

Confidential Real Estate Company

High-rise Office Tower



About the Real Estate Company

Founded in 1982, the company is comprised of a leading nationwide chain of income-producing properties (predominantly offices and shopping malls), infrastructure services and financial services. Known for its use of highly advanced construction technology, the company owns a total leasable area of approximately 10 million ft² with approximately 5 million ft² under construction.

The Challenge

The real estate company owns an iconic high-rise building in the heart of a major city, and wanted to decrease the energy consumption of its HVAC system while improving comfort at the same time. The air handling units (AHU) have a constant flow of outside air to ventilate the building. High energy consumption is required to condition the air in this seaside climate, with hot, humid summers. Improving energy efficiency, particularly during summer days, was a key driver as electricity costs are more than double during these peak demand hours.



Figure 1: The 50-story skyscraper has a shopping center on the first 10 floors, 38 office floors, and an observation deck at the top.

The Building

This 50-story building has 38 floors of Class A office space on top of 10 floors of shopping and restaurants. Construction was completed in the late '90s, with a modern architectural style.

The tower's perimeter is over 450 feet, with each floor having a little more than 16,000 ft², bringing the building total to over 800,000 ft².

Customer: Real Estate Company

ASHRAE Climate Zone: 2a

Deployed: June 2014

Industry: Commercial Real Estate, Shopping Malls, Banking, Energy

Annual Revenue: \$2.35 billion (Year Ended December 31, 2015)

Challenges: Reduce HVAC energy expenses across 38 office floors in iconic high-rise building and maintain excellent indoor air quality (IAQ).

Solution: 38 enVerid HLR modules – one installed on each office floor – to scrub air of contaminants and reduce the amount of outside air ventilation required. Also, added Variable Speed Drives (VSD) to the AHU outside air intake fans.

Results:

- 557-ton reduction in HVAC cooling peak load
- 1.7 million kWh reduction in annual energy consumption compared to VRP
- 20% annual / 24% summer reduction in energy consumption
- 65% average reduction in outside air (using ASHRAE IAQP with HLR modules vs ASHRAE VRP)
- Maintained excellent IAQ
- Improved indoor air quality by reducing VOC and formaldehyde concentrations
- Eliminated complaints about indoor air quality and comfort
- Extended filter life

The Project

The project was led by enVerid Systems working together with the head of HVAC systems for the real estate company, whose participation and support were essential for all logistical and technical aspects of the installation.

The real estate company chose to start with a pilot deployment of one HLR module on the 48th floor, home to their executive offices. Once completed and verified, they would then implement the other thirty-seven office floors.

The kickoff began with a site survey by the enVerid team of the building mechanical layout, an indoor air quality (IAQ) assessment and identification of potential locations for integrating the HLR module into the existing HVAC system.

The outside air is supplied by the building’s four dedicated outside air systems (DOAS¹) shown in figure 2. Two DOAS are located on the roof of the building and two units are in the basement. Each unit can supply up to 50,000 CFM of treated outside air. The outside air from the four DOAS is distributed to the building floors through two shafts located in the center of the building.

The mechanical room on each floor receives outside air through openings in the shafts located at each side of the room. There are dampers on the AHU to control the volume of outside air supplied to the floor.

With HLR technology, less outside air volume is required, thereby reducing the number of outside air shafts required from two to one – a 35% reduction in area (see figure 2). With this change, the second shaft was reassigned to handle the exhaust from the HLR cartridges during the regeneration phase.

