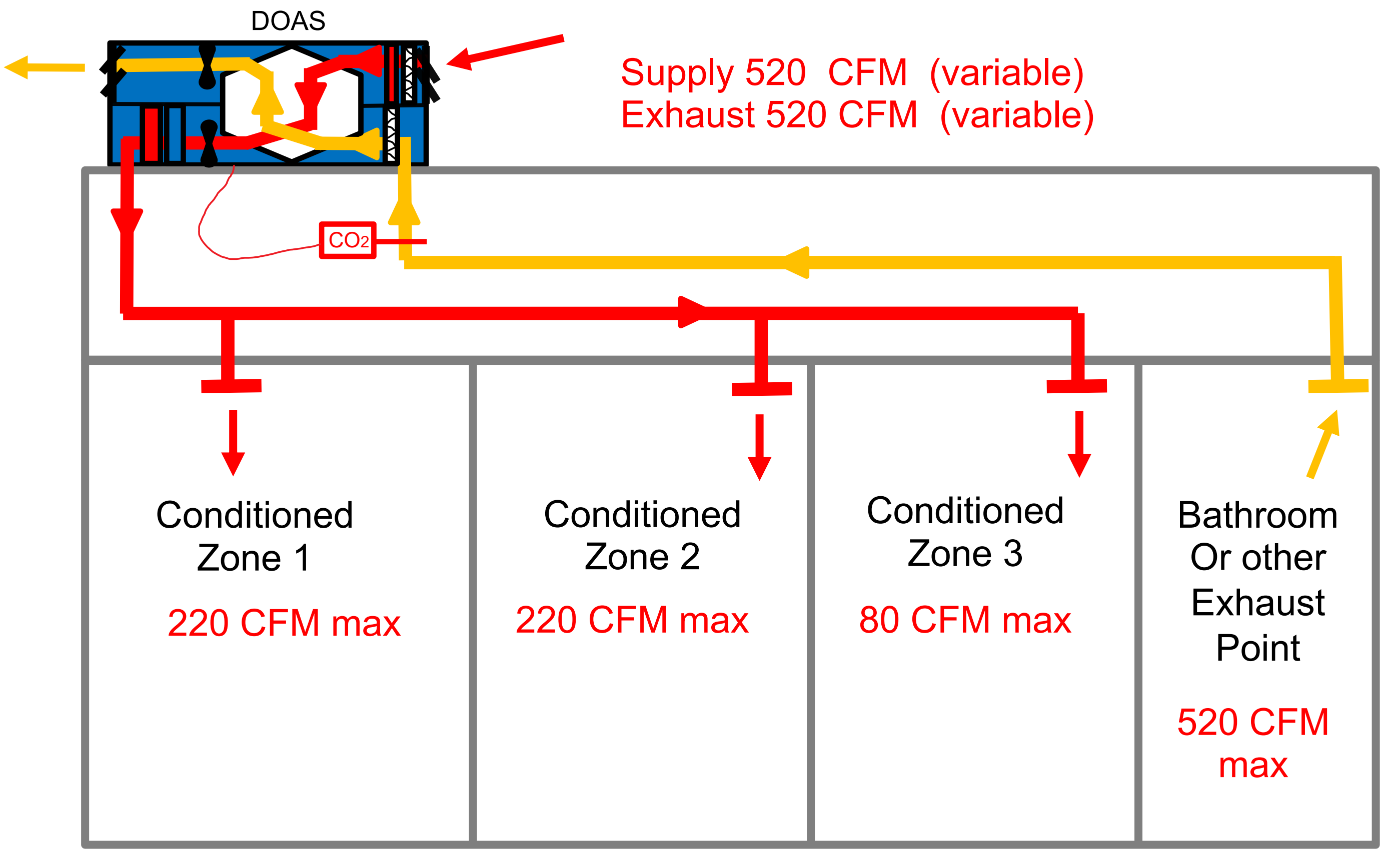
- Multiple strategies for controlling a DOAS from simple to sophisticated depending upon goals and budget.
- Some brands have flexible and elegant internal controls while others require a BMS system to do anything beyond basic control

DOAS Control Strategies:
CAV – Constant Air Volume



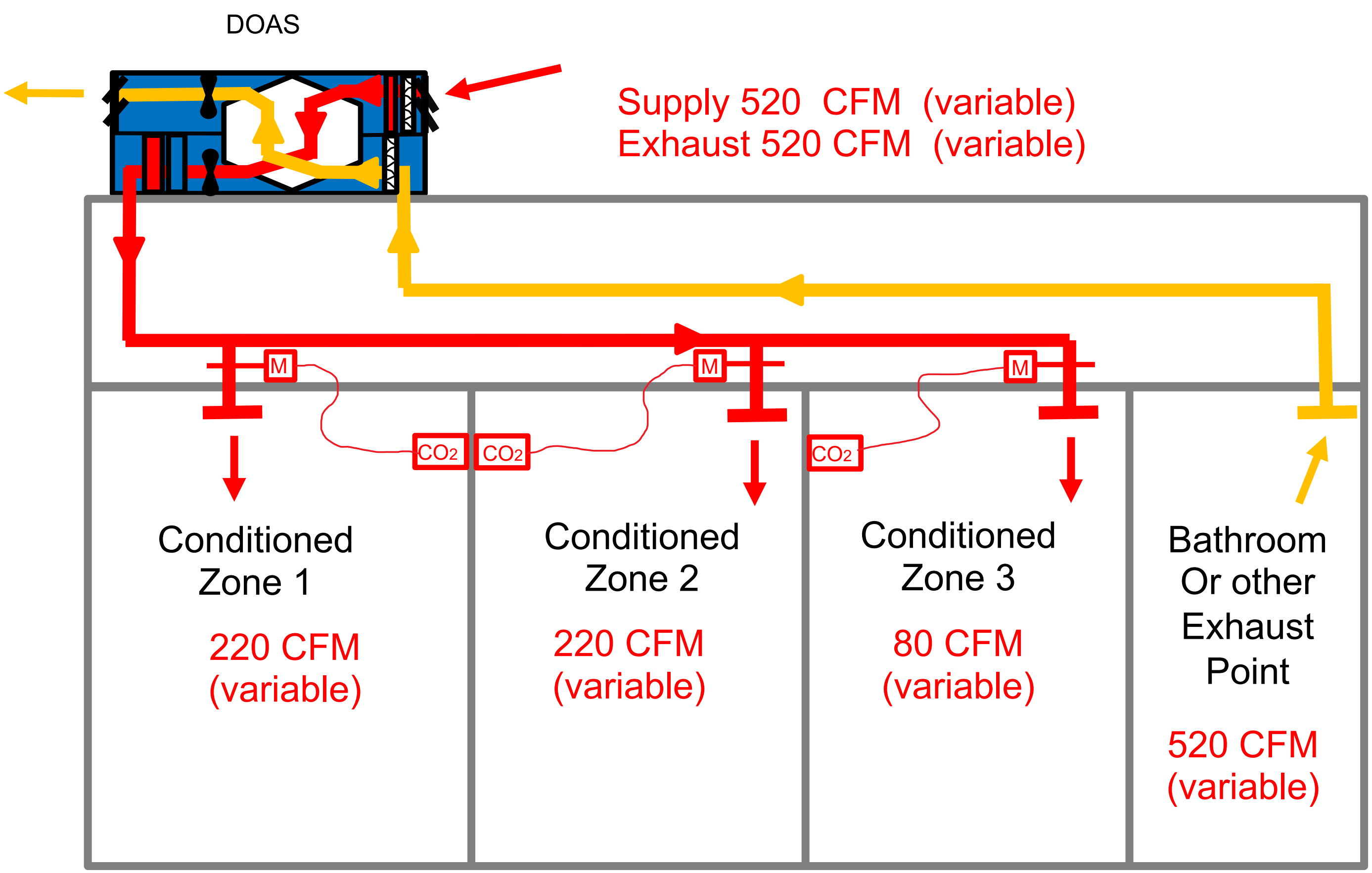
- During occupied hours DOAS runs at a constant single rate to meet the design airflows
- During unoccupied hours DOAS is in stand-by mode
- Schedule can be overridden for special events

DOAS Control Strategies:
DCV – Demand Control Ventilation



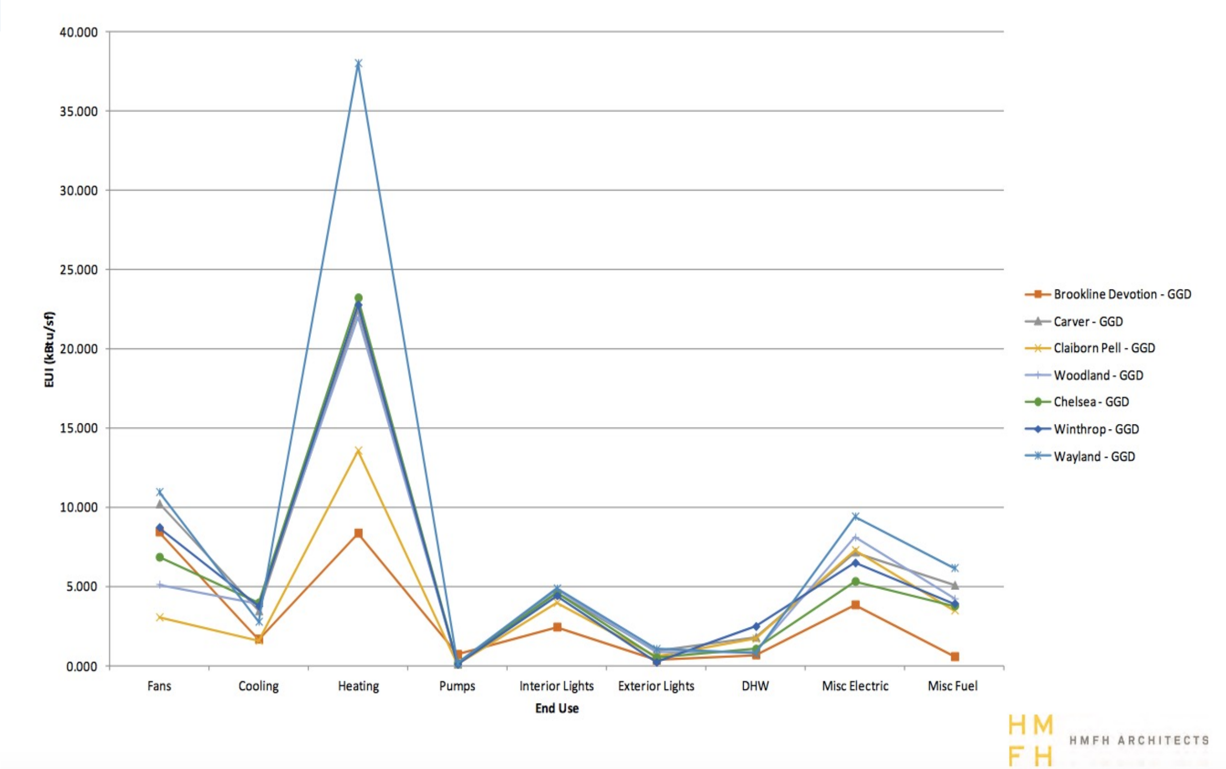
- Demand control ventilation allows system to ramp down during periods of lower occupancy
- Both supply and exhaust side fluctuate in parallel
- Lowest setting based on area rate or exhaust requirement.

