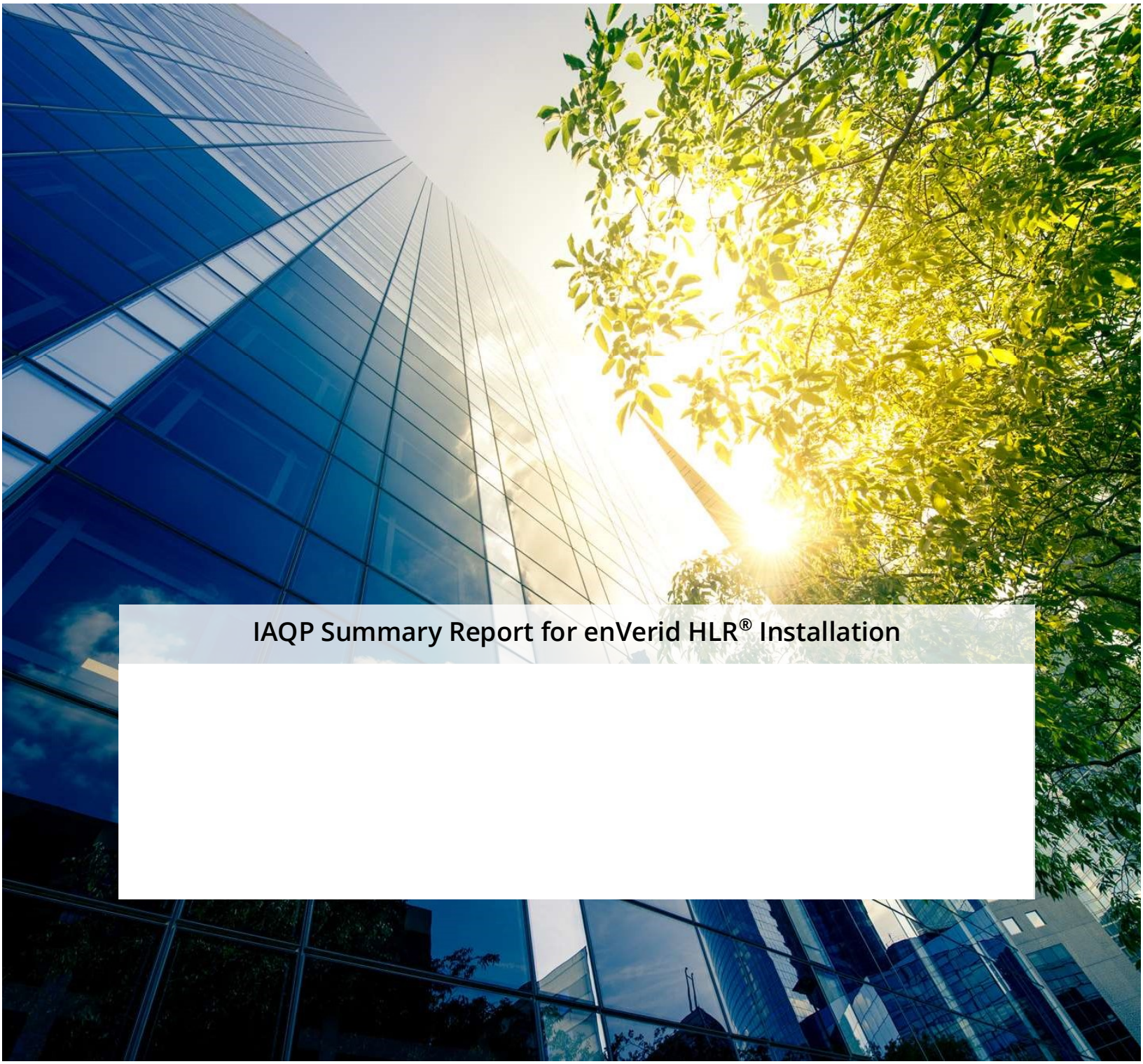


IAQP Summary Report for enVerid HLR® Installation

enVerid's leading products deliver energy savings while providing healthier indoor air quality (IAQ). Our expertise is in chemistry, indoor air quality, electronics, software and systems.