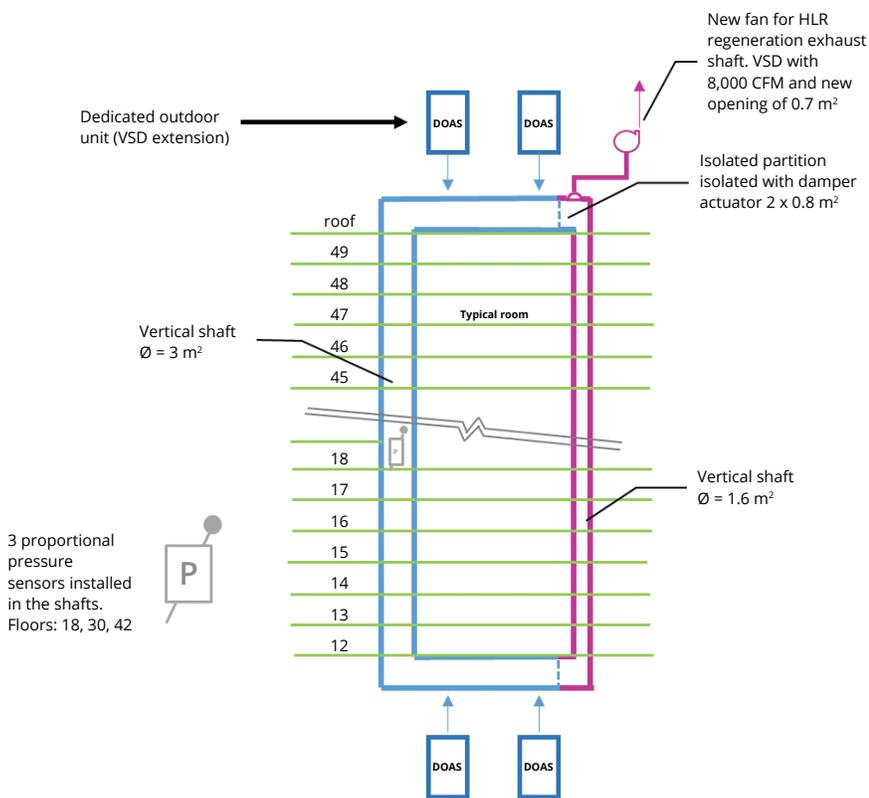


Figure 2: Outside air distribution with HLR module installed.

¹ DOAS is also known as an Outside Air Unit (OAU).



The prior year we had 164 complaints about air quality and comfort. With the HLR system our occupants are more comfortable, resulting in zero complaints about indoor air quality or comfort.

CEO

High-rise building complex

Air pollution is a concern for the tower as it's located by the highway and two of the DOAS are on the ground level, drawing in particulate matter (PM_{2.5}), carbon monoxide, and other hazardous chemicals from the traffic.

Air conditioning for each office floor is supplied by a central AHU, which delivers air to concealed VAV terminal boxes throughout the floor. The AHU on each office floor is rated at 27,000 CFM (the flow varies according to frequency control), regularly operating from 7:00 AM to 9:00 PM. It is supplied with chilled water and, without HLR technology, has a constant outside air flow representing about 20% of the total supply air.

Before shipping the HLR modules, the enVerid project team completed their assessment of the HVAC mechanical environments, provided a detailed installation plan and obtained the necessary permits. They developed an energy metering and monitoring plan, and collected and analyzed air samples for baseline indoor air quality. This information was shared with the facilities management team.

During the installation phase the enVerid project team selected and supervised all electrical and mechanical subcontractors with the customer's approval. Installation was completed without disruption in HVAC operations to building occupants.

An HLR module was installed in the AHU mechanical room (used as an air plenum – mixing return air and outdoor air) on each floor, beginning with the 48th floor (see figure 3).