DOAS Control Strategies:
VAV – Variable Air Volume



- Variable Air Volume is a zone by zone demand control ventilation system
- Each zone flow controlled by CO_2, Occupancy, or other sensor
- Minimum flow to meet area flow rates
- DOAS run in constant pressure mode

THE PATH TO NET ZERO?



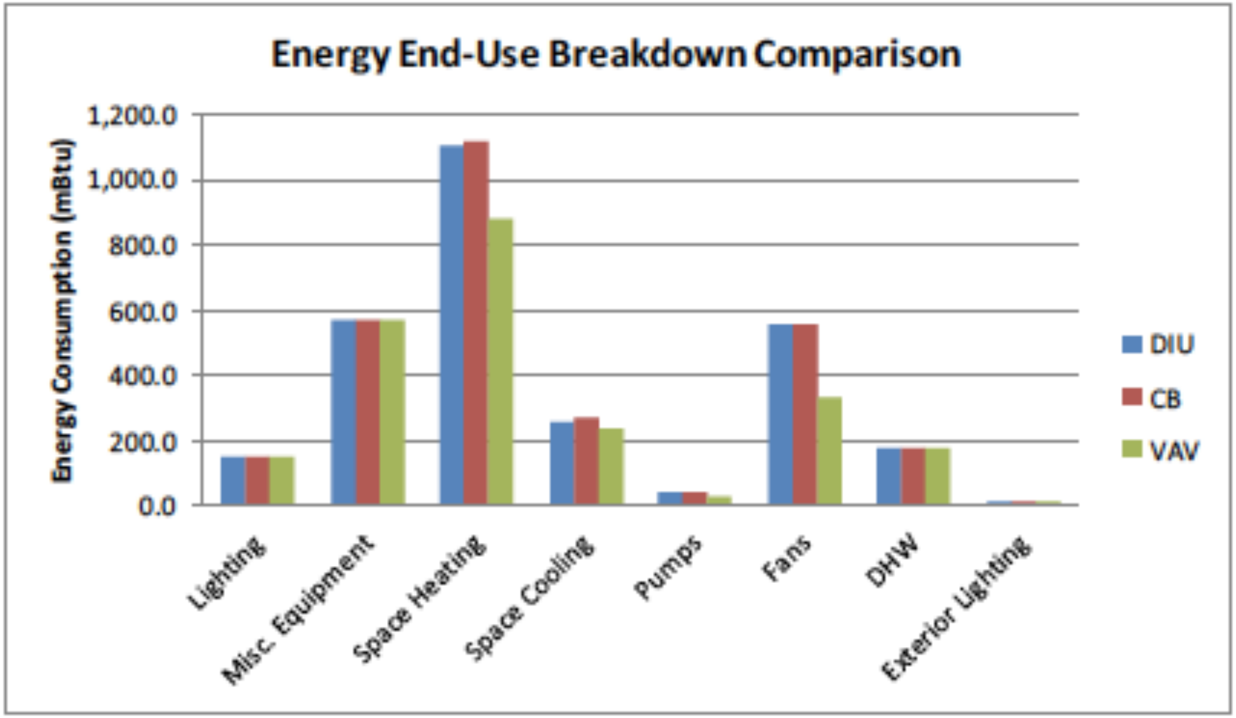
- **NEW ENGLAND HIGH EFFICIENCY SCHOOLS**

- **Ventilation energy buried in HVAC numbers**
- **RTUs do not allow for Demand Control Ventilation**
- **Cut HVAC load in half, , how many solar panels saved to get to Net Zero?**

VENTACITYSYSTEMS

Making Buildings Healthy – Efficient – Smarter

TYPICAL NUMBERS FOR CONVENTIONAL APPROACHES TO HVAC



FANS STAND OUT

- Fans drive high energy use
- Systems do not allow for Demand Control Ventilation
- Large air volumes require very large ducts

VENTACITYSYSTEMS

Making Buildings Healthy – Efficient – Smarter

San Francisco High School

TMHS - SFUSD Readings — Class — Lunch — 6800 cu. ft At 430 cfm = 3.8 air changes per hour

VS500 in Room 218 — No class — Mtgs.

Demand Controlled Ventilation

Date		Time	216		218		218				
			Telaire		Telaire			Outside	Return	Supply	
Mode	CFM	of Day	Room T	CO2	Room T	CO2	CO2	Air	Air	Air	Bypass
Wed	160	7:00 AM	70	465	69	417	440	55	68	66	0
5.8.19	171	8:00 AM	70	487	69	421	440	55	68	66	0
DCV	170	8:30 AM	72	715	69	423	440	56	68	66	0
	158	9:00 AM	73	927	69	417	440	57	68	66	0
Mostly	158	9:20 AM	74	1052	69	424	420	58	68	66	0
Cloudy	169	9:50 AM	73	1532	69	437	440	59	68	65	46
in AM		9:55 AM	73	1627							
	169	10:00 AM	74	1669	69	433	460	59	68	65	52
		10:08 AM	74	1727							
	168	10:15 AM	74	1821	69	426	440	59	68	64	60
		10:25 AM		1900							
	203	10:30 AM	74	1958	69	441	460	60	68	63	82
		10:35 AM	74	2001							
	215	10:55 AM	74	2001	70	450	460	61	68	63	100
	221	11:25 AM	75	1291	70	457	480	62	68	64	100
	204	Noon	73	1023	70	461	480	63	68	65	100
	169	12:55 PM	73	824	70	424	440	64	69	65	100
	445	1:30 PM	75	1147	73	635	720	63	72	66	100
	445	1:40 PM	75	1287	73	663	760	63	73	66	100
	445	1:50 PM	76	1349	73	657	740	64	73	66	100
	446	2:00 PM	76	1423	74	659	740	64	73	67	100
	446	2:30 PM	77	1370	75	661	760	64	74	67	100
	222	3:15 PM	75	612	74	461	500	63	73	66	100
	158	4:00 PM	75	549	74	425	440	64	73	67	100

GREEK SCHOOL, BROOKLYN, NY

LEED FOR SCHOOLS GOLD CERTIFICATE

- **Designed to meet Passive House level of efficiency**
- **Advanced VHE HVAC systems**
- **Mixed use, as school during the day, as Community Center during evenings and weekends**

GREEK SCHOOL, BROOKLYN, NY

VHE HVAC

- **Two VS3000 RTe ERVs**
- **VRF Heat Pumps with heat recovery**

GREEK SCHOOL, BROOKLYN, NY

CONTROLS ARE THE KEY

- **Individual heating and cooling in each space**
- **Simultaneous heating and cooling with heat recovery VRF**
- **Demand control for ventilation in each classroom**
- **Remote access to system for optimizing and managing**

GREEK SCHOOL, BROOKLYN, NY

DEMAND CONTROL

- **Each classroom monitors CO2, system delivers increased ventilation as needed**
- **Damper/Diffusers combined with Constant Static controls at the ERV provide needed flows**

GREEK SCHOOL, BROOKLYN, NY

SIZED FOR OPTIMUM COMFORT AND EFFICIENCY

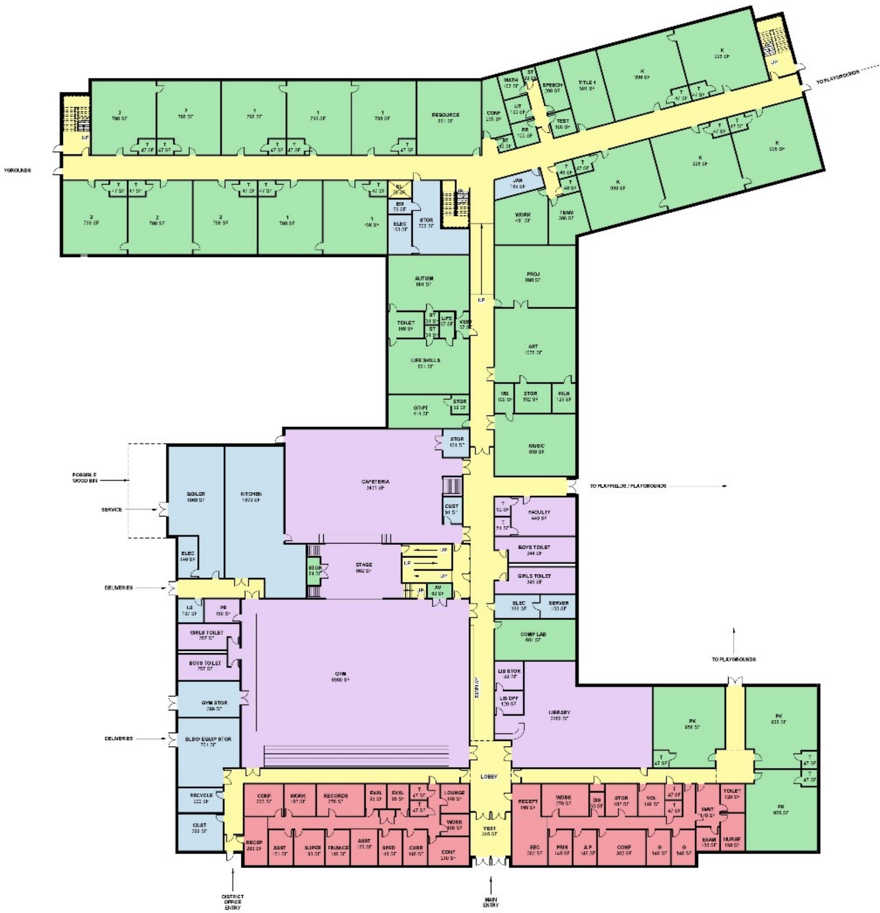
- **Upper classrooms utilize ceiling cassettes for H&C**
- **Damper/Diffusers provide ventilation and optimum IAQ and health**

