enVerid
Energy savings. Air quality.

HLR® and 62.1 IAQP

Agenda

- Relevant Documentation
- COVID!
- Product Overview: 14M, 15M, 15R – What's Inside?
- Unit Operation
  - Adsorption Mode
  - Regeneration Mode
- Standard Use Cases
- Design Integration

enVerid Systems: a technology leader in “Air Care”

enVerid
Energy savings. Air quality.

About Us

- Founded in 2010, privately held
- Headquarters in Boston, ~ 30 employees

Markets

- Products that deliver massive energy savings + air quality in buildings
- Also developing solutions for residential, transportation and special apps

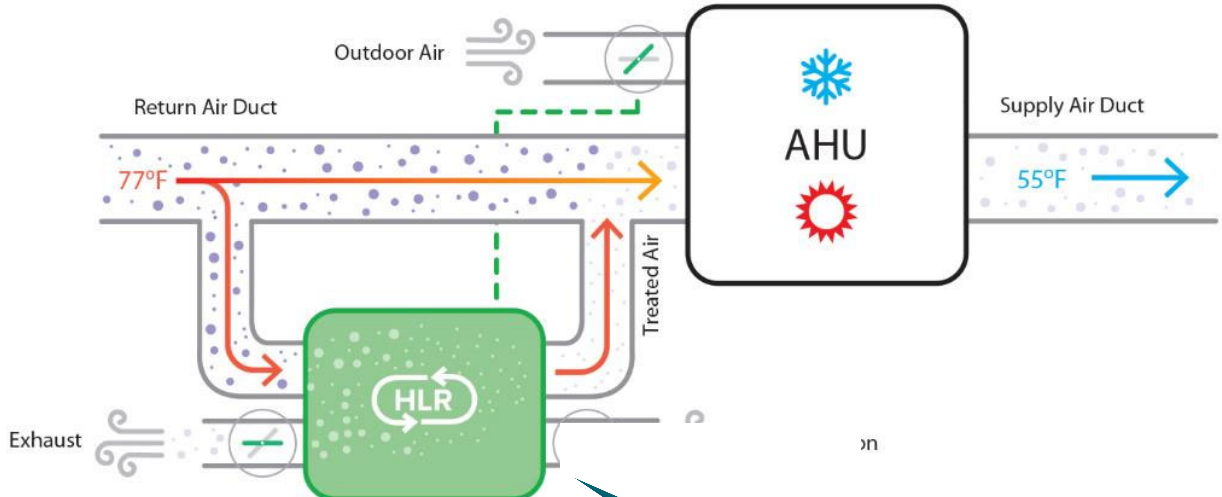
Technology

- Chemistry / Material Science / Systems / IoT & Data
- Deep expertise in air quality and air treatment
- 60+ patents

Business

- Proven performance with top tier customers
- Two product lines in production: HLR® (USA-focused), AQR® (China-focused)
- Units deployed worldwide (Canada: Ontario, US: East Coast + South, China, India, Europe, Middle East)

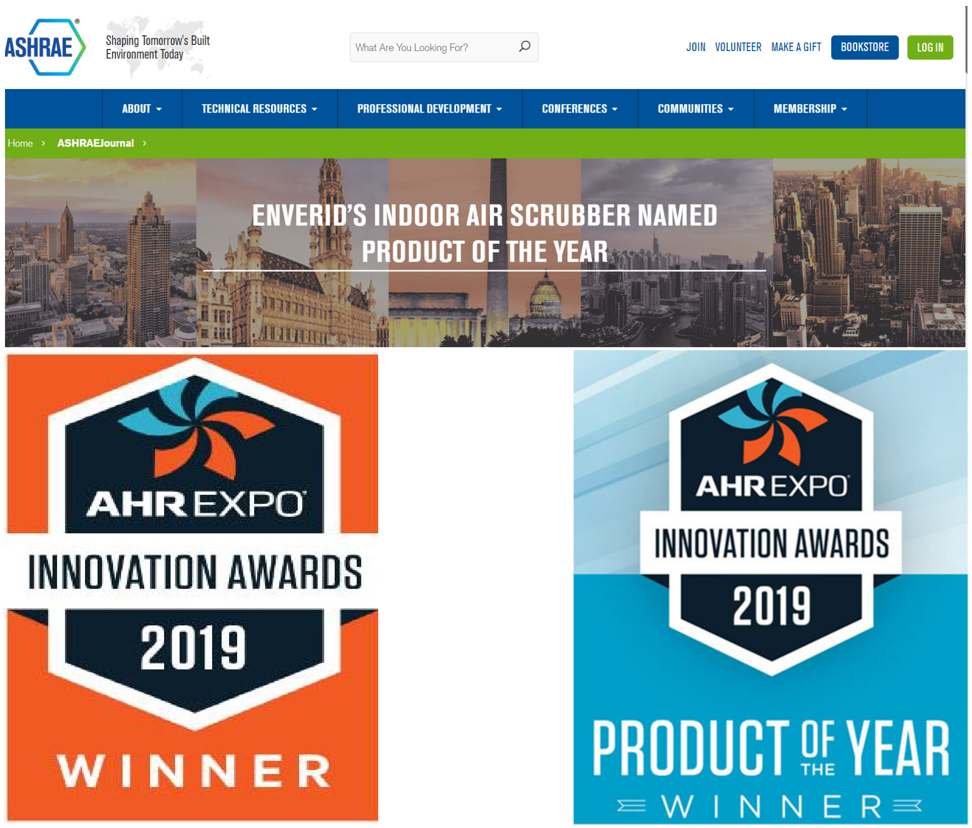
A scalable solution, compatible with most buildings.



Slip stream of return air is scrubbed by enVerid sorbents

enVerid HVAC Load Reduction (HLR®) reduces required outside air by 60-80%

Industry validation: 2019 AHR Expo Awards



"enVerid's first-of-its-kind solution safely removes all molecular contaminants, including carbon dioxide (CO_2), formaldehyde and a full range of volatile organic compounds (VOCs) from indoor air."

ASHRAE press release

Judges commented that the enVerid HLR technology "was not only innovative, but visionary," and called it "an industry game-changer."

enVerid in the News

FOR IMMEDIATE RELEASE

enVerid HLR Technology Ranked as Top Energy Saving Opportunity in Department of Energy Study

Prioritized in top 3 of over 300 technologies for commercial buildings

Boston, MA—February 27, 2018— enVerid Systems, Inc. announced today that its HVAC Load Reduction® (HLR®) technology has been listed as one of the top three priorities for commercial HVAC energy efficiency in a study commissioned by the U.S. Department of Energy (DOE) – providing potential energy savings of 250,000 billion BTU per year in the US. The study evaluated over 300 technologies and determined a final set of 18 high priority technologies.

Energy Savings

Demonstrations with the DOE and GSA field studies suggest 20-35% HVAC energy savings for the advanced filtration technology:

- A 2015 field study at a University of Miami (FL) wellness center found a 28% reduction in total HVAC energy consumption by reducing outside airflow by 75%.[43]
- A 2016 field study at a large office building in Arkansas found a 36% decrease in peak HVAC loads by reducing outside airflow by 65%.[44]
- Other case studies show 22-35% energy savings.[45]

>140+ MEPs adopted HLRs for global clients

ASHRAE Standard 62.1 Overview

- Ventilation Rate Procedure (VRP)
  - *PRESCRIPTIVE*

- Indoor Air Quality Procedure (IAQP)
  - *PERFORMANCE-BASED (no minimum OA requirements)*
  - *Since 1981**

+ USGBC LEED IAQP
+ IMC
+NY Mechanical Ventilation Code

SECTION MC 403
MECHANICAL VENTILATION

403.1 Ventilation system. Mechanical ventilation shall be provided by a method of supply air and return or exhaust air. The amount of supply air shall be approximately equal to the amount of return and exhaust air. The system shall not be prohibited from producing negative or positive pressure. The system to convey ventilation air shall be designed and installed in accordance with Chapter 6.

403.2 Outdoor air required. The minimum outdoor airflow rate shall be determined in accordance with Section 403.3. Ventilation supply systems shall be designed to deliver the required rate of outdoor airflow to the breathing zone within each occupiable space.

Exception: Where a registered design professional demonstrates that an engineered ventilation system design will prevent the maximum concentration of contaminants from exceeding that obtainable by the rate of outdoor air ventilation determined in accordance with Section 403.3, the minimum required rate of outdoor air shall be reduced in accordance with such engineered system design.

ANSI/ASHRAE Standard 62.1-2016
(Supersedes ANSI/ASHRAE Standard 62.1-2013)
Includes ANSI/ASHRAE addenda listed in Appendix K

Ventilation for Acceptable Indoor Air Quality

See Appendix K for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

 ISSN 1041-2336

ASHRAE Standard 62.1

Indoor Air Quality Procedure (§6.3)

The Indoor Air Quality Procedure (IAQP) may be used as an alternative to the Ventilation Rate Procedure (VRP). While the VRP is a prescriptive procedure that determines minimum outdoor air ventilation rates for typical applications, the IAQP is a performance-based design approach that determines minimum outdoor airflow rates and air cleaning necessary to control the concentrations of contaminants to certain levels and maintaining a specified percentage of occupant or visitor satisfaction. The VRP is an indirect solution to achieving acceptable IAQ. The IAQP is a more direct approach to the goal, but it requires very different methods, knowledge, evaluations, decisions, and documentation than those of the VRP.

While the VRP allows (and in some cases requires) that recirculated air be cleaned, the specified outdoor air ventilation rates may not be reduced. On the other hand, the IAQP allows any method to be used to achieve the contaminant concentration limits, including source control, air cleaning, or dilution of indoor contaminants with outside air.