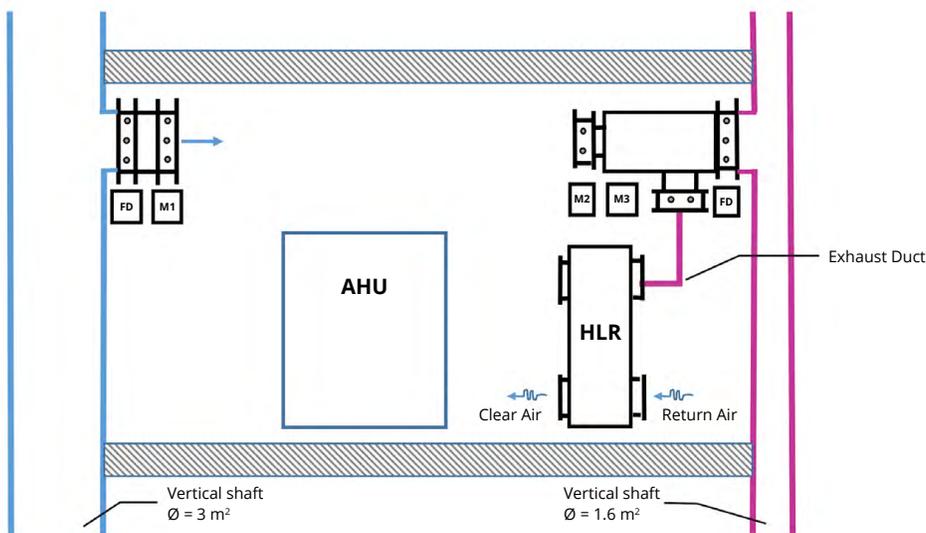


Figure 3: The HLR module continuously scrubs the air by pulling in air from the plenum and returning it to the plenum.

Installation included wireless Internet connectivity to feed air quality data into the enVerid Cloud for 24/7 monitoring. In addition, HLR modules support BACnet integration into the building management system (BMS). Beginning first with the 48th floor, then with the other thirty-seven office floors, each HLR module underwent its own acceptance test, and final acceptance tests for the building were completed after all units were tested individually.

Additionally, the enVerid project team continues to work with the company's Facilities Management team post-installation to optimize energy, IAQ and environmental comfort.



Having HLR modules on each floor allowed us to reduce outside air by 65%, and optimize climate control and energy efficiency by floor.

HVAC Director

The real estate company

Energy and Air Quality Measurements

Measurements for the 48th floor began on June 30, 2014 and were completed on August 1, 2014. Energy savings and air quality were confirmed, so the project was expanded to all 38 office floors and energy consumption was measured again in summer 2016.

Fifteen electrical meters (for the 11 chillers and 4 DOAS) were installed to monitor the actual electricity consumption. The electrical meters monitor instant energy, daily energy, monthly energy and total cumulative energy consumption. This allows for the most accurate determination of the cooling load and the commensurate energy consumption of the AHU.

Energy metering began prior to HLR module installation to accrue baseline performance of the HVAC system in its current “conventional” operating mode without the HLR modules. Once the HLR modules were installed, the meters were again used to track energy consumption so that a comparison could be done. Additionally, indoor temperature and humidity were monitored to ensure consistency across the measurement period.

For indoor air quality (IAQ), contaminant concentrations were measured prior to the HLR operation, then again after the HLR module had been installed and running for at least one week. IAQ monitoring was performed per US Environmental Protection Agency (EPA) standards and the results were analyzed and certified by an independent lab (PRISM Analytical Technologies).

This investigation included environmental and indoor air quality sampling of temperature, relative humidity, carbon dioxide (CO₂), 30 speciated (separated by species) volatile organic compounds (VOC) and total VOC, and formaldehyde. These include all the contaminants of concern found in office buildings. The investigation included sampling at different locations in the building. To prevent instrument-based discrepancies, enVerid calibrated and tracked the instruments used for each type of measurement, along with the manufacturer reported detection principle, resolution, and uncertainty.



We began the project by installing one enVerid HLR module on the 48th floor. The energy savings and indoor air quality were so compelling that we quickly moved forward to outfit all 38 office floors in the tower.

VP & Head of Offices

The real estate company

² Outside air reduced from 200,000 to 70,000 CFM.

The Impact

557-ton Peak HVAC Load Reduction

The HLR modules reduced peak HVAC load by 24%, or 557 tons on peak days with enthalpy of 41. This has enabled the building to run with fewer chillers in operation, and an upcoming renovation will only replace those chillers necessary, saving significant capital expense.

Reduced Energy Consumption by 1.7 million kWh per Year

Using the HLR modules and their indoor air cleaning capability, the company could take advantage of ASHRAE 62.1 Indoor Air Quality Procedure (IAQP) and use 65% less outside air² compared to using the ASHRAE 62.1 Ventilation Rate Procedure (VRP). The total energy saved in one year was calculated to be 1.7 million kWh. Savings were higher in the middle of the day during summer months when electricity tariffs are double.



HLR technology has reduced our annual energy consumption by 1.7 million kWh compared to using just outside air ventilation.