GREEK SCHOOL, BROOKLYN, NY

CONTROLS

- Cloud connected SBC100 control platform
- CO2 sensors in each classroom
- Damper/Diffusers manage air flow
- VRF system maintains zone control of heating and cooling

Application: Schools



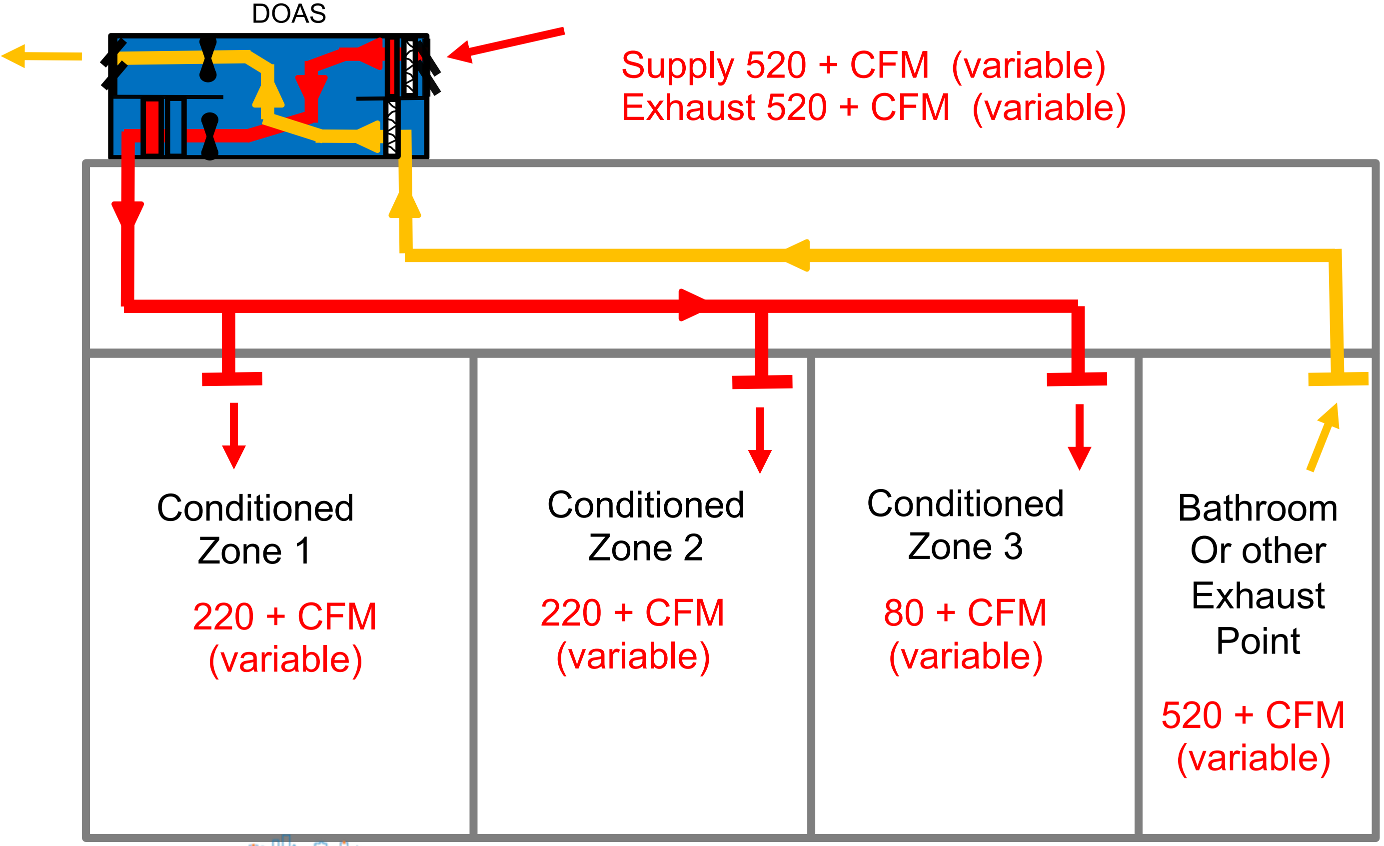
- **Classroom Strategies:**

- Individual classroom HRVs
- CO_2 Demand control potential
- Minimize ductwork

- Central Systems
- Can use CO_2 demand control with zone dampers
- Possibility for reduced equipment sizing with diversity if not all spaces used simultaneously.

- Quiet equipment operation critical

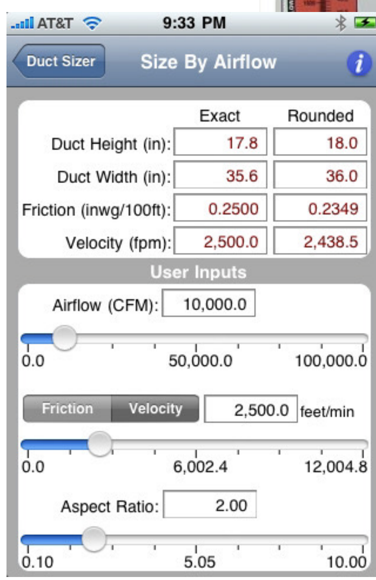
DOAS Control Strategies:
Economizer



- A DOAS with an Economizer feature can bypass the heat exchanger and ramp up flow to take advantage of "free cooling" conditions.
- Smart systems can modulate bypass to control supply temperature.

Chapter 7:Duct Design Optimization

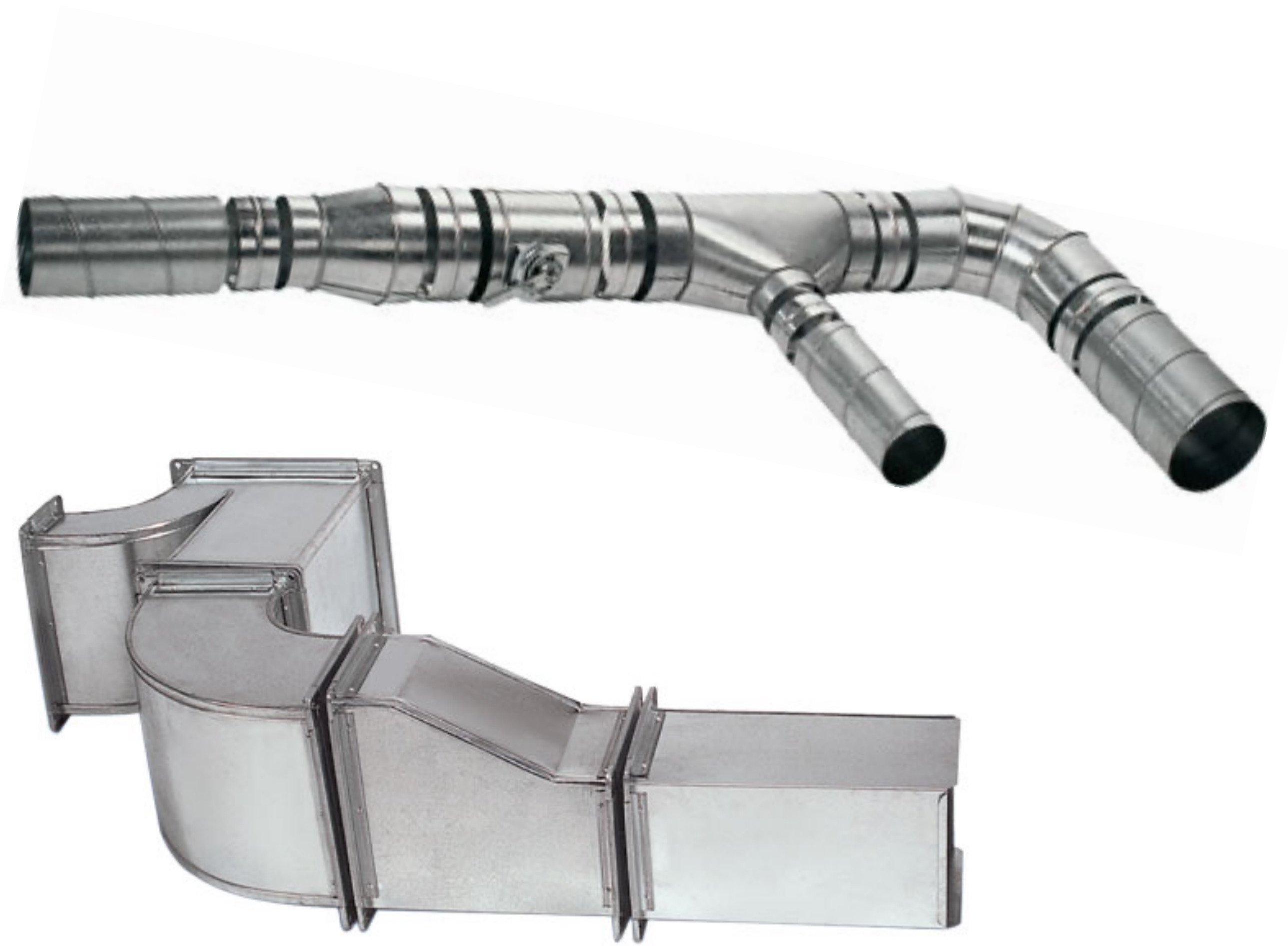
Ductwork Design:Duct sizing



0.08 in W.C.
Per 100' duct

- Overall duct sizing done by friction loss for that airflow.
- Good rule of thumb less than 0.08 in W. C. of friction losses per 100 ft of ductwork
- Ductulators (paper or electronic) will have round and equivalent rectangular.
- Round most efficient.

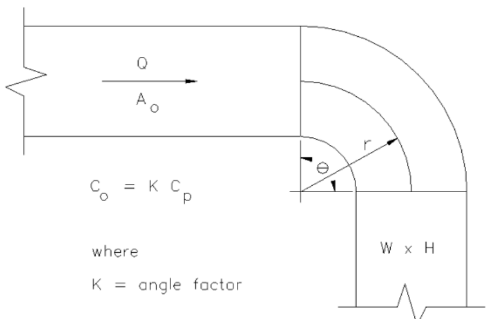
Ductwork Design: Duct sizing



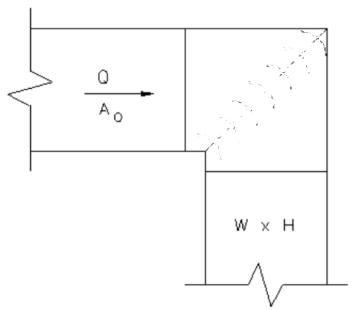
- Round ductwork is most efficient for airflow.
- Rectangular duct can sometimes fit in shallower height.
- Avoid aspect ratios of greater than 5:1 for most efficient flow.