Objective

The objective of this report is to provide recommendations that optimize indoor air quality an HVAC energy performance through the use of HLR Technology. The recommendations were developed in compliance with ASHRAE 62.1-2016 Indoor Air Quality Procedure (IAQP), International Mechanical Code, and Ontario Mechanical Code.

Appendix A provides an overview of HLR Technology.

IAQP Calculation Results

Per the IAQP calculations, it is recommended to install **(1)** HLR Module This results in **51%** reduction (~2,000 CFM) in minimum outside air flow. A summary of inputs and outputs for th IAQP calculations is provided in Table 1 below.

Table 1 - IAQP Summary - Whole Building

Building Type	**Office**	Per "Zone&Space Layout.jpg"
Floor Area (ft^2)	**24,84**	Per "62.1 Ventilation Calculations.pdf"
Occupancy	**260**	Per "62.1 Ventilation Calculations.pdf"
Baseline Minimum Outside Airflow (CFM)	**3,655**	Per "62.1 Ventilation Calculations.pdf"
System Efficiency (%)	**0.80**	Per "62.1 Ventilation Calculations.pdf
IAQP Minimum Outside Airflow (CFM)	**1,800**	Per ASHRAE 62.1 IAQP Calculations
Outside airflow reduced (CFM)	**1,855**	= [VRP – IAQP]
Number of HLR Modules	**1**	Per ASHRAE 62.1 IAQP Calculations

Note that the proposed number of HLR modules can be optimized (increased or decreased) pending further discussion on project goals specific to indoor air quality, pressurization requirements, capital costs / budget, and available space in mechanical rooms / rooftops.

Capital Savings / Load Reduction

The proposed solution results in a new design minimum outside airflow. Designing towards this reduced outside airflow can have a systemic effect on the HVAC design and can allow for the following cost saving measures:

1. Reduce overall load on central heating and cooling equipment.
2. Reduce overall capacity of cooling and heating coils inside HVAC equipment.
3. Downsize or eliminate energy recovery systems.
4. Eliminate demand control ventilation / CO_2 sensors, if applicable
5. Downsize outside air intakes and respective ductwork.
6. Downsize or eliminate general-exhaust fans.
7. Leverage the use of existing base building ventilation systems in lieu of installing new ventilation systems.

Design Integration

HLR modules can be easily integrated with the air handling units. Refer to the *HLR Technology Design Guide* (provided electronically).

Project specific integration sketches and proposed layout of HLR modules in mechanical rooms can be provided upon further request.

Additional Considerations

1. LEED points via pilot credit *EQpc124* (6 points available) + additional points from energy cost savings via Optimize Energy Performance credit (up to 6 avai Up to **12 points** total.
    a. LEED cost savings associated with not having to pursue the following credits when complying with EQpc124:
        i. Enhanced Indoor Air Quality Strategies,
        ii. Indoor Air Quality Assessment,
        iii. Construction IAQ Management Plan,
        iv. Low Emitting Materials
    b. The above analysis may be refined to align with LEED pc124 requirements.

2. Annual operational / energy cost savings (in dollars) can be determined based on expected buildin operating hours, occupancy profiles, energy utility rates, energy modeling results, and several other parameters not covered in this report.

3. Utility rebate incentives may be available to offset first costs of HLR modules.

Appendix A: HLR Technology Overview

The HLR unit is a smart scrubber with unique air cleaning and sensing capabilities. It includes patented CO_2, formaldehyde, and volatile organic compound (VOC) sorbents housed in proprietary cartridges; a heating element for regeneration; two small fans for regeneration and sorption; and a set of sensors measuring temperature, relative humidity, carbon dioxide, and volatile organic compounds of return, supply, treated, and regenerated air. The HLR system interprets the output of these sensors using control algorithms to actively and automatically manage the outside air, HVAC load, and indoor air quality. Figure 1 compares conventional air handling to HLR system air handling. As shown in the figure on the right, during normal operation, a fraction of the return airstream is directed through the sorbent cartridges to remove contaminants of concern. The sorbent cartridges automatically regenerate, releasing the captured contaminants and performing a self-cleaning process. During the regeneration cycle, the HLR system is blocked from the building's air systems, and warm air is blown over the cartridges and exhausted into the ambient air via the building's existing restroom exhaust ducts.