CEO

High-rise building complex

Month	Average Outdoor Enthalpy (2012-2015)	Outdoor minus Indoor Enthalpy	Chillers Energy Saving (kWh)	Heater Energy Saving (kWh)	OA fan savings minus HLR power consumption (kWh)	Total saving (kWh)	Average HVAC capacity load reduction
Jan	59.45	12.55		216,705	9,048	225,753	
Feb	60.08	11.92		205,827	9,048	214,875	
Mar	63.65	8.35		144,182	9,048	153,230	
Apr	27.49	-0.31	(5,853)		9,048	3,195	
May	31.09	3.29	62,179		9,048	71,227	159
June	35.03	7.23	136,655		9,048	145,703	349
July	37.98	10.18	192,308		9,048	201,356	491
Aug	39.36	11.56	218,378		9,048	227,426	557
Sep	36.57	8.77	165,729		9,048	174,777	423
Oct	33.31	5.51	104,111		9,048	113,159	266
Nov	28.35	0.55	10,334		9,048	19,382	26
Dec	62.28	9.72		167,839	9,048	176,887	
Total			883,840	734,553	108,576	1,726,969	

Figure 4: Monthly savings calculations based on 24 working days with average of 13 hours per day. Enthalpy averages per 2012-2015 Metrologic database.

Energy Consumption Reduced 24% in the Summer, and 20% Annually

When comparing energy consumption for the building with and without the HLR modules, energy savings during the summer was about 24% and roughly 20% annually. Figure 5 shows a sampling of daily measurements of energy consumption during the summer of 2016. The HLR modules were on most days but some days the HLR modules were purposely turned off to compare energy consumption. Figure 6 shows the difference in energy consumption between HLR On and Off, focusing on days when the outdoor enthalpy was similar and the chilled water temperatures were maintained at the same value.



A bonus of using HLR technology is that reducing outside air has resulted in additional savings on filters and maintenance.