Ductwork Design: Fittings

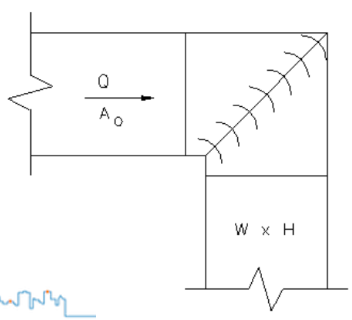
Example: 12”x12” duct with 800 CFM



Radius Elbow r = 1.5W
Co = 0.17 ΔP = 0.01 in WG
Approx equal to 13’ of ductwork



Mitered Elbow
Co = 1.18 ΔP = 0.05 in WG
Approx equal to 63’ of ductwork

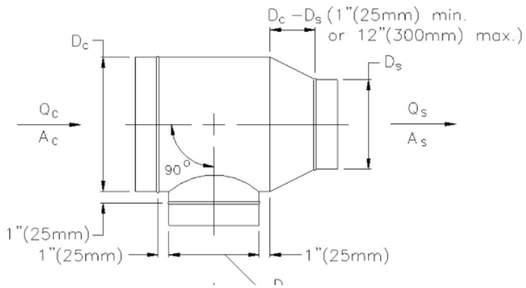


Mitered Elbow with vanes (1-1/2”)
Co = 0.11 ΔP = 0.00 in WG
Approx equal to <6’ of ductwork
Note: wider spacing and/ double Thickness vanes increase ΔP

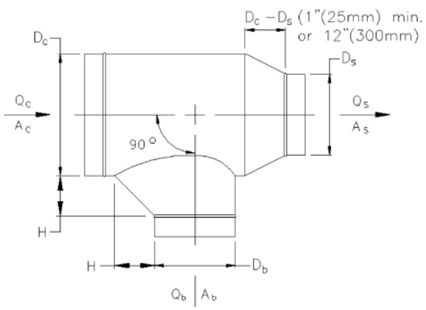
- Selection of fittings can make a big difference in system pressure drop.
- ASHRAE Ductwork Database and related App are good tools for selection and comparison

Ductwork Design: Fittings

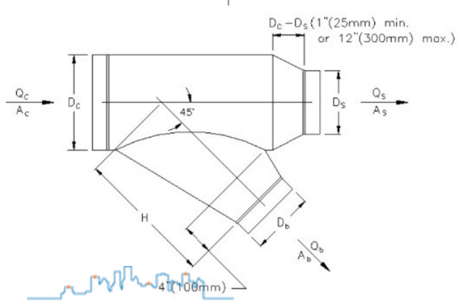
Example: 12” Φ duct with 600 CFM and 200 CFM take-off
12” x 10” x 8” Fitting



90° Straight Tee
Branch ΔP = 0.04 in WG
Approx equal to 50’ of ductwork



90° Straight Tee w/ 45° Entry
Branch ΔP = 0.02 in WG
Approx equal to 25’ of ductwork



45° Conical Wye
Branch ΔP = 0.01 in WG
Approx equal to 13’ of ductwork

- Selection of fittings can make a big difference in system pressure drop.
- ASHRAE Ductwork Database and related App are good tools for selection and comparison

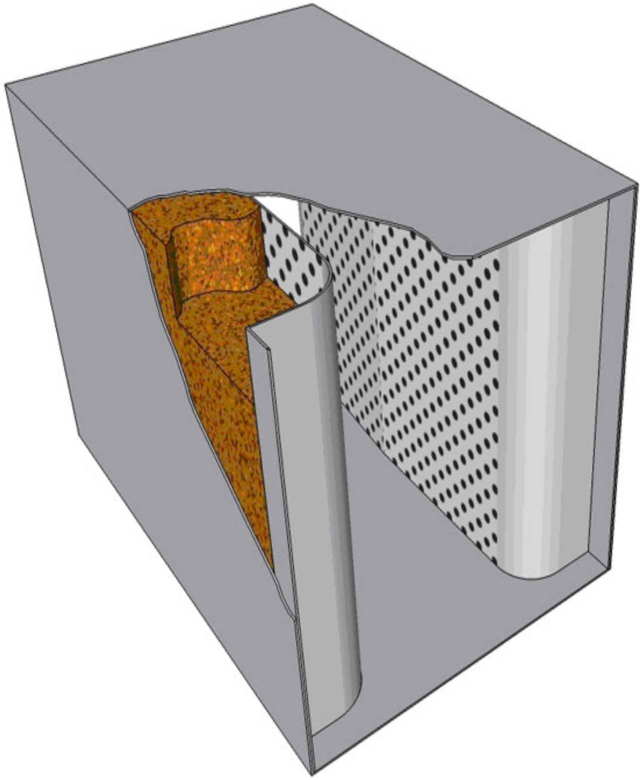
Ductwork Design: Air Sealing

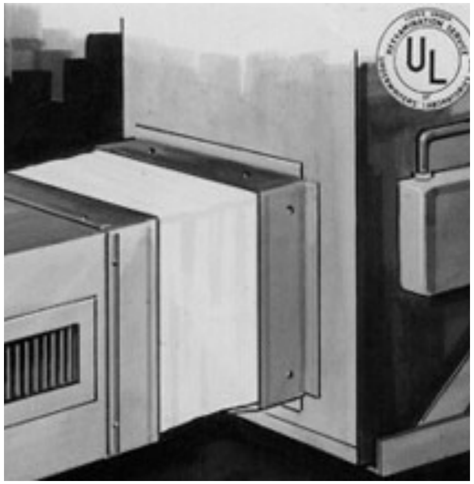
- Proper air sealing of ductwork is critical for efficient delivery of air to designed locations.
- Leakage = fans run harder to meet design airflows.
- Duct blaster testing important for confirmation.
- A duct is just a pipe for air. Plumbers can make their pipes 100% airtight!

Ductwork Design: Fire and Smoke Dampers

- Stops fire and smoke from moving through the ductwork.
- Required when ducts penetrate a fire rated assembly (with some exceptions).
- Coordinate with architects about what assemblies are fire and/or smoke rated.
- Access panel required for maintenance.

Ductwork Design: Acoustics and Vibration





- It is good design to connect ductwork to equipment with a flexible connector to isolate vibration from ductwork. Vibration isolating mounts may also be needed.
- Sound attenuation may be useful for critical environments (schools, auditoriums, sound studios)
- Quiet equipment important for high performance buildings

Ductwork Design: Challenges

- Connect through roof with shortest duct/curb possible.
- Avoid bends.
- Reduce or eliminate insulated ducts.
- Minimize leaks.

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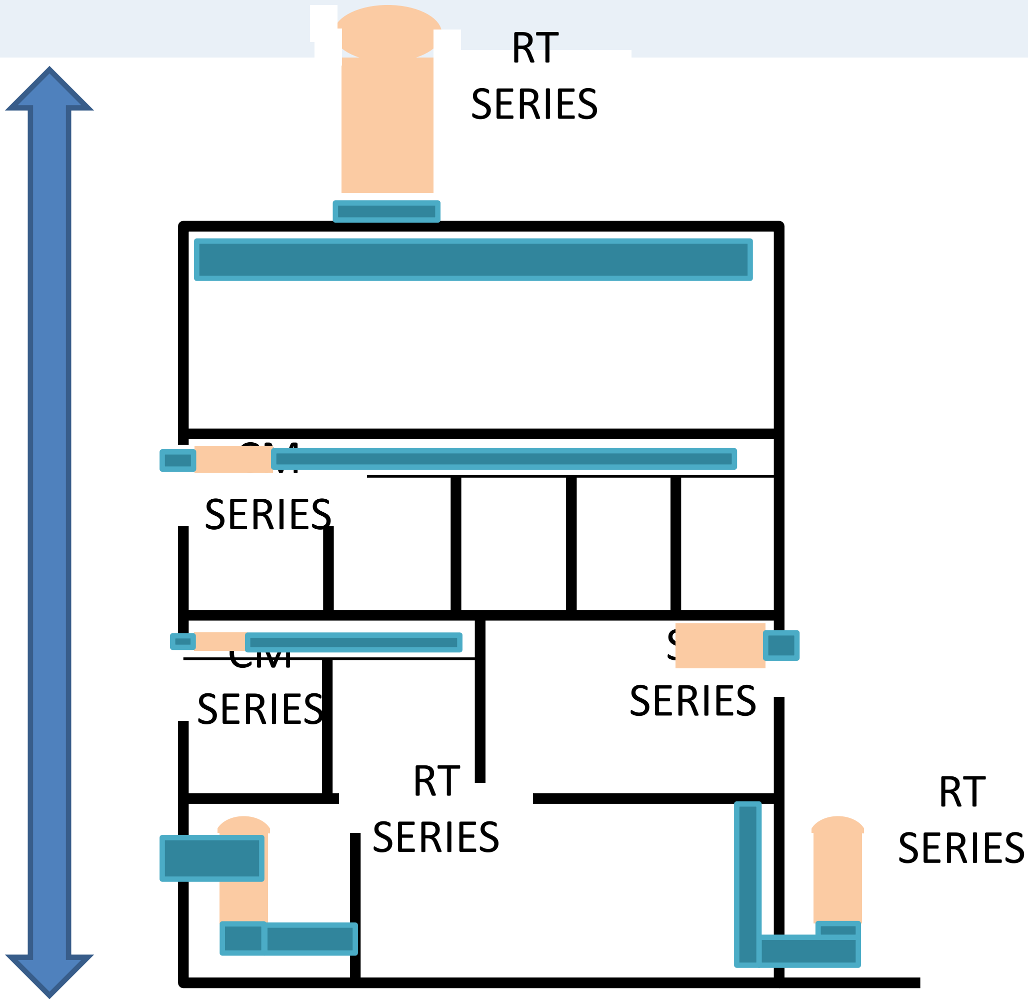
Market Challenges