The performance of the HVAC system in maintaining good air quality is based upon two requirements:

- Maintaining concentrations of specific contaminants below concentration limits, and
- Achieving a design target level of perceived indoor air quality acceptability.

Sometimes meeting the concentration limits will result in perceived acceptability and sometimes not. For instance, the human nose is very sensitive to odors that may or may not be addressed by the contaminant concentration limits. On the other hand, meeting only the perceived acceptability targets is not sufficient since some contaminants cannot be sensed even if harmful levels are reached (for instance radon and carbon monoxide).

Sometimes meeting the concentration limits for each individual contaminant will result in perceived acceptability and sometimes not. Since odors may add (see "Two Component Approach and Additivity" in Section 6.2), the outdoor air needed to dilute odorous contaminants might be the sum of the outdoor air needed to dilute each odorous contaminant.

The IAQ Procedure requires the building and its ventilation system to be designed to achieve both objective and subjective criteria. The IAQP allows ventilation air to be reduced below rates that would have been required by the VRP, if it can be reliably demonstrated that the resulting air quality meets the required criteria described ir §6.3.4.

The IAQP may allow for a more cost effective solution to providing good air quality since all design strategies may be considered and compared, including:

- Dilution ventilation and the commensurate added energy costs of conditioning greater volumes of outdoor air;
- Controlling contaminants at the source by specifying low-emissions carpets, wall coverings, paints, adhesives and furnishings;
- Air cleaning strategies; and
- Evaluation of occupant and/or visitor satisfaction based on perceived air quality in similar buildings or through post-occupancy evaluation.

Many of these strategies involve added construction and maintenance costs but can have the benefit of conditioning less outdoor air. They can also result in higher levels of perceived acceptability by building occupants and/or visitors. The IAQP may also be used to achieve better air quality than the VRP (lower contaminant levels and/or higher perceived acceptability) with or without increasing first cost or maintenance cost.

COMPLIANCE REQUIREMENTS

Designing for compliance using the IAQ Procedure requires four steps:

The **IAQP** may allow for a **more cost effective** solution to providing good air quality since all design strategies may be considered and compared including:

- Dilution ventilation and the commensurate added energy cost of conditioning greater volumes of outdoor air
- Controlling contaminates at the source by specifying low-emissions carpets, wall coverings, paints adhesives and furnishings
- **Air cleaning strategies** and
- Evaluation of occupant and/or visitor satisfaction based on perceive air quality in similar building or through post-occupancy evaluation

Many of these strategies involve added construction and maintenance costs but can have the **benefit of conditioning less outdoor air**. They can also result in higher levels of perceived acceptability by building occupants and/or visitors. The **IAQP may also be used to achieve better air quality than the VRP** (lower contaminants levels and/or higher perceived acceptability) with or without increasing first cost or maintenance cost.

IAQP Use Cases

Conditions	Outcome
Outdoor air is non-attainment for NAAQS or polluted	Reduces burden of ambient sources of particulate and gaseous pollutants Reduces frequency of PM filter replacement
Buildings with existing capacity limitations (aging of HVAC equipment, re-purpose of the space, adding more people)	Enables compliance with the code using existing equipment with adding additional HVAC capacity
New buildings with limited HVAC capacity (e.g., geothermal projects)	Engineers or owners gain from the economic advantages of the IAQP
Building is located in cold or hot/humid climates	Allows reduction in kWh and operating peak demand
LEED buildings	Allows earning LEED points related to energy, indoor air quality, and innovation.

	American Lung Association		EPA
Outside air ratings	**24-Hour Particle Pollution**	**Ozone Grade**	**8-Hr Ozone Classification**
Washington-Baltimore-Arlington, DC-MD-VA-WV-PA	C	F	Nonattainment

VRP 2019 Changes

Unusual sources

3. DEFINITIONS (SEE FIGURE 3.1)

Unusual Source: an item or activity that could create or emit contaminants that occurs rarely within an occupancy category.

- What:
  - Clarification is added regarding the presence of unusual or strong sources of contaminants

- Why:
  - Contaminant sources and sources strengths that are not typical for the occupancy category require additional evaluation in order to provide proper ventilation

6.2.2.1.2 Source Strengths. The Ventilation Rate Procedure minimum rates are based on contaminant sources and source strengths that are typical for the listed occupancy categories. For sources that are not typical of the occupancy, the additional ventilation or air cleaning required must be calculated using Section 6.3.6 of the IAQ procedure.

Demand Control Ventilation (DCV) – Sensor Requirements

Addendum 62.1 al

Addendum al to 62.1-2016

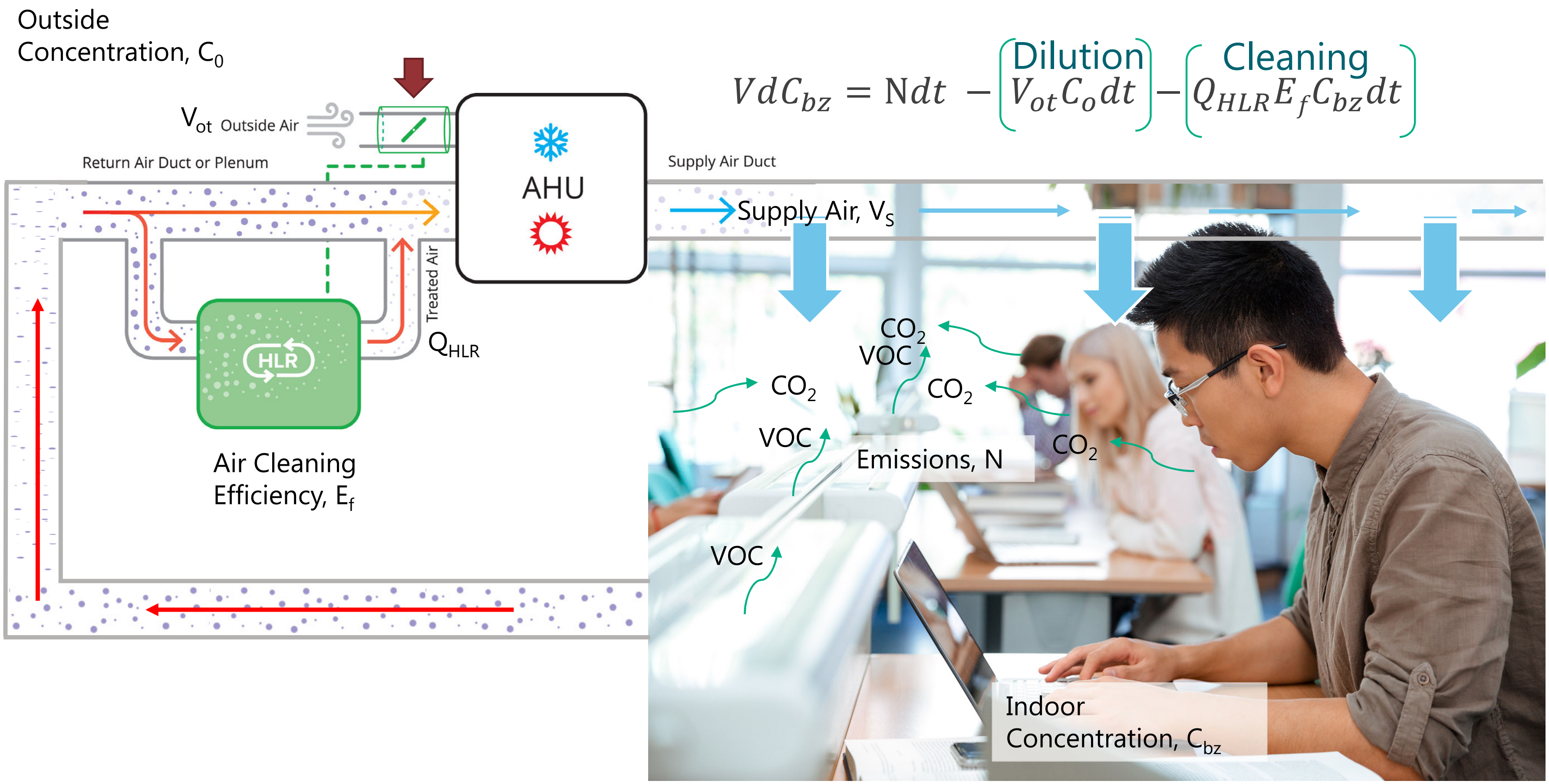
Add new Section 6.2.7.1.3 as shown. Renumber the existing sections as appropriate.

6.2.7.1.3. Where CO_2 sensors are used for DCV, the CO_2 sensors shall be certified by the manufacturer to be accurate within plus or minus 75 ppm at a 600 ppm and 1000 ppm concentration when measured at sea level at 25°C. Sensors shall be factory calibrated and certified by the manufacturer to require calibration not more frequently than once every 5 years. Upon detection of sensor failure, the system shall provide a signal that resets the ventilation system to supply the required minimum quantity of outdoor air (V_{bz}) to the breathing zone for the design zone population (P_z).

IAQP: Objective Evaluation Steps

Mass Balance Analysis

$$V dC_{bz} = N dt - \underbrace{V_{ot} C_o dt}_{\text{Dilution}} - \underbrace{Q_{HLR} E_f C_{bz} dt}_{\text{Cleaning}}$$



Why enVerid HLR?