HVAC Director
The real estate company

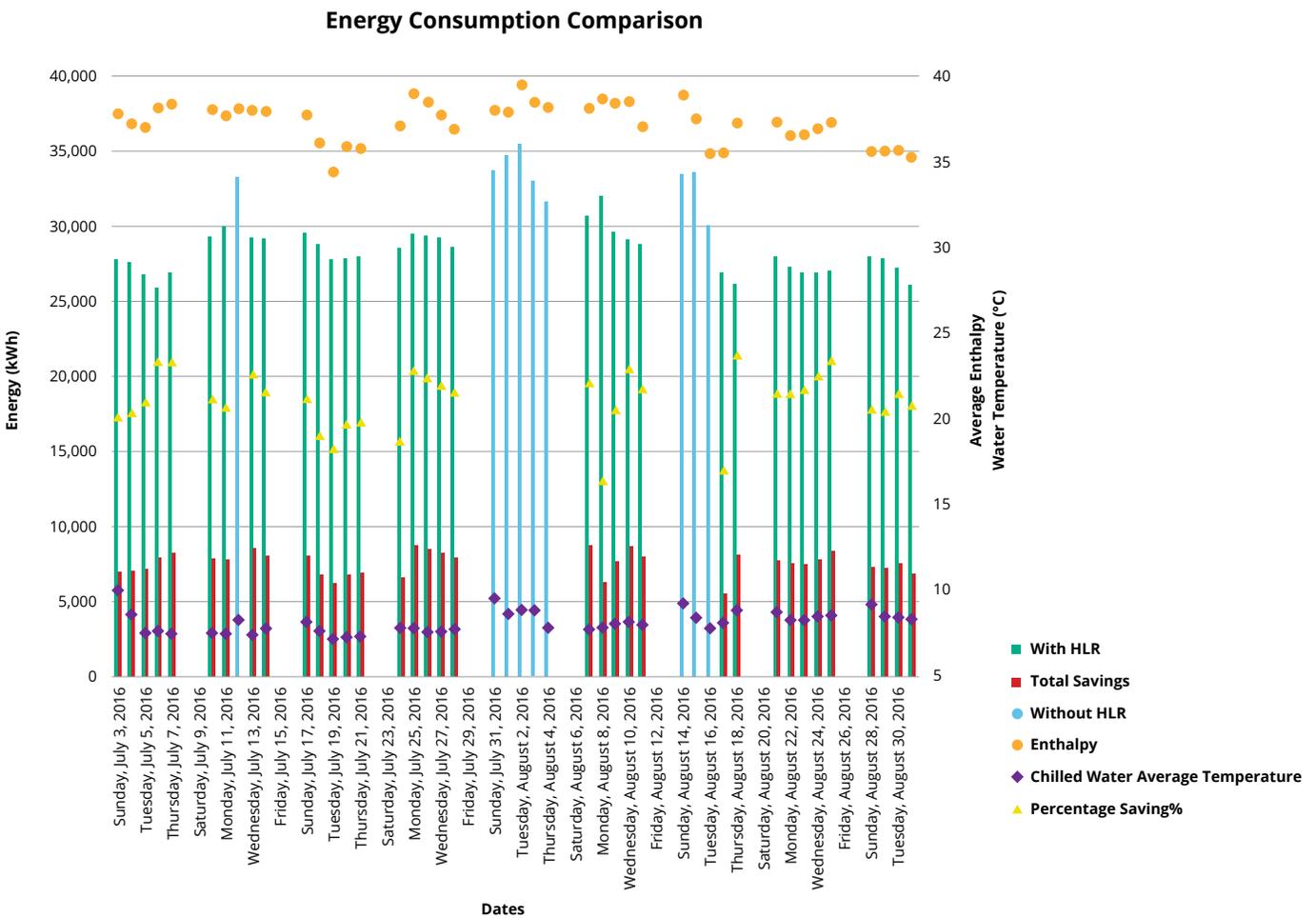


Figure 5: Daily electrical consumption comparison of with and without HLR system. Note: August 3-4 one DOAS was in maintenance.

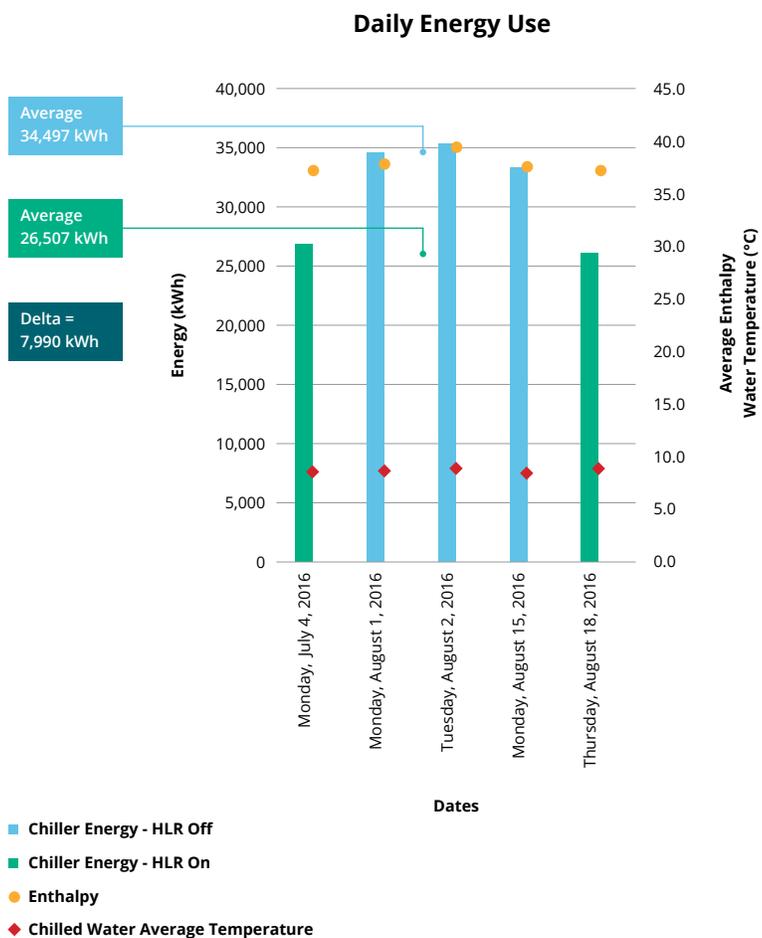


Figure 6: Detailed comparison of daily electrical consumption across days with similar enthalpy and similar indoor conditioning (based on chilled water temperature). The average savings is 23% for those days.