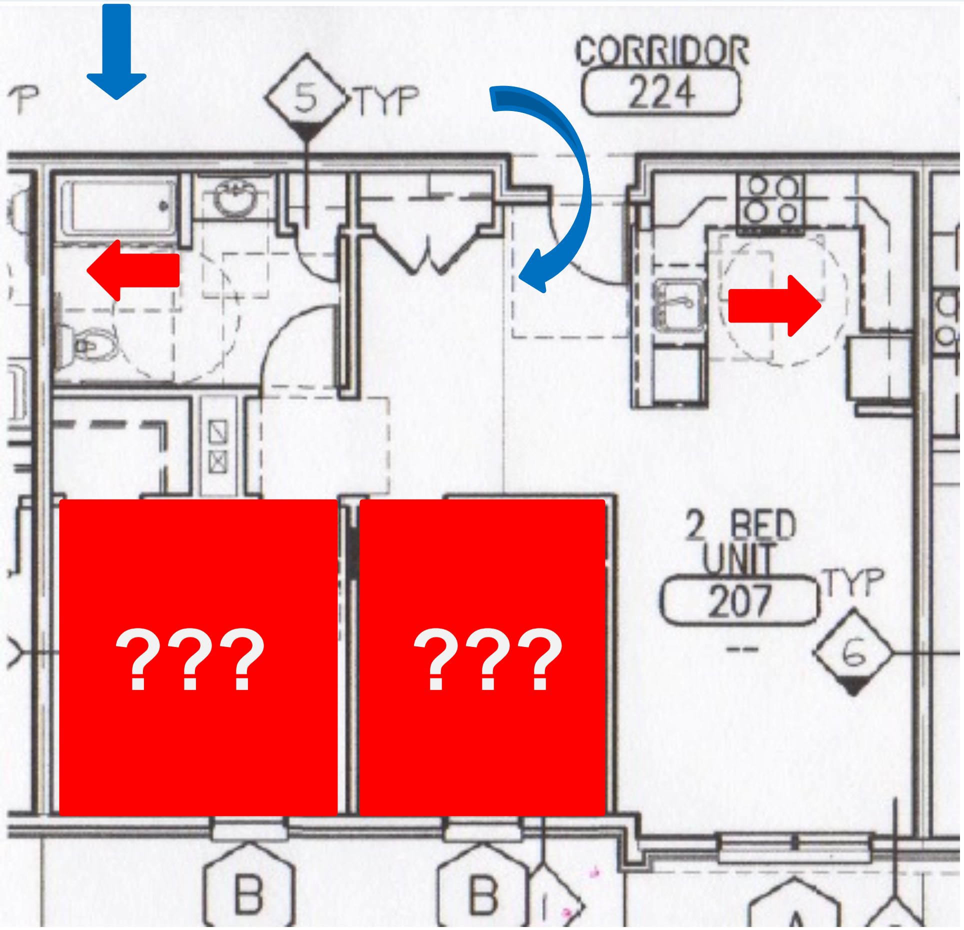
Chapter 8: Applications

Mounting for most commercial installs



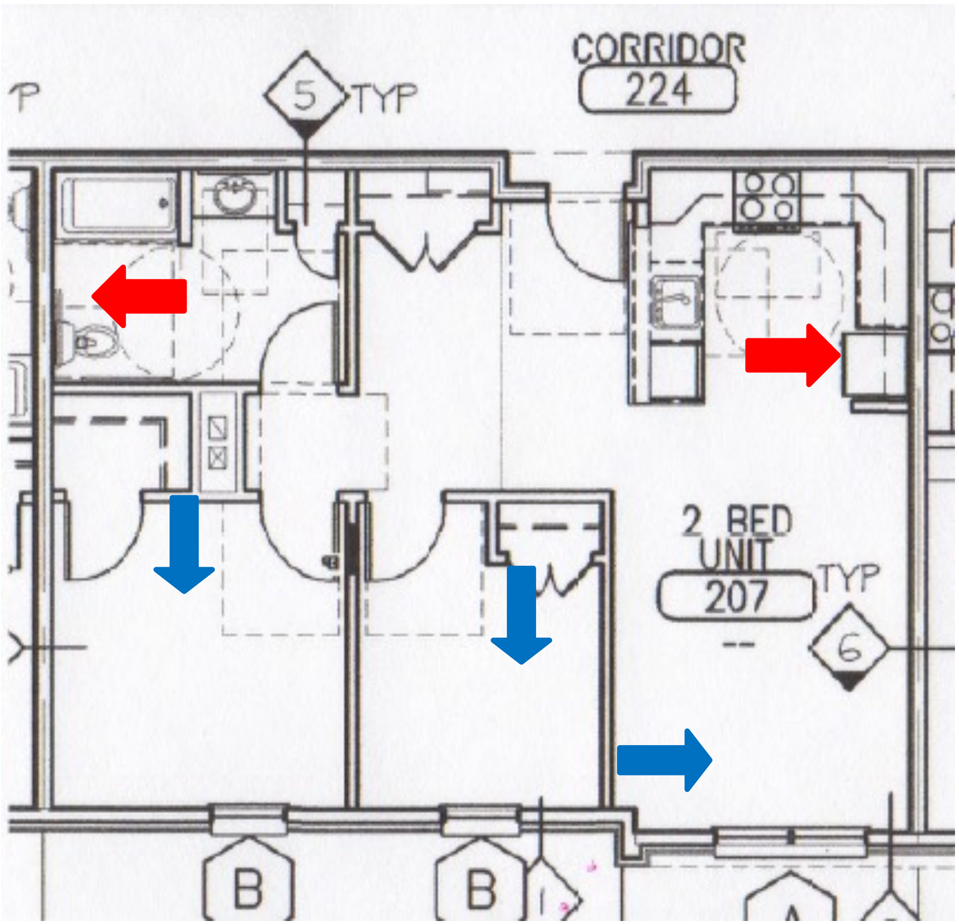
- Rooftop units ready to install outdoor as standard
- Decentralized units are quick and require minimal mechanical installation (no ducts)
- Units can be configured or available in multiple voltages
- HRV or ERV
- CM units are ideal for floor by floor or other drop ceiling installations and have four sizes to choose from
- RT unit also can be ducted in mechanical rooms or outside on stand

Application: Multifamily Residential Traditional Design



- Exhaust Air Locations
- Bathrooms
- Kitchen
- Supply Air Locations
- Corridors
- What is the ACH in the Bedrooms?

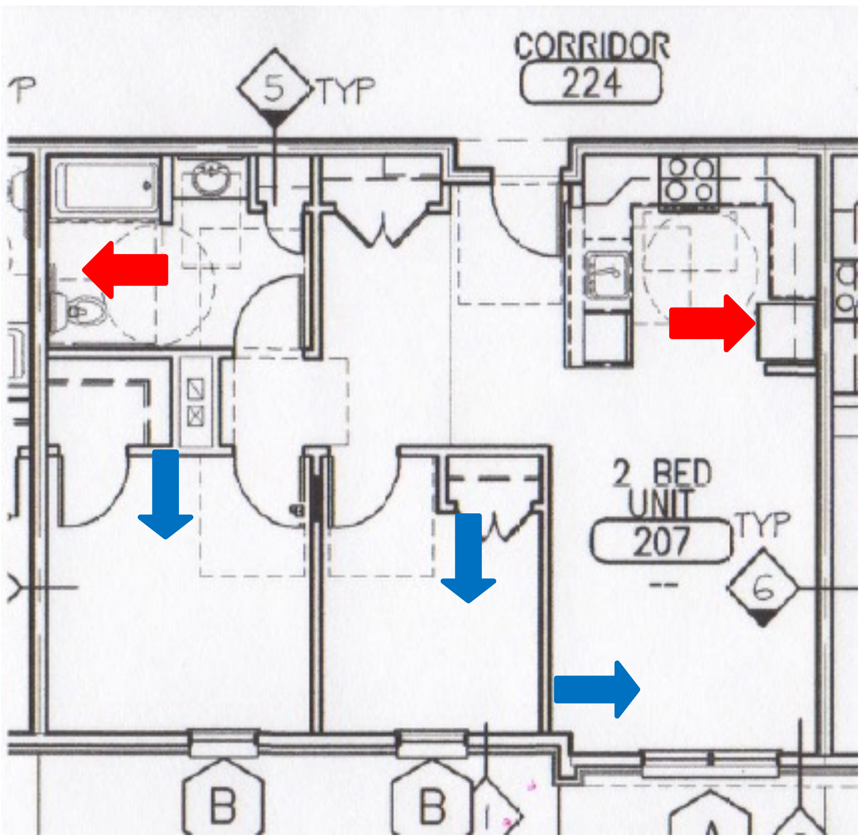
Application: Multifamily Residential Optimized Design



- Exhaust Air Locations
- Bathrooms
- Kitchen
- Laundry
- Moisture/Odor Laden Areas
- Supply Air Locations
- Bedrooms
- Offices
- Living/Family Rooms*
- Remote Rooms

* Depending upon layout

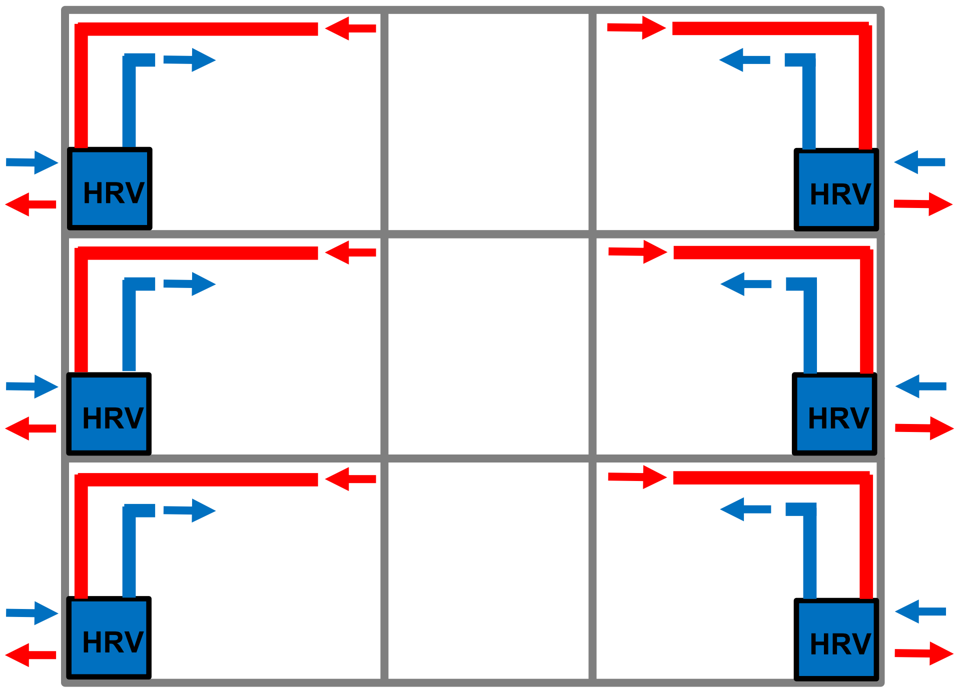
Application: Multifamily Residential System Options: Example Apartment