- Unique product line 62.1 compliant ➔ lower the total cost HVAC
  - Solutions that is not dilution
- First Cost Savings of 10 - 20% (vs DCV or ERV)
  - Can downsize equipment (if you choose)
  - Utility rebates covering up to 50% of system cost
- OpEx Savings (up to 30% of energy)
  - Unit pays for itself in first year on Plan & Spec
  - Reduce OA ~75%
- LEED & ASHRAE Approved
  - Up to 16 LEED Points
- Proven, tested, recognized by DOE, ASHRAE, & Utilities
  - 3rd party lab tested for ASHRAE 52.2, 62.1, 145.2

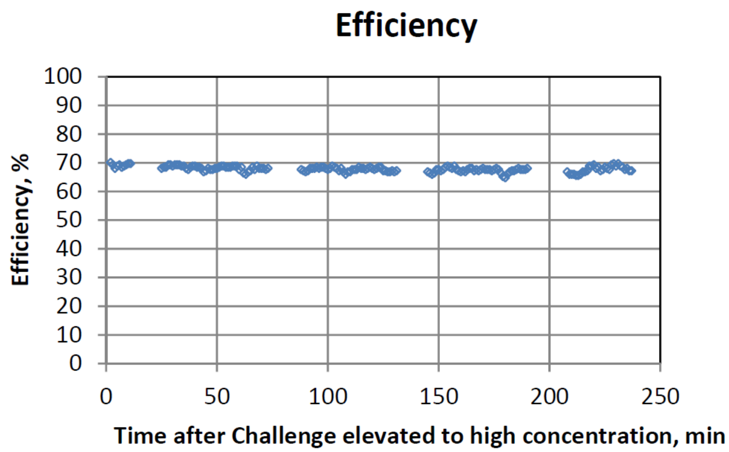
ENBRIDGE

ASHRAE: Compliance

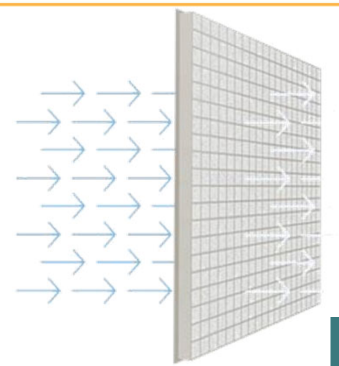
- Air cleaning certification data according to ASHRAE Standards is needed to apply the Indoor Air Quality Procedure (IAQP) and LEED IAQP
- enVerid obtained certifications according to ASHRAE Standard 145.2 and 52.2 for the sorbent cartridge in the HLR module from Research Triangle Institute (RTI)

Example: Ozone test data from RTI:

- Efficiency = 70%
- By-product VOCs and ozone concentrations = 0 ppb



Multiple breakthroughs in sorbent materials.



- **Proprietary amine polymers**
  - Low-cost **CO_2** capture *and* release
  - Exceptional formaldehyde removal
  - Multiple other air-cleaning functionalities
- **Mineral – polymer synthetics**
  - Formation of high surface solid sorbents and catalysts
  - Reduced thermal mass for low-energy temperature swing
  - Modular form factors for diverse applications
- **Capabilities that span all contaminants (Over 250+)**
  - BTX / aromatics, aldehydes, polyols
  - VOCs and VVOCs
  - Inorganics: NOx, SOx, H_2S, ozone, radon

Massachusetts Institute of Technology

USC

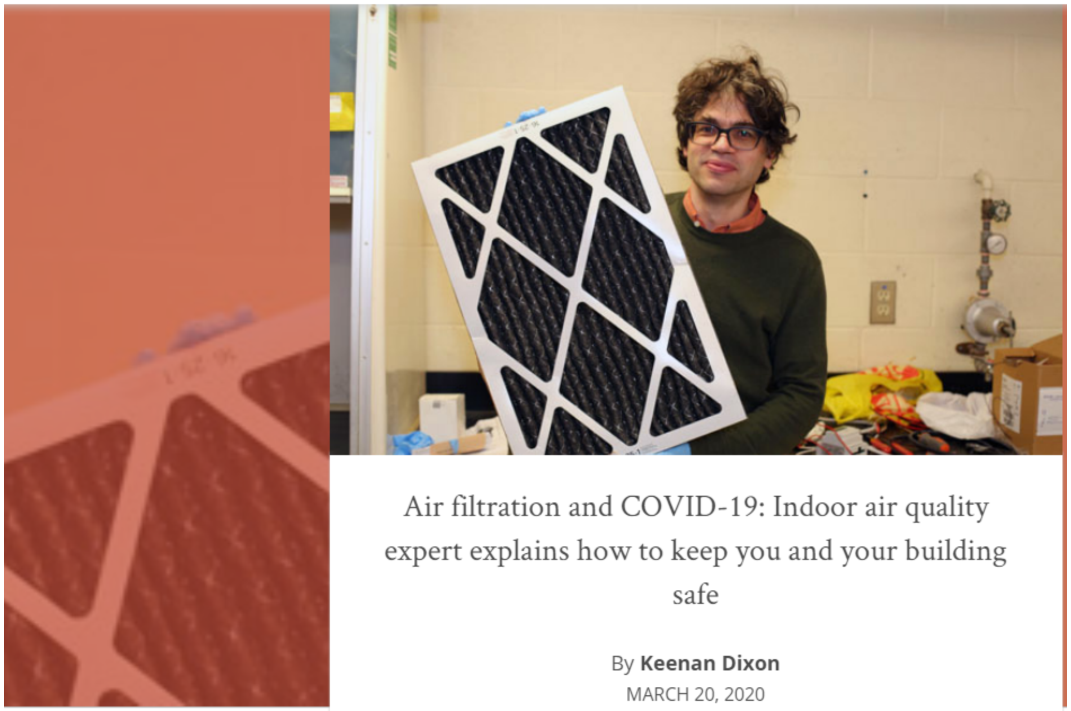
BERKELEY LAB

Challenge Gas	Efficiency Measured by RTI Lab[1]
Ozone	70%
Hexane	74%
Xylene	60%
Isopropanol	77%
Toluene	52%
Benzene	87%
Formaldehyde	55%
Carbon dioxide	57%

Covid-19

COVID-19 and Safety

UNIVERSITY OF TORONTO ENGINEERING NEWS



Air filtration and COVID-19: Indoor air quality expert explains how to keep you and your building safe

By **Keenan Dixon**
MARCH 20, 2020

From the Study:

- No direct evidence of (filtration) benefit to Covid-19 exposure
- Ionizers, ozone generators, plasma, and other air cleaning technologies

  “None of these technologies have been proven to reduce infection in real buildings, even if they have promise based on tests in a laboratory or other idealized settings.

  Some of them have substantial concerns about secondary issues”
- Most public health guidance suggests that COVID-19 transmission is predominantly associated with large droplets. This is why air filtration is only a small part of a solution as it does not address transmission from surface contact or from close contact between individuals.

ASHRAE Journal: Dec 2018

enVerid
Energy savings. Air quality.

"New York state education department determined Corona discharge air cleaner systems cannot be used in schools in New York state."

"Where the registered design professional demonstrates that an engineered ventilation system design will prevent the maximum concentration of contaminants from exceeding that obtainable by the rate of outdoor air ventilation…the minimum required rate of outdoor air shall be reduced in accordance with such engineered system design."

Corona discharge (sometimes labeled: ionizing, negative ion, bipolar ionizing, activated oxygen, mountain fresh air, etc.) often is a proposed air cleaning technology to remove airborne contaminants. Corona discharge ionizes oxygen in air and generates an electrostatic field. The design of the corona discharge system can be modified to create mixtures of reactive oxygen species (ROS): ozone, hydroxyl radicals, and superoxide anions.[2] Ozone emissions from air cleaners are regulated in California[3] and are generally discouraged in many states' guidance documents (see, for example: Connecticut, New York[4]); the manufacturer's marketing materials claim this air cleaner does not produce ozone. ROS initiate radical reactions that rapidly decay unsaturated volatile organic compounds (VOC) and generate particles. The radical reactions propagate, creating and destroying radicals and ROS until the reactants are transformed and the products do not react further.[5] For "air cleaning" the final reaction products would be carbon dioxide and water but in practice, corona discharge transforms airborne contaminants into myriad products that are not well-characterized for their chemical identities, yields or toxicities. We designed this study to evaluate the changes in IAQ caused by a corona

Todd Crawford, Patricia Fritz, and Thomas Wainman are research scientists at New York State Department of Health in Albany, N.Y.