Maintained Excellent Indoor Air Quality

CO₂, Formaldehyde and VOC levels were kept well below target levels specified for excellent indoor air quality (see figures 7, 8 and 9).



Figure 7: HLR technology maintains CO₂ below 850 ppm, well below the 1,100 ppm target. Lower set points can be enabled which will adjust adsorption and regeneration time.

All contaminants of concern, including **CO₂, formaldehyde and VOC** concentrations are well below the guidelines set by ASHRAE and the USGBC when using the HLR modules.

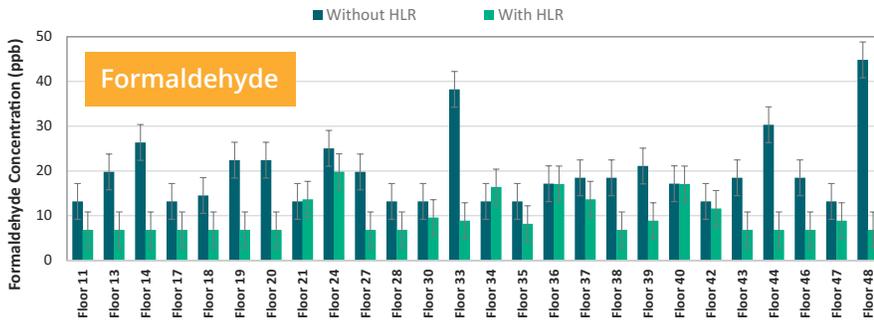


Figure 8: Formaldehyde concentrations are below the level established by CARB and adopted by the LEED IAQP Credit of 27 ppb. This was not always the case without the HLR technology.

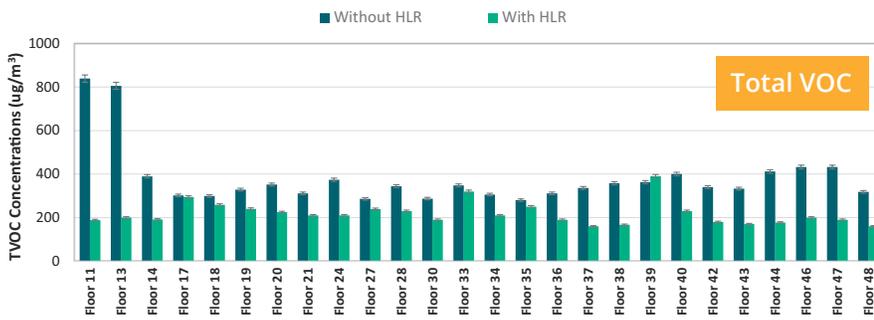


Figure 9: TVOC are well below the recommended level of 500 µg/m³ based on USGBC guidelines. This was not always the case without the HLR technology.



With HLR technology, we were no longer pushing the chillers to capacity. In fact, we now operate with fewer chillers and will not need to replace some of the aging systems.

HVAC Director
The real estate company

enVerid also tested samples of 30 individual speciated (separated by species) VOCs. The results, shown in figure 10 below, demonstrate the air scrubbing effect of the HLR technology.