- Given Conditions:
- 800 SF TFA (~80 SM)
- 2 Bedrooms
- Living Room
- 1 Bathroom
- 7'x8' Kitchen (56 SF)

Standard	Supply	Exhaust
PHI	32 CFM	59 CFM
62.2-2013	47 CFM	57 CFM

Multi-Family Options



Individual Apartment Units

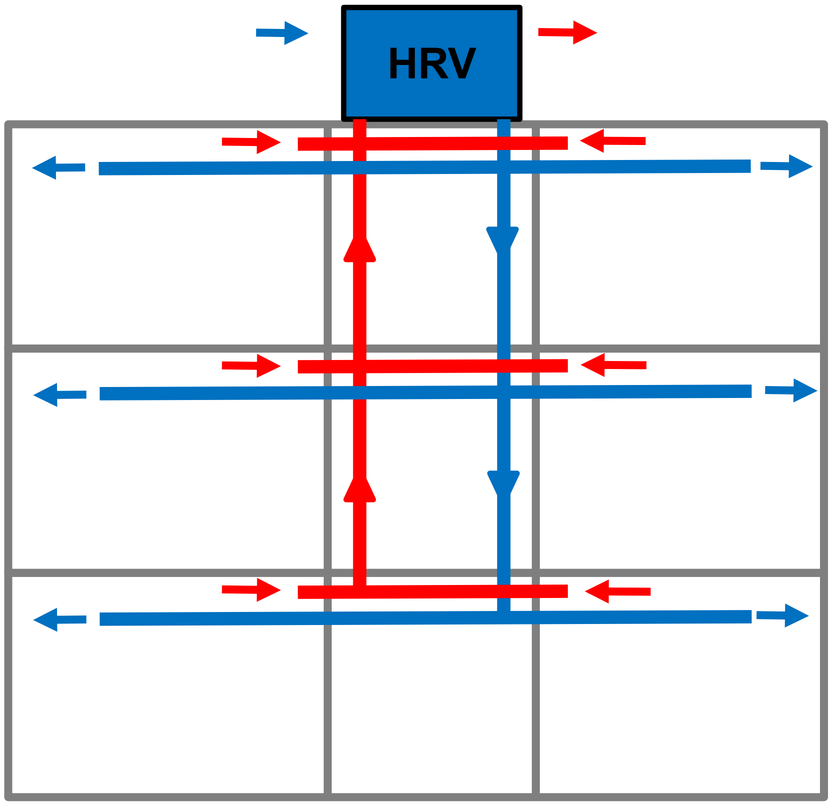
Pros

- Better Compartmentalization
- Minimize Stack Effect
- Individual Control
- Easy Boost Capacity
- Good for Condominiums
- Minimize Duct Runs
- Minimize energy usage
- Energy paid by occupant

Cons

- Multiple Wall Penetrations
- Dispersed Maintenance
- May be more expensive

Multi-Family Options



Central Ventilation Units

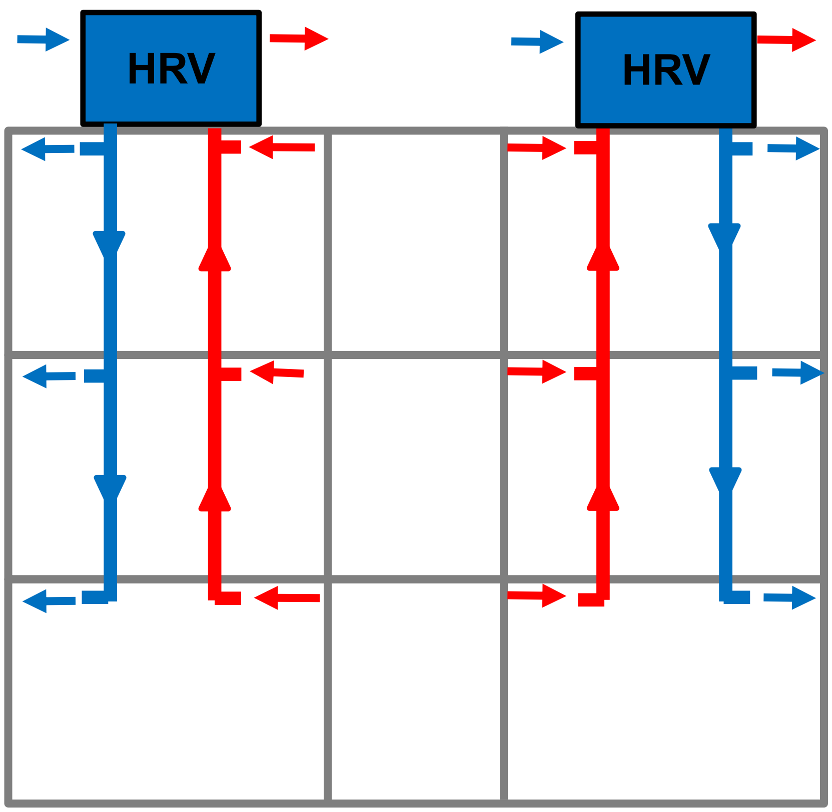
Pros

- Central Maintenance
- May be less expensive
- Minimize Penetrations

Cons

- Central Ductwork & Fire Dampers
- Fighting Stack Effect
- Loss of Floor Space for Shafts
- More Complex to Boost
- Harder to Balance
- Higher energy usage
- Energy paid by building owner

Multi-Family Options



Semi-central Ventilation Units
Vertical Configuration

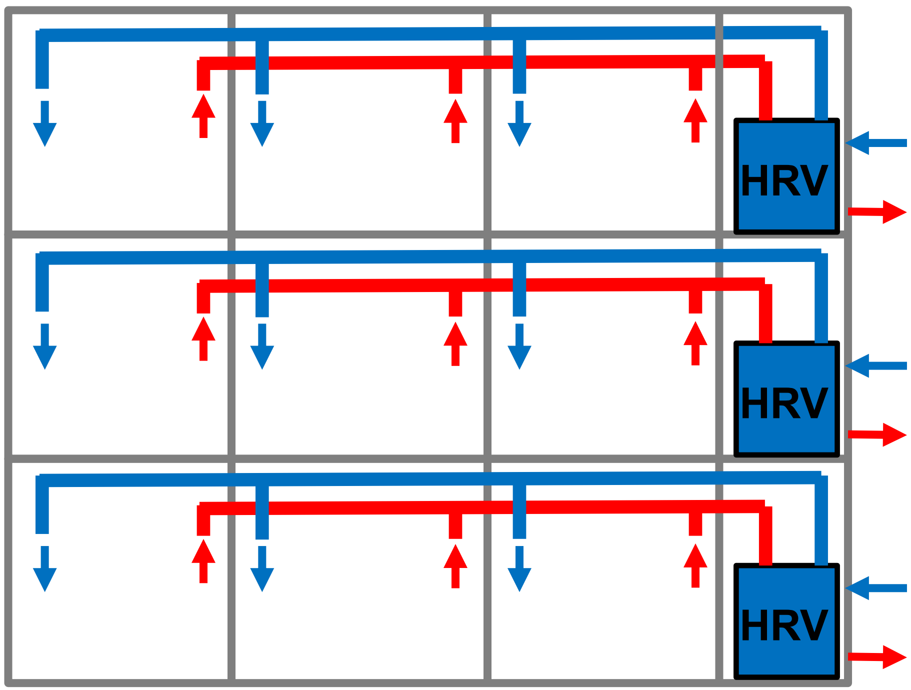
Pros

- Consolidated Maintenance
- May be less expensive
- Minimize Penetrations
- Reduce Ductwork
- Reduce Energy Usage

Cons

- Central Ductwork & Fire Dampers
- Fighting Stack Effect
- Loss of Floor Space for Shafts
- More Complex to Boost
- Harder to Balance
- Energy paid by building owner

Multi-Family Options



Semi-central Ventilation Units
Horizontal Configuration

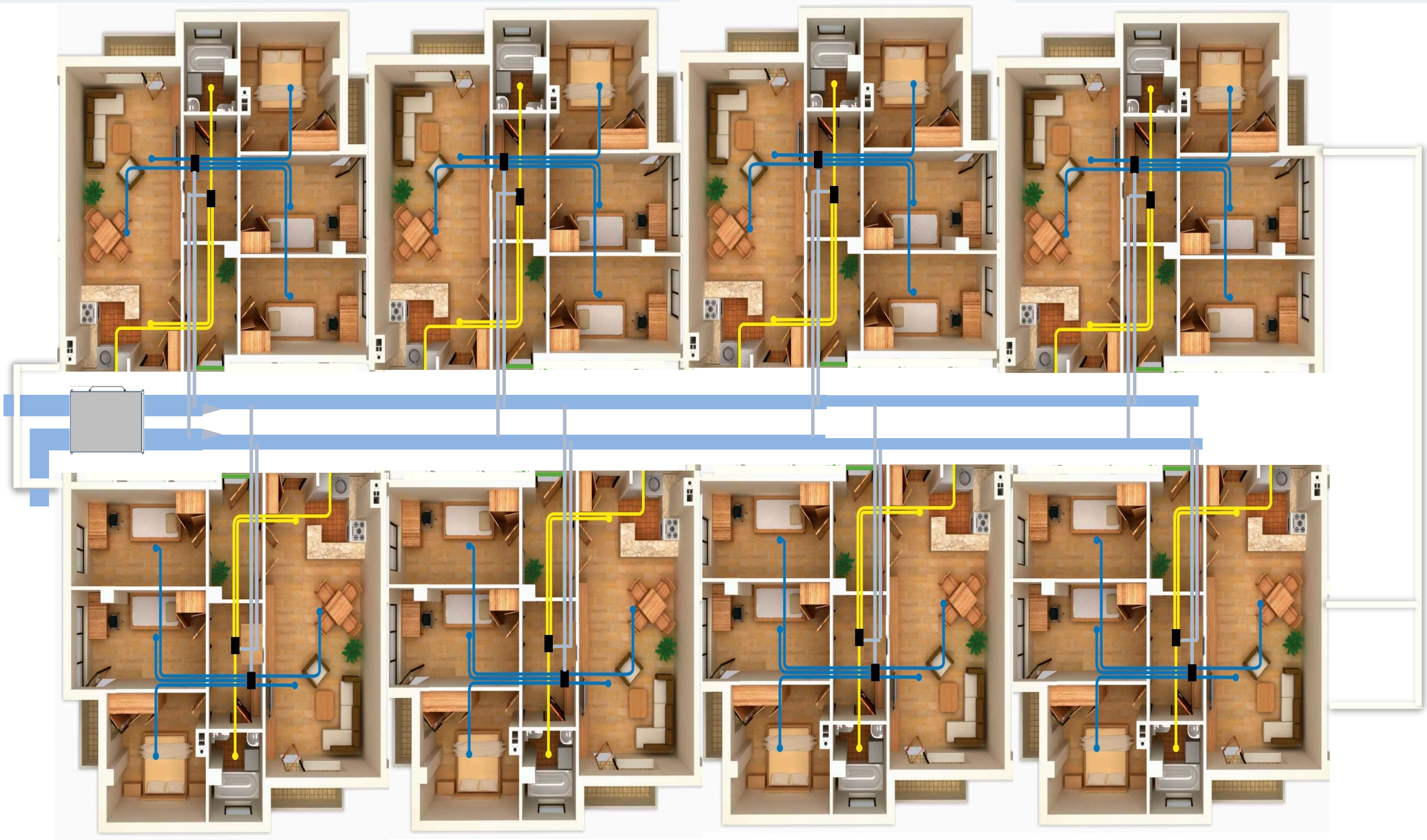
Pros

- Consolidated Maintenance
- Minimize Stack Effect
- Eliminate Shafts
- May be less expensive
- Minimize Penetrations
- Reduce Energy Usage
- Possibly Eliminate Fire Dampers