COVID-19 Transmission Routes Details

Known routes:

- Coughing and sneezing respiratory droplets (>5 micron in diameter can travel < 1m)
- The droplets (containing the virus) can be contagious by:
  - Direct contact with mouth, nose or eyes of person in proximity
  - Infection of objects and surfaces

Other possible routes (<u>No evidence for any COVID-19 infection through these routes in commercial building</u>):

- Airborne virus particles (fine respiratory droplet 5< micron in diameter, can travel >1m) also called **aerosols**
- COVID-19 might be present in feces and lead to fecal–oral transmission and formation of droplets or aerosols

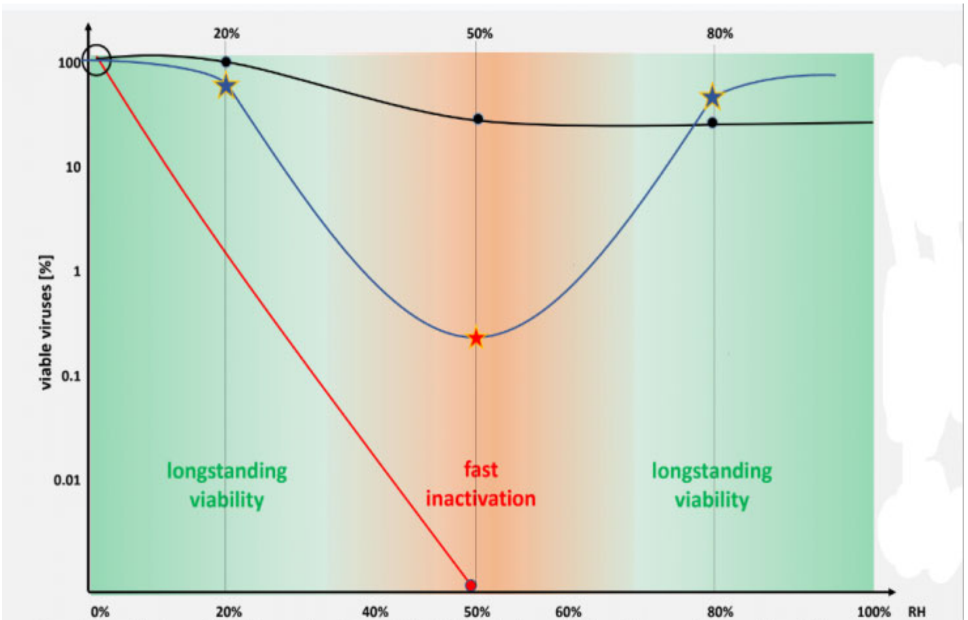
Droplet with viruses inside. Small droplet can be airborne and is called aerosol.

Can HVAC System Design and Operation Prevent COVID-19 Airborne Transmission?

- Filtration? **YES**
  - HVAC filters are designed to efficiently remove airborne particles from the air
  - High levels of PM may be vehicles for Covid transport
  - The higher the MERV rating the higher the filtration. (enVerid Side stream is MERV 11)
  - HEPA filters can probably eliminate all airborne viruses
- UV ? **YES**
  - UV is a proven technology that can effectively disinfect the air
  - Need to be properly designed, installed and maintained in concert with filtration and humidity control
- Increased Ventilation should lead to faster dilution of the indoor virus aerosols? **NO**
  - RH at 50% is strongly related to virus inactivation. Increasing ventilation will make it hard to keep the building at 50% RH.
  - Particulate matter (PM) can serve as a carrier for virus aerosols, therefore increasing ventilation will increase the PM and lead to an increase in the number of virus aerosols indoor.

Why Increased Ventilation is not a good approach

- Airborne COVID 19 survive much longer at RH <40% and RH >65%.
- HVAC systems maintain RH near 50% while maintaining comfortable temperature. **This is ideal for COVID-19 fast inactivation.**
- Increasing ventilation will undermine the ability to maintain RH near 50%, resulting in higher humidity when it is hot or rainy and lower humidity when it is cold and dry. **This can lead to a longer time in which the COVID-19 is viable and increase the probability of airborne transmission.**



Graph 2 Inactivation of SARS Coronavirus–Surrogate TGEV after 2 days, at different temperatures and humidities. Outdoor temp. 4°C, room temp. 20°C und desert temp. 40 °C. Fastest inactivation at all temperatures in intermediate humidity.

WHO Position on Airborne Transmission (March 27,2020)

enVerid
Energy savings. Air quality.

Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations

Scientific brief
27 March 2020

World Health Organization

Modes of transmission of virus causing COVID-19

According to current evidence, COVID-19 virus is transmitted between people through respiratory droplets and contact routes.[1-6]

Droplet transmission occurs when a person is in in close contact (within 1 m) with someone who has respiratory symptoms (e.g. coughing or sneezing,) and is therefore at risk of having his/her mucosae (mouth and nose) or conjunctiva (eyes) exposed to potentially infective respiratory droplets (which are generally considered to be > 5-10 μm in diameter). Droplet transmission may also occur through fomites in the immediate environment around the infected person.[7] Therefore, transmission of the COVID-19 virus can occur by direct contact with infected people and indirect contact with surfaces in the immediate environment or with objects used on the infected person (e.g. stethoscope or thermometer).

Airborne transmission is different from droplet transmission as it refers to the presence of microbes within droplet nuclei, which are generally considered to be particles < 5μm in diameter, and which result from the evaporation of larger droplets or exist within dust particles. They may remain in the air for long periods of time and be transmitted to others over distances greater than 1 m.

There is some evidence that COVID-19 infection may lead to intestinal infection and be present in faeces. However, to date only one study has cultured the COVID-19 virus from a single stool specimen.[8] There have been no reports of faecal−oral transmission of the COVID-19 virus to date.

Implications of recent findings of detection of COVID-19 virus from air sampling

To date, some scientific publications provide initial evidence on whether the COVID-19 virus can be detected in the air and thus, potentially involve airborne transmission. These initial findings need to be interpreted carefully.

A recent publication in the *New England Journal of Medicine* has evaluated virus persistence of the COVID-19 virus.[9] In this experimental study, aerosols were generated using a three-jet Collison nebulizer and fed into a Goldberg drum under controlled laboratory conditions. This is a high-powered machine that does not reflect normal human cough conditions. Further, the finding of COVID-19 virus in aerosol particles up to 3 hours does not reflect a clinical setting in which aerosol-generating procedures are performed—that is, this was an experimentally induced aerosol-generating procedure.

There are reports from settings where symptomatic COVID-19 patients have been admitted and in which no COVID-19 RNA was detected in air samples.[10-11] In addition, it is important to note that the detection of RNA in environmental samples based on PCR-based assays is not indicative of viable virus that could be transmissible.

In the context of COVID-19, airborne transmission may be possible in specific circumstances and settings in which procedures that generate aerosols are performed (i.e. endotracheal intubation, bronchoscopy, open suctioning, administration of nebulized treatment, manual ventilation before intubation, turning the patient to the prone position, disconnecting the patient from the ventilator, non-invasive positive-pressure ventilation, tracheostomy, and cardiopulmonary resuscitation).

In analysis of 75,465 COVID-19 cases in China, airborne transmission was not reported.

IAQP Impact

Comparison Outside Air Requirements

ASHRAE Standard 62.1-2016

Method	Office
VRP (CFM)	**2,125**
DCV (CFM) - # People = 80	2,000
DCV (CFM) - # People = 50	1,812
DCV (CFM) - # People = 20	1,625
IAQP (CFM)	**652**
Design Outside Air Savings (CFM)	1,473

Case Study – Typical Office Building LCCA- VAV

LCCA - VAV			
	VAV RTU (non-ERV)	VAV RTU with ERV	VAV RTU with enVerid
Energy Consumption (10^3 kWh/yr)	571	464.9	445.8
Utility Rates $/kWh	0.13	0.13	0.13
Annual Energy Cost	$74,230	$60,437	$57,954
Annual Energy Savings $	**Baseline**	**$13,793**	**$16,276**
Equipment Cost $ (RTUs and enVerid)	$150,000	$160,000	$150,000
Add'l Maintenance Cost ($/yr)	Baseline	$4,000	$2,500
Payback Time (yr)	**Baseline**	**1.0**	**0.2**
Lifespan (yr)	20	20	20
Life Cycle Energy Savings	Baseline	$205,205	$242,146
Total Life Cycle Cost	$1,254,355	$1,118,660	$1,049,403
TLCC Savings	**Baseline**	**$135,695**	**$204,952**

Notes: 1. A 3% inflation rates has been considered.
2. Life Cycle Energy Savings have been calculated to present value.

SPECTRUM

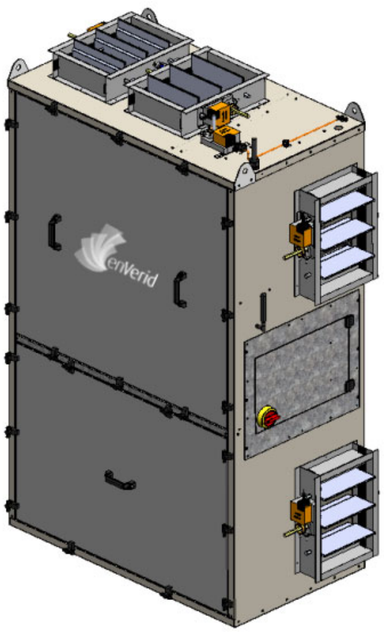
Case Study: 100 Sheppard Ave East, Toronto

enVerid
Energy savings. Air quality.