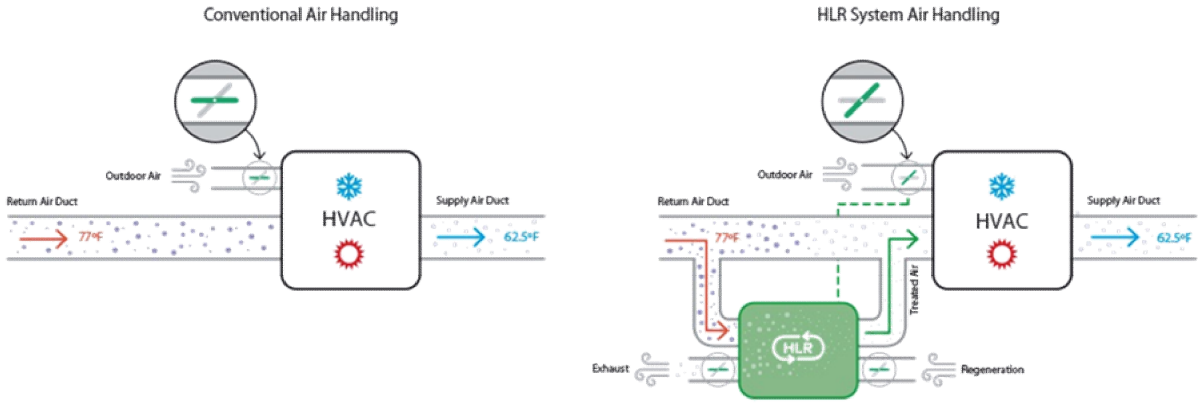


Figure 1 - HLR Technology

3rd Floor

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

Space Breathing Zone Contaminant Concentration

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

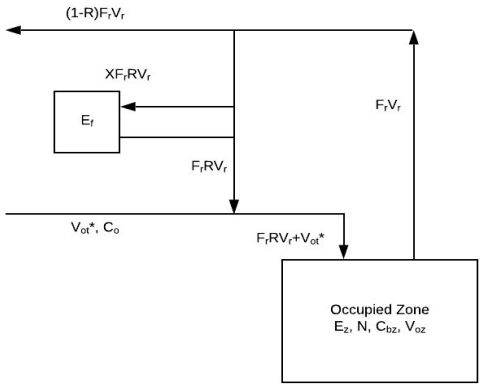
Required Zone Outdoor Airflow

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

Area (ft^2)	24,842	Number of people	260
# of HLRs	1	outside air CFM required	1,578

Symbol or Subscript	Definition
V	volumetric flow (CFM)
C	contaminant concentration ($\mu g/m^3$)
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

Ventilation System Schematic - Variable Air Volume System



*$V_{ot} = V_{oz}$ for single-zone systems

General Notes	
Air Cleaning Efficiency References:	**Hygieia Sciences** for CO2, **RTI International** for all other contaminants
Percentage of satsified Building Occupants:	>80% of occupants
Design Approach:	Steady State Mass Balance Analysis