Cons

- Central Ductwork
- More Complex to Boost
- Harder to Balance
- Energy paid by building owner

Multi-Family Options



VENTACITY FAMILY PROTFOLIO

OUR FULL LINE OF HEAT & ENERGY RECOVERY VENTILATORS

Ultra-Efficient & Intelligent – Ventacity's HRVs and ERVs are Dedicated Outside Air Systems (DOAS), offering the highest efficiencies and greatest number of features available.

- Up to 93% Efficiency
- Lower Cost of Operation
- Improved Occupant Health and Comfort

FAMILY OF VENTILATION SYSTEMS

0-250 CFM → 0-3000 CFM

VS1000RT h
VS1000RT e

VS3000RT h
VS3000RT e

VS500SQ h
VS500SQ e

VS250CM h
VS250CM e

VS400CM h
VS400CM e

VS900CM h
VS900CM e

VS1200CM h
VS1200CM e

1. Highest Efficiency
2. Highest Intelligence
3. Complete Ventilation SYSTEMS

- UL 1812, UL1815, CSA, Passive House certified

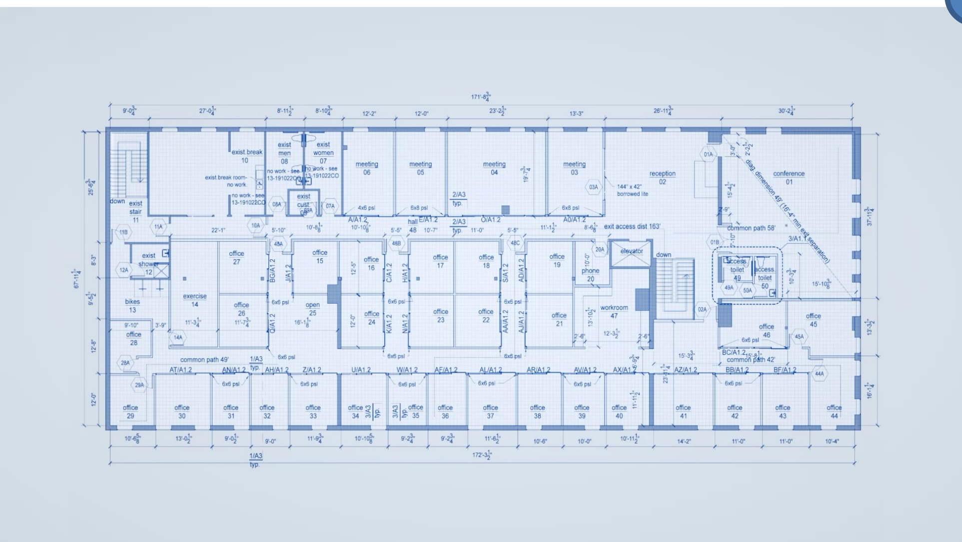
CERTIFIED COMPONENT
Passive House Institute

Rooftop Hrv/erv units

VENTACITYSYSTEMS
Making Buildings Healthy - Efficient - Smarter

RT INSTALLATION EXAMPLES

1



1. VS1000RT h for multiple office zones with VRF Ducted Fan Coil System
2. VS1000RT h Mechanical Room
3. Modeling VS1000RT h on Seattle Ecotope Building

2

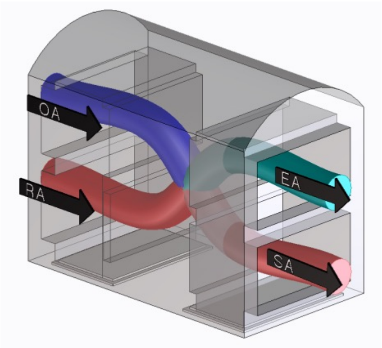
3

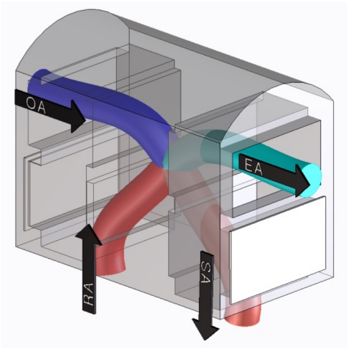
RT SYSTEMS, ROOFTOP OR MR READY

VS1000RT h
VS1000RT e

VS3000RT h
VS3000RT e

Bottom or End
ducted extract and supply
Field configurable





KEY STANDARD FEATURES

- **Galvanized and powder-coated for outdoor operation**
- **Curb or stand mounting**
- **Domed roof for water shedding**
- **Insulated double steel wall**
- **Thermally-broken surfaces between chambers**
- **Intelligent controls with internal and external sensors enable design flexibility and automated, optimized performance**
- **UL/CSA listed**
- **Passive House Certified**

SQ series: decentralized ventilation

VENTACITYSYSTEMS

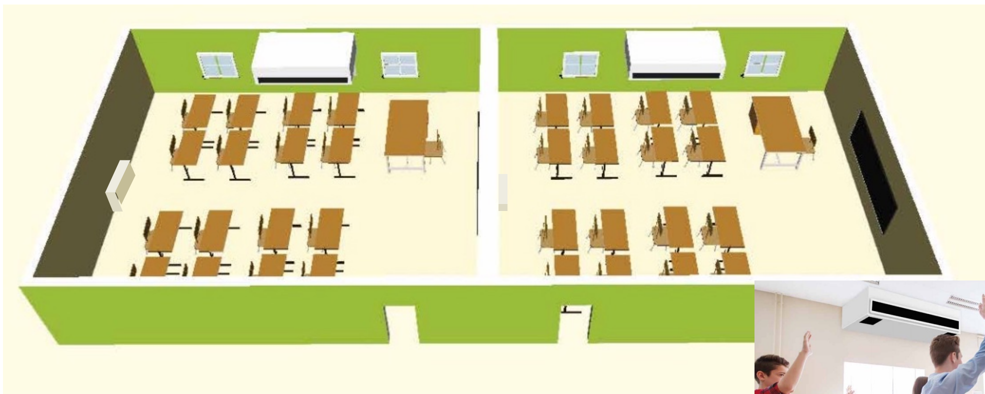
Making Buildings Healthy - Efficient - Smarter

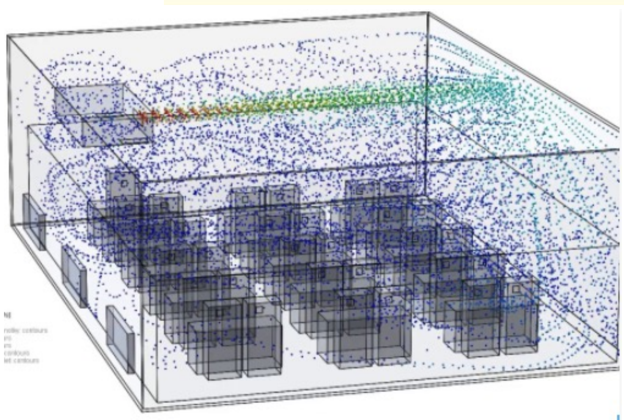
SQ SERIES – DECENTRALIZED VENTILATION

VS500SQ h (HRV)   VS500SQ e (ERV)

- Simple ductless installation
- Below ceiling mount; optimized to create healthy, comfortable classroom
- No internal ductwork minimizes installation time and cost
- Exceptionally quiet operation:
  - Example L_{PA}=10 dB: A Pin Dropping
  - Example L_{PA}=20 dB: Leaves Rustling
  - SQ Series: L_{PA}=23.6 dB @3M, 50% flow
  - Example L_{PA}=30 dB: A Whisper / Library
  - SQ Series: L_{PA}=31.5 dB @1M, 50% flow
- Standard CO_2 sensor for DCV
- Easy filter access
- Post-conditioning option available
- Great for classrooms; libraries
- UL/CSA Listed

SO ADVANCED THAT ITS SIMPLE





- Simple ductless installation reduces cost and time of install
- Health:
- DCV operation with standard CO_2 sensor maintains superior air quality for health and human performance
- Comfort:
- Very low air velocity at student level
- Comfortable fresh air temperature through high recovery effectiveness

NYCSCA PILOT TEST INSTALL

HILLSBORO, OR INSTALLATION

HILLSBORO, OR INSTALLATION

HILLSBORO, OR INSTALLATION

WINDHAM, ME UNIT VENTILATOR UPGRADE

WINDHAM, ME UNIT VENTILATOR UPGRADE

WINDHAM, ME UNIT VENTILATOR UPGRADE

CM SERIES: slim members of the family

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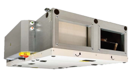
Making Buildings Healthy – Efficient – Smarter

CM SERIES – SLIM LINE INDOOR UNITS

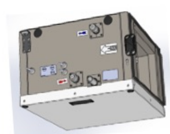


VS250CM h
VS250CM e

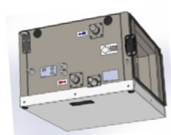
VS400CM h
VS400CM e

VS900CM h
VS900CM e

VS1200CM h
VS1200CM e



CM series accessory:
DX Module couples
to SA duct



CM Series accessory:
Hydronic Changeover
Coil Module

- Typically mounted above T-bar drop ceiling
- Installation similar to ducted fan coils
- Ideal for multi-level office or multi-tenant
- Part of the Ventacity family—complete system with features common to all
- Accessory post conditioning modules
- Best of distributed and centralized world
- Can be remotely monitored, managed and optimized
- UL/CSA listed