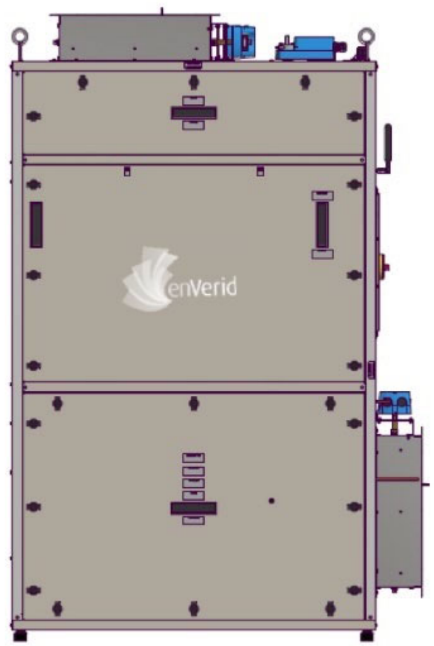
- Benefits
  - 60% OA Reduction
  - Estimated ~18 ton equivalent reduction in cooling load
  - Estimated ~368 MBH heating load reduction

Zone	Area (FT^2)	Occupancy	VRP Outside Air (CFM)	VRP Steady State CO_2 Concentration (ppm)	Min Exhaust / Pressurization Requirement (CFM)*	IAQP Design Outside Air (CFM)	Number of HLR 1000	OA Reduction (CFM)	IAQP Steady State CO2 Concentration (ppm)
Floor 1	23,328	237	2,566	1,407	1,043	1,043	1	1,523	Equivalent to VRP

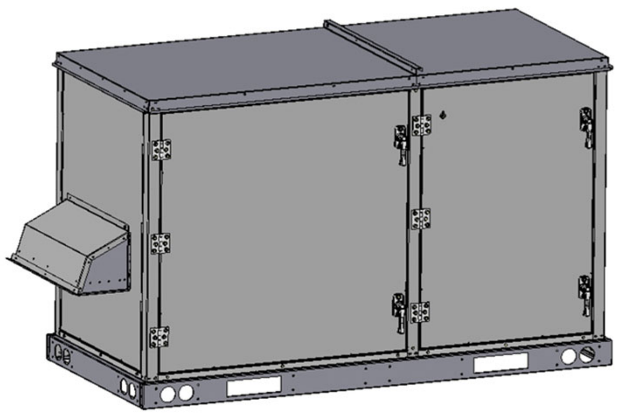
The HLR® family (indoor and outdoor units)



HLR 14M

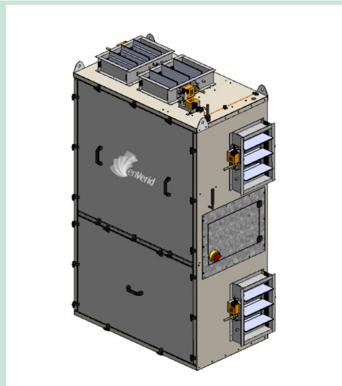
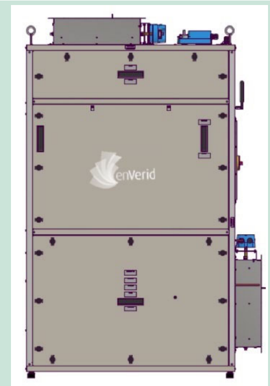
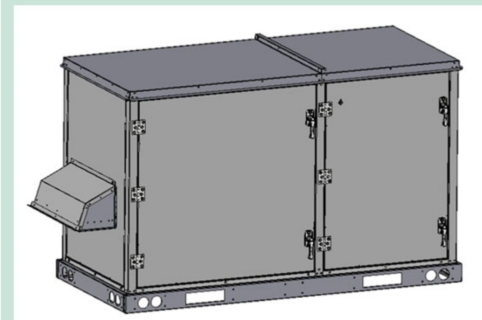


HLR 15M



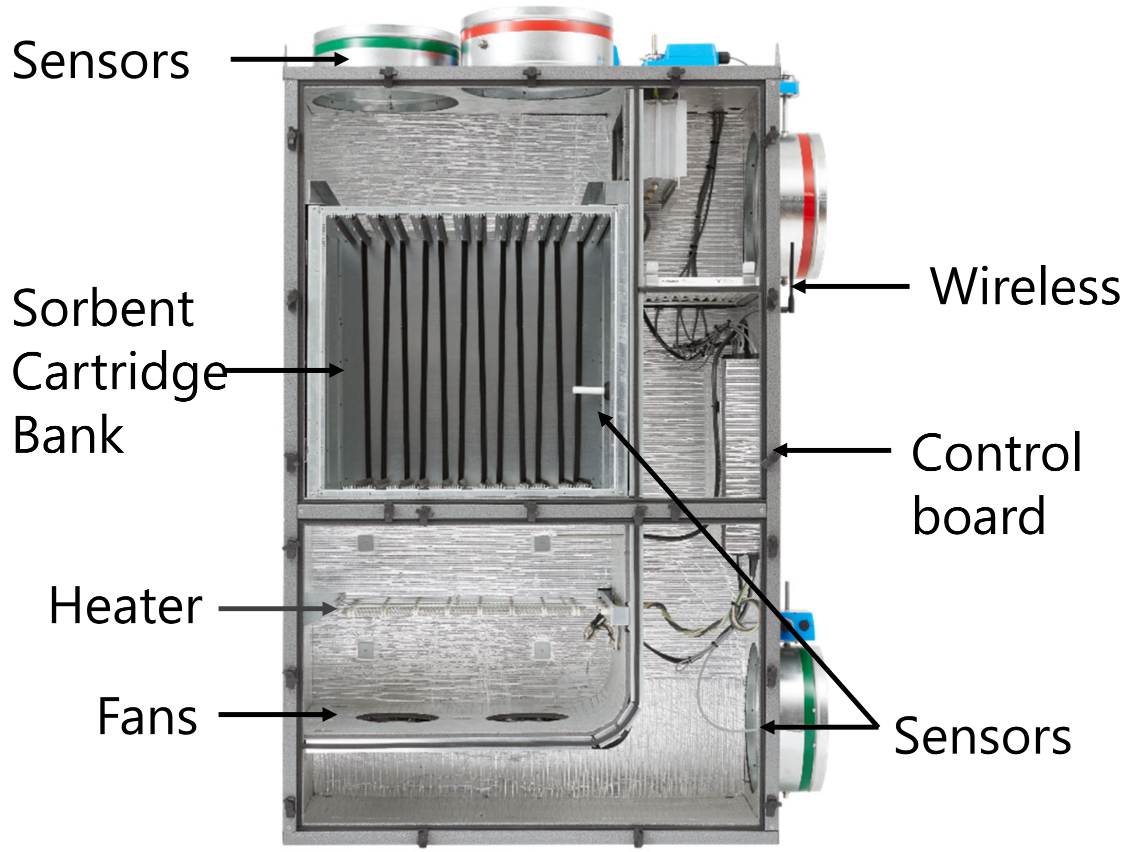
HLR 15R

The HLR® family (indoor and outdoor units)

	14M	15M	15R
			
Application:	Indoors	Indoors	Outdoors
Application Notes:	Ducted Return Air	Plenum	Rooftop
Qty. of Inlet Dampers:	2	1	1

14M, 15M, and 15R all have the same air cleaning capacity, fans, and heater.

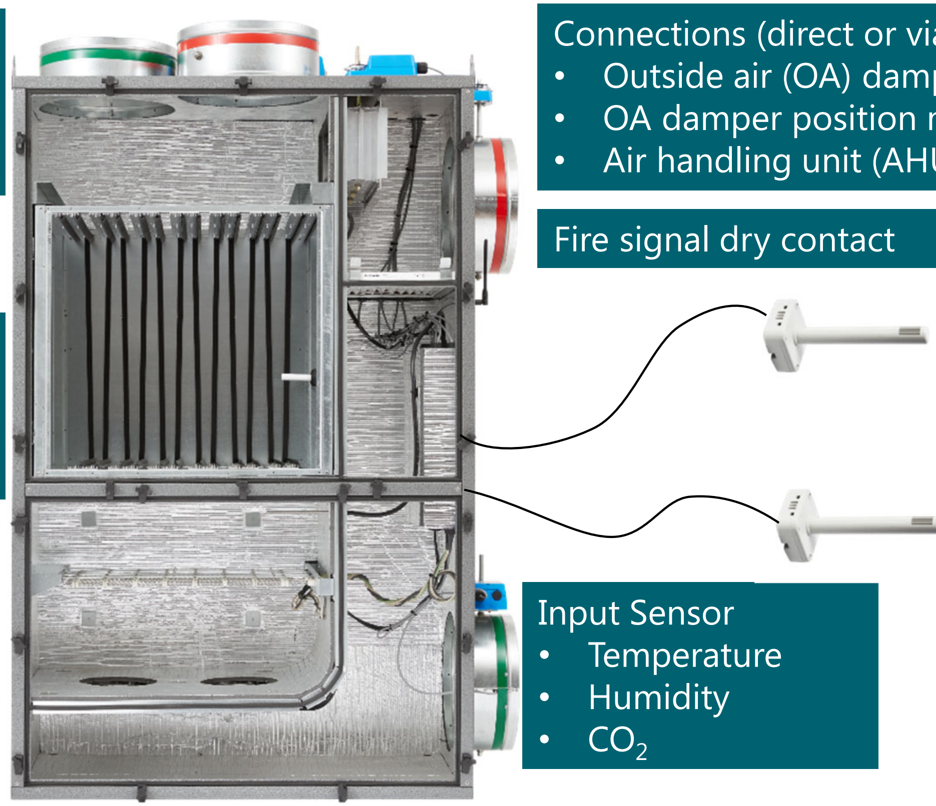
What's Inside



Comprehensive Sensing

Output Sensor
- Temperature
- Humidity
- CO_2

Cartridge Bank Sensor
- Temperature
- Pressure



Connections (direct or via BMS):
- Outside air (OA) damper control
- OA damper position monitoring
- Air handling unit (AHU) status

Fire signal dry contact

Outside duct sensor (optional)
- Temperature
- Humidity

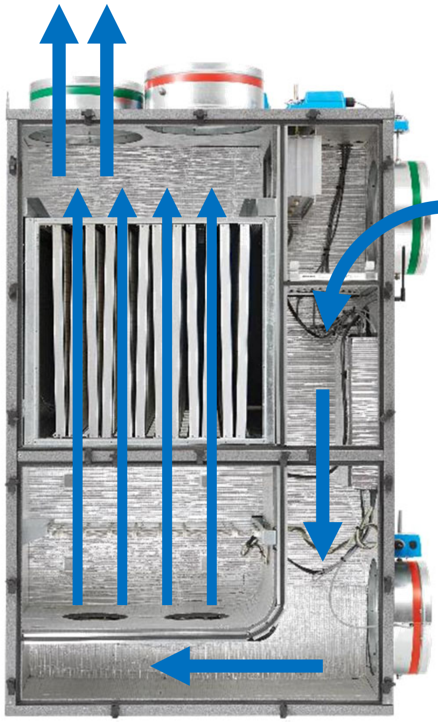
AHU Supply duct sensor (optional)
- Temperature
- Humidity
- TVOC