Contaminant of Concern	CAS Number	Contaminant Strength (N)	Contaminant Strength Reference	Air Cleaning Efficiency (E_f)	Contaminant Target Concentration			Contaminant Compliance
					Limit (C_{bz})	Exposure Period	Cognizant Authority Reference	
Acetaldehyde	75-70-0	40273 µg/h	(Wu et al., 2011; Hodgson and Levin, 2003)	55%	140 $\mu g/m^3$	Chronic	LEED IAQP	✓
Acetone	67-64-1	87008 µg/h	(Wu et al., 2011; Hodgson et al., 2012)	55%	1200 $\mu g/m^3$	Chronic	ATSDR MRL	✓
Benzene	71-43-2	485 µg/h	(Wu et al., 2011)	87%	3 $\mu g/m^3$	8-hr	CA OEHHA REL	✓
CO_2	124-38-9	6873984000 µg/h	(ASHRAE Standard 62.1-2013)	57%	1200 ppm	Chronic	LEED IAQP	✓
Dichloromethane	75-09-2	2723 µg/h	(Wu et al., 2011)	55%	400 $\mu g/m^3$	Chronic	CA OEHHA REL	✓
Formaldehyde	50-00-0	86546 µg/h	(Wu et al., 2011; Hodgson and Levin, 2003)	55%	33 $\mu g/m^3$	Acute	CARB; LEED IAQP	✓
Naphthalene	91-20-3	877 µg/h	(Wu et al., 2011)	70%	9 $\mu g/m^3$	Chronic	ATSDR MRL	✓
Phenol	108-95-2	14424 µg/h	(Wu et al., 2011)	77%	10 $\mu g/m^3$	Chronic	CA OEHHA REL; LEED IAQP	✓
PM2.5	-	13847 µg/h	(Wu et al., 2011)	75%	12 $\mu g/m^3$		NAAQS	✓
Tetrachloroethylene (PCE)	127-18-4	323 µg/h	(Wu et al., 2011)	55%	35 $\mu g/m^3$	Chronic	ATSDR MRL	✓
Toluene	108-88-3	12809 µg/h	(Wu et al., 2011; Hodgson and Levin, 2003)	52%	300 $\mu g/m^3$	1-hr	CA OEHHA REL; LEED IAQP	✓
Trichloroethane (TCE)	71-55-6	277 µg/h	(Wu et al., 2011)	55%	1000 $\mu g/m^3$	Intermediate	ATSDR MRL	✓
Xylene, total	108-83-3, 95-47-6, and 106-42-3	0 ug/h	(Wu et al., 2011)	60%	500 $\mu g/m^3$	Chronic	NAAQS, LEED IAQP	✓
Ozone	10028-15-6	only applicable in case of a source or outdoor source		70%	70 ppb		NAAQS	✓
Carbon monoxide	630-08-0	only applicable in case of a source or outdoor source		57%	9 ppm		NAAQS	✓

System Checksums

3rd Floor

Multiple-Zone Recirculating System

Design System Population	260
Population Diversity	1.00
Number of Zones	33
Primary Air Flow:	5,482
Number of HLRs:	1
IAQP Outdoor Intake:	1,800
Steady-State CO2 Concentration (ppm)	1,500

Zone Design IAQP Outside Air

Zone Name	Zone Number	Occupancy Category	Zone Floor Area Az [ft2]	Zone Population Pz [people]	Zone Air Distribution Effectiveness Ez	Primary Zone Airflow Vpz [CFM]	Zone IAQP OA Vou [CFM]
Work Area 1	1	Office space	1312	8	0.8	223	73
Work Area 2	2	Office space	2430	18	0.8	442	145
Work Area 3	3	Office space	2535	18	0.8	454	149
Work Area 4	4	Office space	1275	8	0.8	218	72
Work Area 5	5	Office space	1430	13	0.8	283	93
Work Area 6	6	Office space	1640	16	0.8	335	110
Work Area 7	7	Office space	1095	12	0.8	236	77
Work Area 8	8	Office space	1435	13	0.8	283	93
Work Area 9	9	Office space	5255	40	0.8	966	317
Common Area	10	Breakrooms	1470	8	0.8	406	133
Offices	11	Office space	110	3	0.8	41	13
Offices	12	Office space	110	3	0.8	41	13
Offices	13	Office space	145	6	0.8	73	24
Offices	14	Office space	360	7	0.8	106	35
Offices	15	Office space	110	2	0.8	31	10
Meeting Room	16	Office space	130	4	0.8	52	17
Electrical Room	17	Occupiable storage rooms for dry	200	0	0.8	23	8
Washroom	18	Breakrooms	280	3	0.8	91	30
Janitor's Closet	19	Occupiable storage rooms for dry	45	0	0.8	5	2
Offices	20	Office space	245	6	0.8	84	28
Meeting Room	21	Office space	385	10	0.8	137	45
Offices	22	Office space	330	6	0.8	93	31
Washroom	23	Breakrooms	325	3	0.8	101	33
Offices	24	Office space	355	8	0.8	115	38
Offices	25	Office space	245	6	0.8	84	28
Offices	26	Office space	110	3	0.8	41	13
Offices	27	Office space	110	3	0.8	41	13
Offices	28	Office space	220	5	0.8	72	24
Meeting Room	29	Office space	385	10	0.8	137	45
Offices	30	Office space	230	6	0.8	82	27
Meeting Room	31	Office space	375	10	0.8	136	45
Janitor's Closet	32	Occupiable storage rooms for dry	45	0	0.8	5	2
Washroom	33	Breakrooms	115	2	0.8	45	15
Totals			24842	260		5482	1800