VOC	CAS	Exposure Limit (µg/m³)	Measured Results (µg/m³)
Acetaldehyde	75-07-0	140	3.5
Acetic Acid	64-19-7	25,000	5
Acetone	67-64-1	590,000	5
Benzene	71-43-2	3	0.5
Benzothiazole	95-16-9	Exposure limit not established	17
Butane (C 4)	106-97-8	1,900,000	5
C6-C8 Hydrocarbon	N/A	1,800,000	2
C9-C11 Hydrocarbon	N/A	1,800,000	2
C10-C12 Hydrocarbon	N/A	1,800,000	4
C12-C14 Hydrocarbon	N/A	1,800,000	8
Carbon Tetrachloride	56-23-5	40	0.5
Ethanol	67-17-5	Exposure limit not established	9.5
Ethylbenzene	100-41-4	2,000	0.4
N-formylmorpholine	4394-85-8	98,000	15
Isoprene	78-79-5	Exposure limit not established	3
p-Isopropyltoluene	99-87-6	Exposure limit not established	0.5
Limonene	138-86-3 or 5989-27-5	150,000	12
2-Methylbutane	78-78-4	2,950,960	2
Methylene Chloride	75-09-2	400	0.2
m-tert-Butyl phenol	585-34-2	Exposure limit not established	4.5
Styrene	100-42-5	900	0.3
Tetrachloroethene	127-18-4	35	0.3
Tetradecane (C 14)	629-59-4	1,800,000	2
Toluene	108-88-3	300	3.8
1,2,4-Trimethylbenzene	95-36-3	125,000	0.4
Undecane (C 11)	1120-21-4	1,800,000	2
m,p-Xylene	108-38-3; 106-42-3	700	1.3
o-Xylene	95-47-6	700	0.5

Figure 10: Measured results of individual VOCs on are well below their established limits.



I highly recommend enVerid. The enVerid project team was professional and a pleasure to work with, and went beyond to identify other HVAC optimizations while they did the HLR project.

Chief M&E

The real estate company

Intelligent Indoor Air Quality Management

The HLR deployment was designed to limit CO₂ to 900 ppm and remove VOCs and formaldehyde, and does so on a per-floor basis. If there is a sudden, unexpected increase in occupant density on a floor, like with a special event, the HLR can detect this based on an increase in CO₂ levels. In response, if the HLR cleaning cannot maintain the target CO₂ levels, it can increase outside air for just that floor's AHU to maintain the desired air quality targets. Without the HLR, the existing HVAC system does not have this dynamic outside air ventilation capability. HLR modules also provide anytime, anywhere 24/7 IAQ monitoring using the enVerid Cloud.

Additional Savings:

- **Filters:** A 65% reduction in outside air can extend the lifetime of the outside air particulate filters.
- **Reduced Water Consumption:** Reduced water consumption was not measured specifically but can be a significant savings depending on both water and wastewater rates.
- **Reduced Corrosion:** A reduction in outside air intake reduces the introduction of saline latent outside air, providing several secondary benefits that include extending the useful life of the existing mechanical equipment and ductwork.

Conclusion

The real estate company is a multibillion-dollar corporation with a large portfolio of a commercial real estate, shopping malls, banking, and energy entities. One of their buildings, located in the heart of a major city, is a skyscraper with a shopping center at its base. Prior to enVerid, the air handling units (AHU) had a constant flow of untreated outside air to ventilate the 50-story building resulting in a high cost of energy consumption to cool (or heat) this outside air.

Faced with higher than desired energy costs and a commitment to high air quality and comfort, the company turned to enVerid for help. Installation of 38 HLR modules was completed on all the office floors without disrupting HVAC operations.

Results: Reduced HVAC capacity, Improved Energy Efficiency and Indoor Air Quality (IAQ)

- 557-ton reduction in HVAC cooling peak load
- 1.7 million kWh annual reduction in energy consumption compared to VRP
- 20% annual / 24% summer reduction in energy
- 65% average reduction in outside air (using ASHRAE IAQP with HLR technology vs ASHRAE VRP)
- Extended particulate filter life
- Reduced corrosion of equipment and ductwork
- No more occupant complaints - great indoor air quality and comfort



Compliance with ASHRAE 62.1

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enVerid Systems, Inc. is committed to improving energy efficiency and indoor air quality in buildings worldwide through its innovative HVAC Load Reduction® (HLR®) solutions. Awarded the prestigious 2016 R&D 100 Award, enVerid is the only solution that helps commercial, education and government buildings remove carbon dioxide (CO₂), aldehydes, volatile organic compounds (VOCs) and particulate matter (PM_{2.5}) from indoor air, reducing the outside air intake required for ventilation. enVerid's HLR technology is ASHRAE-compliant and has been recognized by the U.S. Department of Energy, the U.S. General Services Administration's Green Proving Ground Program, and the U.S. Green Building Council. For more information, please visit www.enverid.com.