Input Sensor
- Temperature
- Humidity
- CO_2

Note: BACnet integration to BMS eliminates need for optional sensors & connections

Advanced algorithms use sensor data to optimize energy savings & IAQ

Air Cleaning Mode

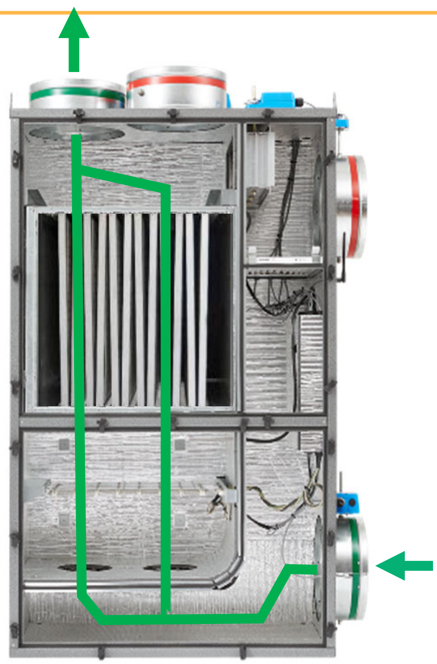


Captures:

- Carbon Dioxide
- VOCs
- Formaldehyde
- Ozone
- Acids

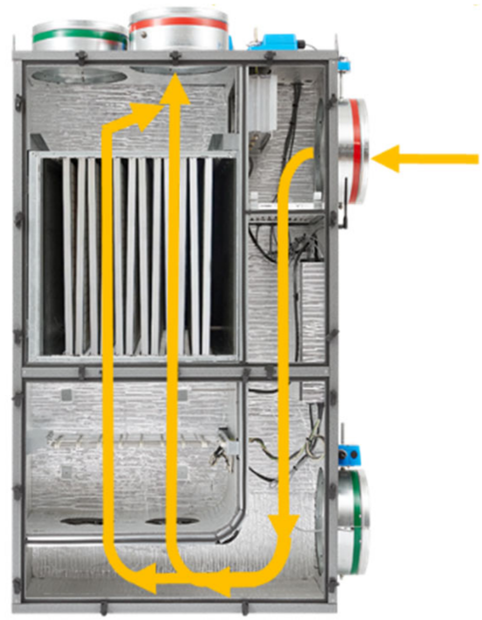
Zero by-products

How the HLR works: An in-situ regenerating scrubber



Adsorption

(cleaning indoor air)



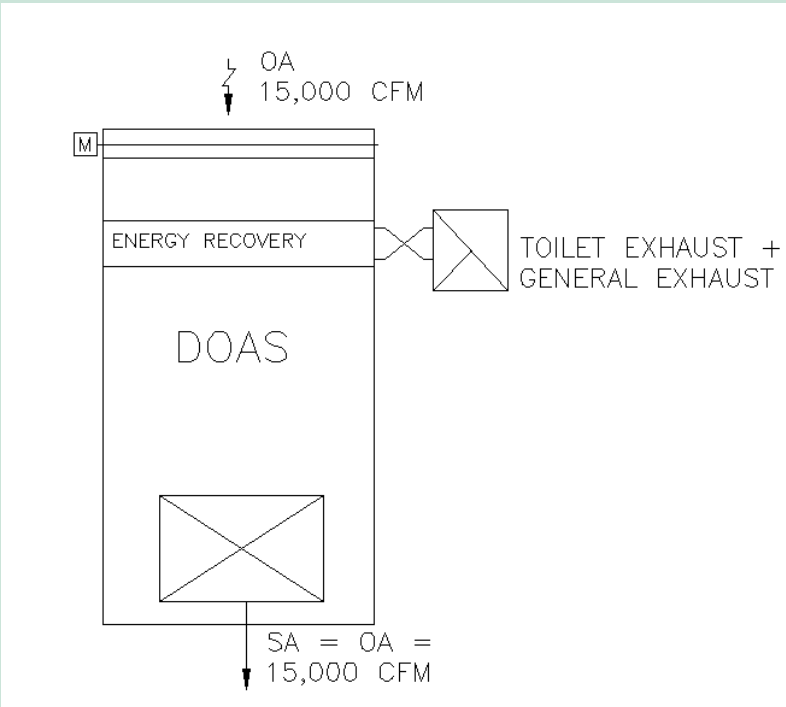
Regeneration part

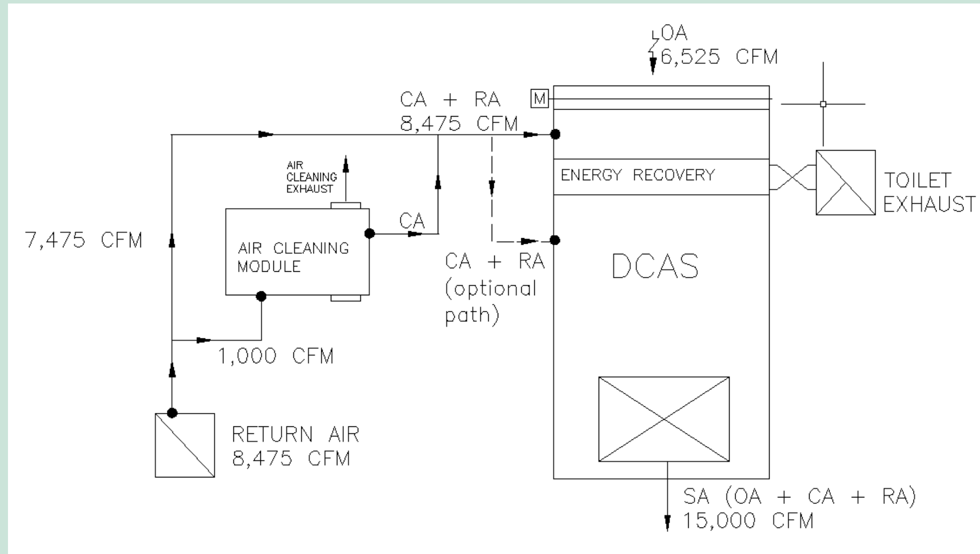
(heating/purge/exhaust)

The Building

Integration With Air-Side Systems

Proposed Building Design: No Air Cleaning	**Proposed Building Design: With Air Cleaning**



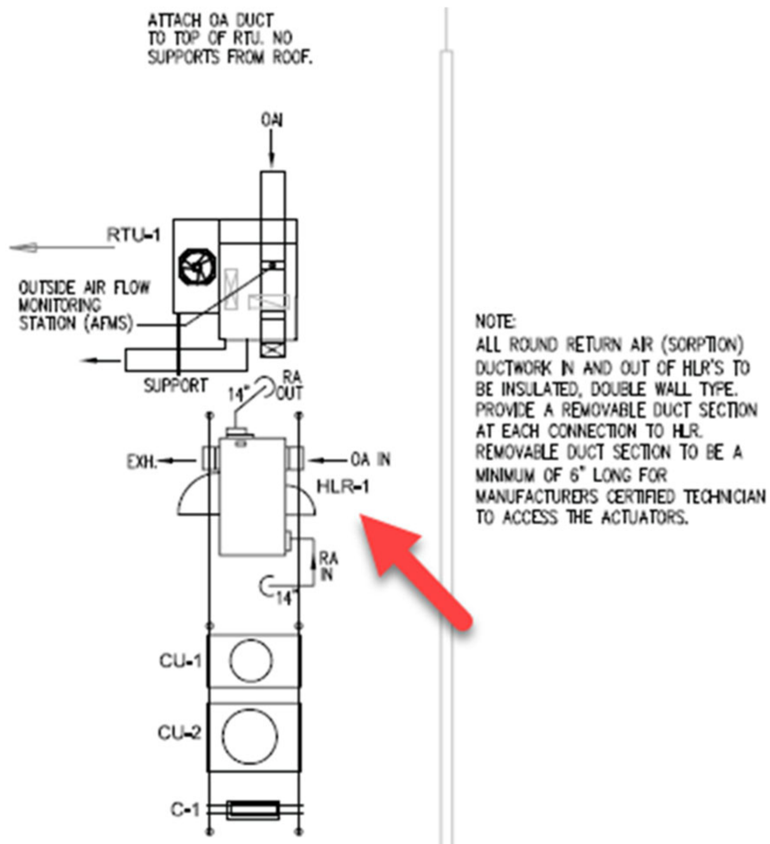


- Return air cleaned by air cleaning module is returned to the DOAS – essentially making it an RTU.
- Integration resulted in total outside air requirement of 13,050 CFM (6,525 CFM per DOAS).

SA = Supply Air; RA = Return Air; OA = Outside Air; CA = Clean Air

enVerid Free Support

- Fully comprehensive IOM available to exclusive partners
  - -Device Specifications
  - -Engineering Specs & Setpoints
  - -Startup and Operation Procedure
- Local Support
  - -Rep & enVerid employees
- FREE Resources:
  - -Engineering
  - -Troubleshooting
  - -Manufacturing



ASHRAE: Compliance and Support

- Enverid provides ASHRAE and LEED compliance reports on OA reduction

1. ***Objective***
   The objective of this report is to document the compliance of enVerid System's HVAC Load Reduction (HLR) installation with ASHRAE Standard 62.1-2016 Indoor Air Quality Procedure (IAQP; Section 6.3, pages 17-18). This document summarizes the indoor air quality (IAQ) compliance calculation results using the HLR system. Appendix A provides a description of the proposed solution and Appendix B shows the Design Approach.