DX Option for VS UNITS

VENTACITYSYSTEMS
Making Buildings Healthy – Efficient – Smarter

VS DX KIT
Specification & Installation

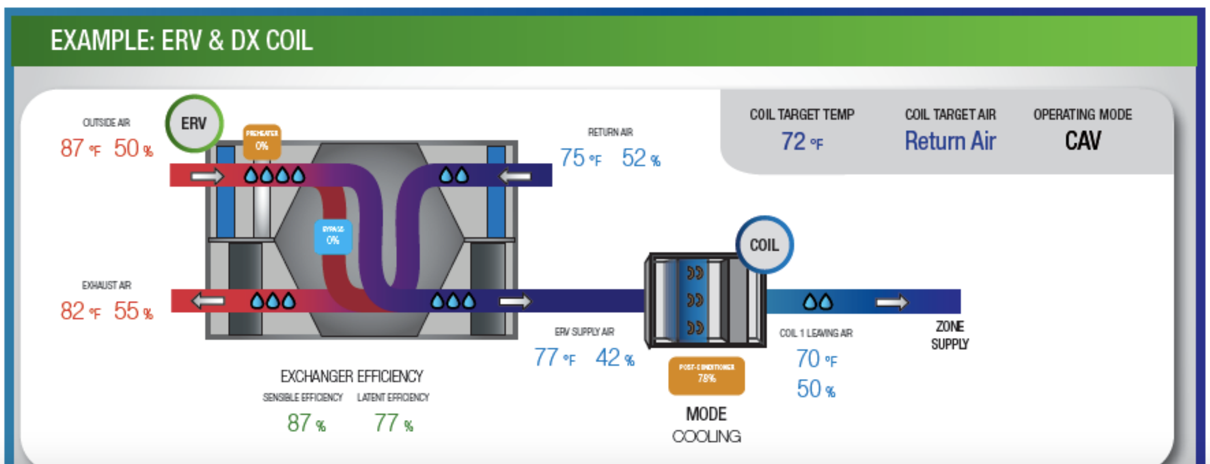
DX COIL & ECO CONTROLLER

FOR ERV/HRV POST-CONDITIONING

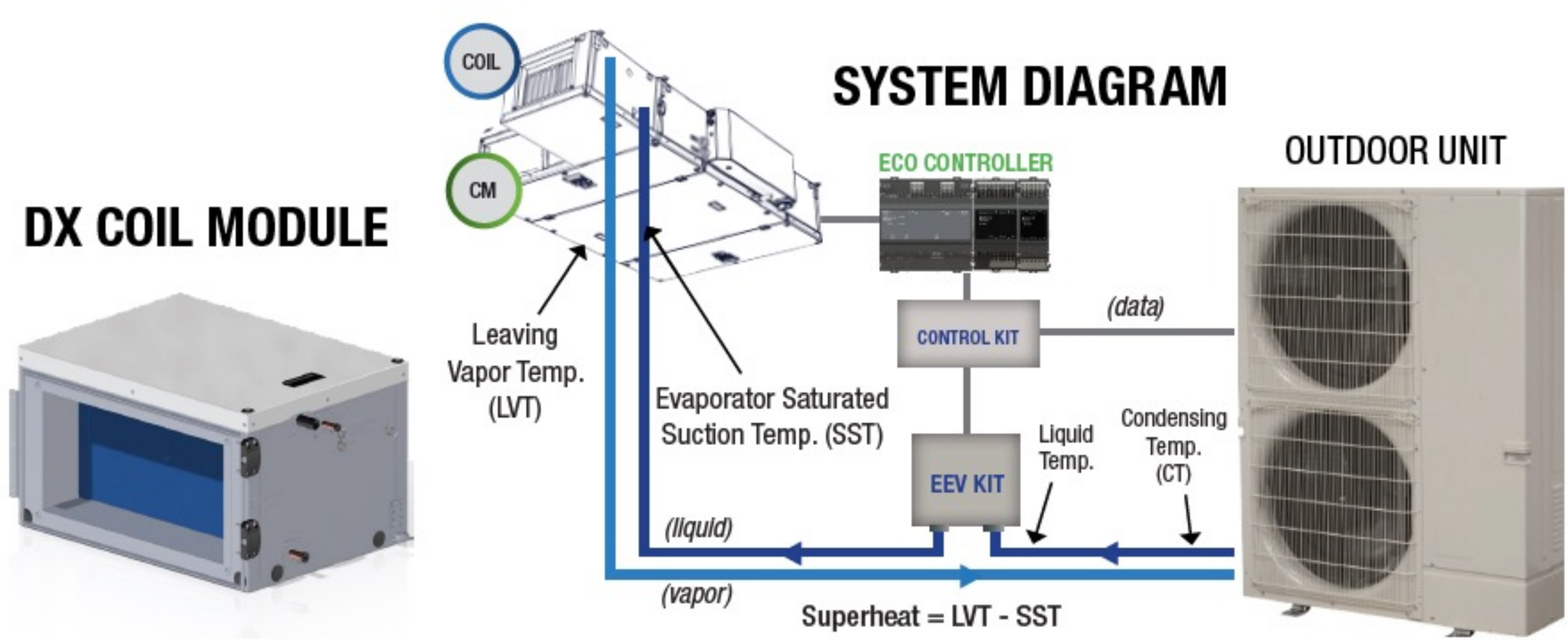
VENTACITY SYSTEMS provides a suite of DX Coil Modules for the following ERV and HRV ventilators:

VS1200CM, VS900CM, VS400CM, VS250CM, VS1000RT*, and VS3000RT.

- DX coils are compatible with VRF systems.
- ECO Controller: Energy Conserving Orchestration. Used for added features (see following pages).



INTEGRATED CONTROLS

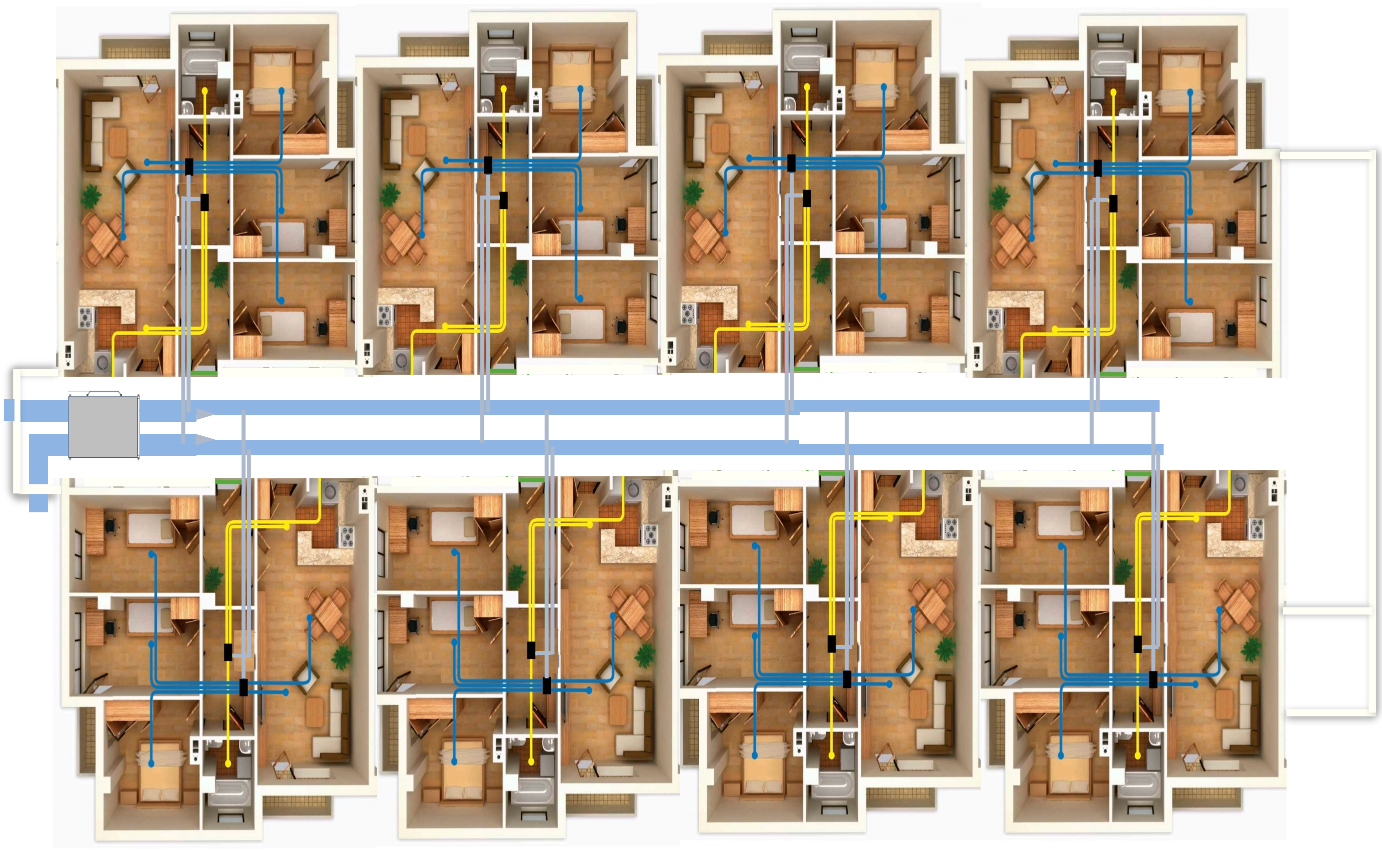


*NOTE: VS1000RT-DX is the VS1200CM-DX

DX and Changeover hydronic kits

1. Easy Installation
2. Seamless Controls
3. Right Sized

CM SERIES – EASY INSTALLS, OPTIMIZED OPERATION



- Multi-level installation coupled with SBC100 makes easy tracking, control, and maintenance
- HVAC[2] solution of CM series plus efficient VRF heating/cooling maximizes efficiency, comfort, and health

BUILT-IN “SMART” ECONOMIZER

FREE COOLING/ECONOMIZER

- INTEGRATED
- MANAGED TO A DELIVERED TEMPERATURE SETPOINT
- CONTINUOUSLY VARIABLE
- SCHEDULE FLEXIBILITY

THANK YOU, from all of us at www.Ventacity.com!

barry@ventacity.com

603-498-9005