2. ***Project***
   The x Building, located in x, consists of 8 floors with mainly office spaces. The total area conditioned by HLRs is 118,854 ft². The scope of this project consists of 7 HLR-1000 units, 1 HLR per floor, from floors 2 through
   8. A summary of inputs and outputs are showing in the tables below.

TYPE OF BUILDING	OFFICE	
AREA (SQUARE FOOTAGE)	118,854	Floors 2 to 8, office space
NUMBER OF FLOORS	7	Floors 2 to 8, office space
NUMBER OF PEOPLE	594	Assuming 5 people / 1000 ft²
VRP CONVENTIONAL DESIGN OUTSIDE AIR (CFM)	26,250	VRP
IAQP HLR DESIGN OUTSIDE AIR (CFM)	16,450	e-mail 9/17/17
EXHAUST (CFM)	16,450	e-mail 9/17/17
OUTSIDE AIR REDUCED (CFM)	9,800	From IAQP calculations
NUMBER OF HLR 1000E	7	7 HLR 1000E
NUMBER OF AHUS		Not specified

Appendix B: IAQP Design Approach

ASHRAE Standard 62.1 - 2016 Section 6.3 Indoor Air Quality (IAQ) Procedure

Space Breathing Zone Contaminant Concentration

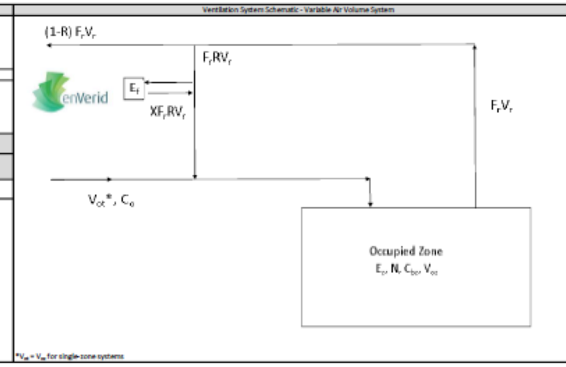
$$C_{bz} = \frac{N + E_z \times V_{oz} \times C_o}{E_z \times (V_{oz} + X \times F_r \times R \times V_r \times E_f)}$$

Required Zone Outdoor Airflow

$$V_{oz} = \frac{N - E_z \times X \times F_r \times R \times V_r \times E_f \times C_{bz}}{E_z \times (C_{bz} - C_o)}$$

Area (ft²)	118,854	Number of people	594
# of HLRs	7	outside air CFM required	16,450

Symbol or Subscript	Definition
V	volumetric flow (CFM)
C	contaminant concentration (μg/m³)
E_z	zone air distribution effectiveness
E_f	HLR efficiency (%)
X	cleaning flow factor
F_r	design flow reduction factor
N	contaminant generation rate or strength (μg/hr)
R	recirculation flow factor
Subscript: o	outdoor
Subscript: r	return
Subscript: b	breathing
Subscript: z	zone



Contaminant of Concern	Common Contaminant Source	Contaminant Strength	Contaminant Strength Reference	Air Cleaning Efficiency (E_f)	Air Cleaning Efficiency (Reference)	Contaminant Target Concentration: Limit	Exposure Period	Cognizant Authority Reference	Percieved IAQ	Design Approach
1,4-DCB	personal care products	1435 ug/h	(Wu et al., 2011)	65%	RTI International	800.0 μg/m³	Chronic	CA OEHHA	>80%	Mass Balance Analysis (6.3.4.1)
2-butoxyethanol	solvents; paints and coatings; strippers and thinners; hydraulic fluid; heavy duty cleaners/degreasers; soaps; pesticides	79391 ug/h	(Wu et al., 2011)	60%	RTI International	966.2 μg/m³	Chronic	ATSDR MRL	>80%	Mass Balance Analysis (6.3.4.1)
acetaldehyde	fossil fuels, building materials, paints and coatings	192681 ug/h	(Wu et al., 2011; Hodgson and Levin, 2003)	70%	RTI International	140.0 μg/m³	Chronic	LEED IAQP	>80%	Mass Balance Analysis (6.3.4.1)
acetone	personal care, especially nail care; cleaners; paints and coatings; strippers and thinners; PVC cleaner; cements; caulks and adhesives; rubber; wood filler; solvent	416280 ug/h	(Wu et al., 2011; Hodgson et al., 2012)	70%	RTI International	3087.9 μg/m³	Chronic	ATSDR MRL	>80%	Mass Balance Analysis (6.3.4.1)
benzaldehyde	cosmetics, soap	16784 ug/h	(Wu et al., 2011)	65%	RTI International	9.6 μg/m³	Chronic	ATSDR MRL	>80%	Mass Balance Analysis (6.3.4.1)

LEED Pilot Credit EQpc124

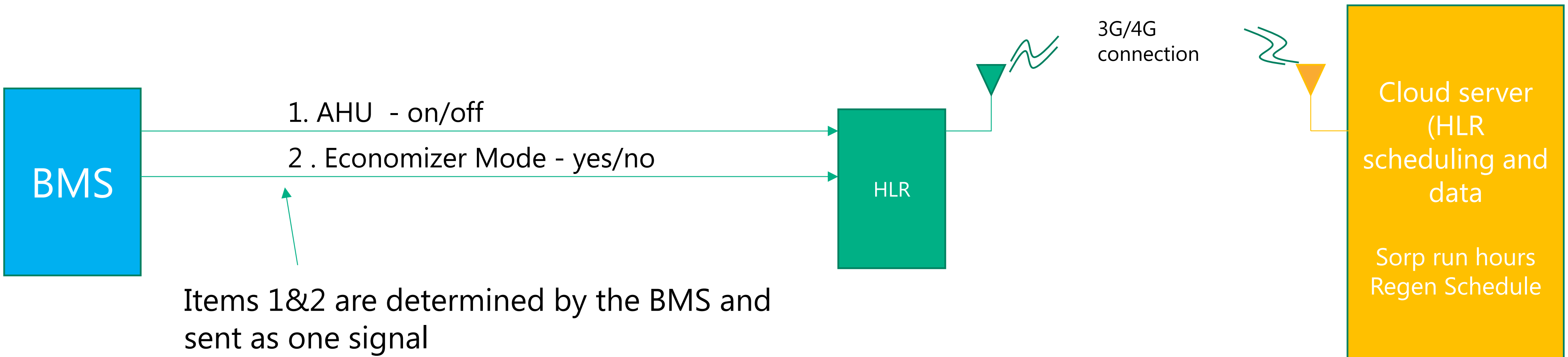
- Minimum IAQ Performance: Must follow ASHRAE 62.1 Ventilation Rate Procedure (VRP):
  - VRP is a prescriptive approach: highly conservative ventilation rates (over ventilation)
  - Studies shows that following the VRP does not necessarily lead to a better indoor air quality*
  - IAQP now included
- New LEED Pilot Credit **EQpc124**: (IAQP)
  - To provide energy savings and better indoor air quality
  - Loosely follows ASHRAE 62.1 IAQP
    - Based on actual contaminants of concern
    - More health focused
    - Includes new construction as well as existing buildings

**Bluyssen et al.1996;, Carpenter 1996; Enermodal 1995; Persily et al. 2003; Chao & Hu 2004; Jeong et al. 2010; Mui & Chan 2006; Herberger & Ulmer 2012; Zaatari et al. 2014, etc.*

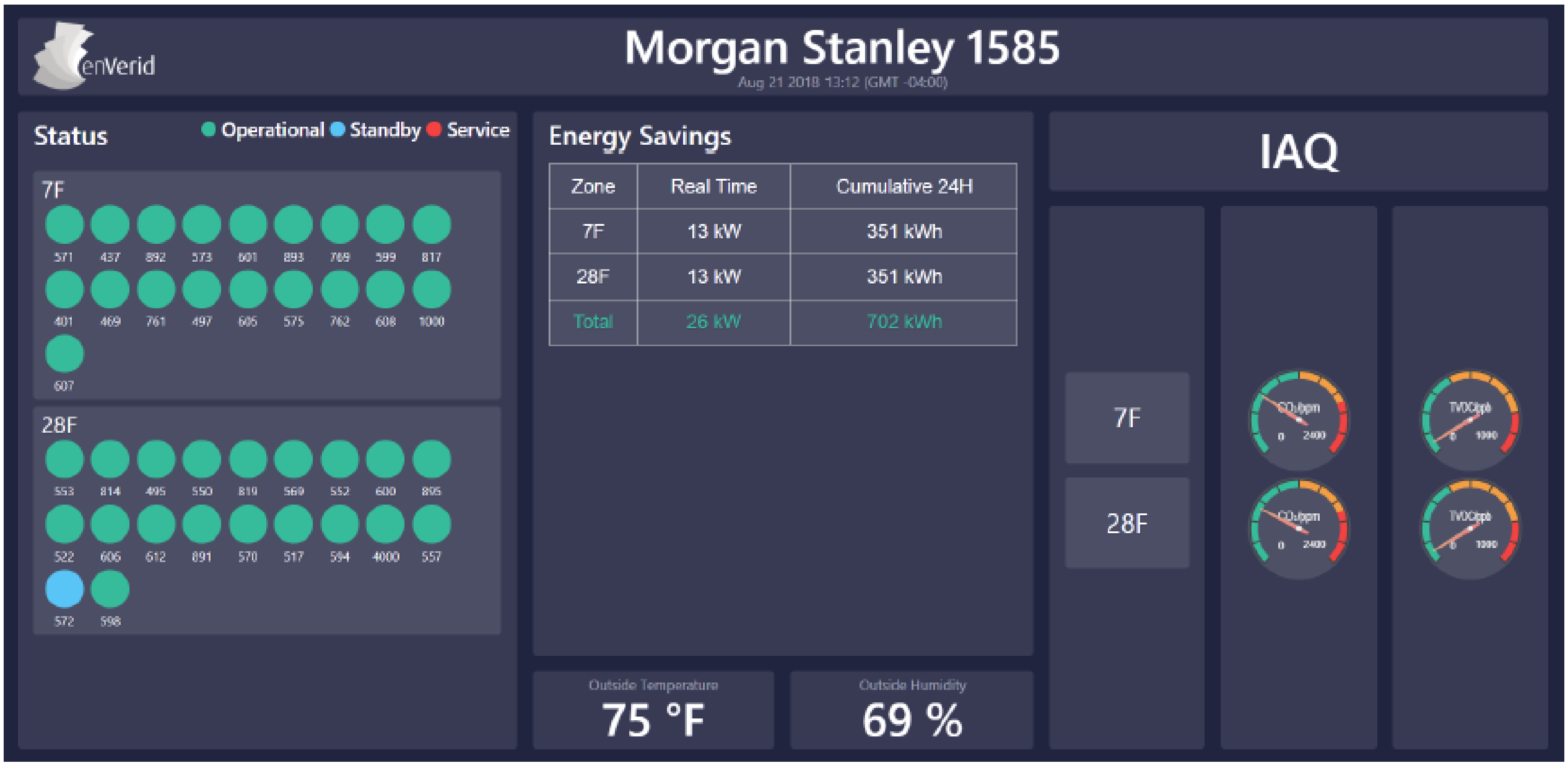
HLR® Technology

enVerid
Energy savings. Air quality.

Generic Diagram – BMS/HLR/Cloud server connections



enVerid Cloud: 24/7 Monitoring and Management of IAQ



Know the quality of the air inside the building anytime, anywhere

Case Study: NYC Skyscraper installation, 40 HLR Modules

IAQP Modeling Results

- 40 HLR modules
- Design OA = 190,000 CFM
- OA when HLR is ON = 70,000 CFM
- OA reduction = 120,000 CFM

Summary Results

Previous

Ventilation Zone 1 **Office buildings**

Square Footage	1346148
Occupancy	6863

	# HLRs	IAQP Outside Air (m3/hr)	Outside Air Reduced ((m3/hr)	% Outside Air Reduction
Option 1	**40.00**	**99781**	**204000**	**63%**

Option 1

COC	Voa m3/hr	Indoor Emissions	Selected Limit Standard
1,4-DCB	Not a COC	0.13 ug/m².h (Wu et al., 2011)	CA OEHHA (800.0 µg/m³)
2-butoxyethanol	Not a COC	7.19 ug/m².h (Wu et al., 2011)	ATSDR MRL (966.2 µg/m³)
acetaldehyde	Not a COC	17.45 ug/m².h (Wu et al., 2011; Hodgson and Levin, 2003)	LEED IAQP (140.0 µg/m³)
acetone	Not a COC	37.70 ug/m².h (Wu et al., 2011; Hodgson et al., 2012)	ATSDR MRL (3087.9 µg/m³)
benzene	Not a COC	0.21 ug/m².h (Wu et al., 2011)	CA OEHHA REL (110.0 µg/m³)
carbon tet.	Not a COC	0.31 ug/m².h (Wu et al., 2011)	ATSDR MRL (188.7 µg/m³)
chloroform	Not a COC	0.10 ug/m².h (Wu et al., 2011)	CA OEHHA; LEED IAQP (300.0 µg/m³)
CO2	87987	22500000.00 ug/ppl.hr (ASHRAE Standard 62.1-2013)	LEED IAQP (1100ppm) (2131800.0 µg/m³)
decanal	Not a COC	16.00 ug/m².h (Wu et al., 2011)	EU-LCI value (920.3 µg/m³)
diethylphthalate	Not a COC	0.58 ug/m².h (Wu et al., 2011)	ATSDR: NIOSH; OSHA (5000.0 µg/m³)
d-limonene	Not a COC	11.30 ug/m².h (Wu et al., 2011)	IARC guideline (150000.0 µg/m³)
ethylbenzene	Not a COC	0.77 ug/m².h (Wu et al., 2011; Hodgson et al., 2012)	CA OEHHA; LEED IAQP (2000.0 µg/m³)
formaldehyde	99781	37.50 ug/m².h (Wu et al., 2011; Hodgson and Levin, 2003)	CARB; LEED IAQP (33.0 µg/m³)
hexanal	Not a COC	6.39 ug/m².h (Wu et al., 2011)	EU-LCI value (920.3 µg/m³)
methylene chloride	Not a COC	1.18 ug/m².h (Wu et al., 2011)	CA OEHHA REL (400.0 µg/m³)
naphthalene	Not a COC	0.38 ug/m².h (Wu et al., 2011)	ATSDR MRL (3.7 µg/m³)
n-hexane	Not a COC	1.35 ug/m².h (Wu et al., 2011)	CA OEHHA REL; LEED IAQP (7000.0 µg/m³)
nonanal	Not a COC	8.57 ug/m².h (Wu et al., 2011)	EU-LCI value (920.3 µg/m³)
octanal	Not a COC	2.93 ug/m².h (Wu et al., 2011)	EU-LCI value (920.3 µg/m³)
PCE	Not a COC	0.14 ug/m².h (Wu et al., 2011)	ATSDR MRL (272.1 µg/m³)
phenol	Not a COC	6.25 ug/m².h (Wu et al., 2011)	CA OEHHA REL; LEED IAQP (200.0 µg/m³)
PM2.5	Not a COC	6.00 ug/m².h (Wu et al., 2011)	NAAQS, LEED IAQP (15.0 µg/m³)
styrene	Not a COC	1.06 ug/m².h (Wu et al., 2011)	ATSDR MRL (851.1 µg/m³)
TCE	Not a COC	0.12 ug/m².h (Wu et al., 2011)	ATSDR MRL (537.6 µg/m³)
toluene	Not a COC	5.55 ug/m².h (Wu et al., 2011; Hodgson and Levin, 2003; Hodgson et al., 2012)	China Code GBT 18883 Hong Kong IAQ Guideline - Good Class (200.0 µg/m³)
α-terpineol	Not a COC	0.40 ug/m².h (Wu et al., 2011)	µg/m³)

Conestoga College Kitchener Market Square

CONESTOGA
Connect Life and Learning

enVerid
Energy savings. Air quality.

- Rep: Odell Associates

Per the IAQP calculations, it is recommended to install **(6)** HLR 1000E-15 modules. This results in a **65%** reduction (~16,000 CFM) in minimum outside air flow. A summary of inputs and outputs for the IAQP calculations is provided in the table below.

Area (square footage)	75,225	Measured per provided plans [TM-LL.3.1, TM-LL.3.2, TM-LL.3.3, TM-UL.3.1]
Number of people	1,000	Provided in email 8/1/19.
Primary Building Use	Classrooms	Provided in email 8/1/19.
Baseline Outside Airflow Requirement (CFM)	25,369	Calculated per ASHRAE 62.1 – Ventilation Rate Procedure. Assumes 1,000 occupants and classroom space type.
Existing Outside Airflow (CFM)	~9,000	Calculated per ASHRAE 62.1 – Ventilation Rate Procedure. Assumes 250 occupants and office space type.
System Ventilation Efficiency	0.75	Assumed.
IAQP + Air Cleaning Outside Airflow (CFM)	8,985	Calculated per ASHRAE 62.1 – Indoor Air Quality Procedure
Outside air reduced (CFM)	16,384	= Baseline - IAQP
Number of HLR 1000E	6	HLR 1000E-15 modules

Kitchener-Waterloo

Conestoga College campus coming to Kitchener Market Square

HLR® Applications

The Target Application

High occupancy, low exhaust

- Office buildings: High rise, or medium/large low rise
- Colleges / universities / libraries
- Malls, big box stores
- Common areas/Conference rooms
- Green / LEED buildings

Generally not good candidates:

- Hotel guestrooms, Hospitals (ASHRAE 170), Kitchens

Use Cases

1. New construction
2. HVAC replacement / upgrade
3. Delay replacement of aging HVAC system
4. Simplify tenant finish-out
5. *Accommodate increased occupant density*
6. Avoid DOAS/ERV replacement
7. Energy retrofit
8. IAQ retrofit

Understanding Cooling Loads

LOAD W/O ERV

- Cooling Equipment Size = 115 tons

LOAD W/ERV

- Cooling Equipment Size = 100 tons

LOAD W/enVerid

- Cooling Equipment Size = 95 Tons

Summary of HLR Technology Benefits

enVerid
Energy savings. Air quality.

HLR

Reduce HVAC CapEx and OpEx

- ✓ $20K – 40K CapEx Savings
- ✓ $3K – 10K Annual OpEx Savings
- ✓ Utility rebates provide additional savings

Proven Technology

- ✓ 10 years of successful deployments
- ✓ ASHRAE and USGBC compliance
- ✓ Validate by DoE & utilities

Intelligent Indoor Air Quality Management (24/7)

- ✓ Active, dynamic management
- ✓ Anytime, anywhere visibility

Great for the Environment

- ✓ Up to 16 LEED points

Occupant satisfaction & productivity

- ✓ $6500/employee productivity increase
- ✓ Healthy, less absenteeism