CASE STUDY

University of Miami

Patti and Allan Herbert Wellness Center

DRAFT

enVerid Systems, Inc.

About University of Miami

A private research university with more than 16,000 students from around the world, the University of Miami is a vibrant and diverse academic community focused on teaching and learning, the discovery of new knowledge, and service to the South Florida region and beyond.

28%
energy savings

The University comprises eleven schools and colleges serving undergraduate and graduate students in more than 180 majors and programs. In 2016, *U.S. News & World Report* ranked University of Miami No. 44 among the top national universities in the country in its "Best Colleges" listings. *U.S. News* also cites several of its programs in "America's Best Graduate Schools.

University of Miami is committed to safeguarding the environment, and in 2005 created the "Green U" initiative to become a community leader in the acquisition of environmentally responsible products and the practice of ecologically sound maintenance and operations procedures.

The Building

Designed to be one of the finest centers in the nation for recreational sports, fitness, and wellness education programs, the Patti and Allan Herbert Wellness Center affirms the University of Miami's commitment to a well-rounded educational environment. Located at the University of Miami Miller School of Medicine in downtown Miami, this 13-story building opened in January 1996 and was expanded in 2011. The Wellness Center occupies the top two stories and spans 60,000 ft^2.

Figure 1: The Wellness Center occupies 60,000 square feet on the top two stories above a parking garage and operates from 6 a.m. to midnight on most days.

Figure 2: The University of Miami's Wellness Center is a state-of-the-art fitness facility.

UNIVERSITY OF MIAMI

Location: Miami, Florida

Enrollment: 16,000 students

Challenge: Poor indoor air quality and high HVAC energy consumption at state-of-the-art university fitness center

Solution: enVerid HLRs installed on each floor of 60,000 ft^2 wellness facility to scrub air of contaminants and reduce the amount of outside air ventilation required.

Outcomes:

- ***28% average reduction in total HVAC energy consumption****
- ***41% peak HVAC capacity reduction****
- ***75% average reduction in outside air***
- Better indoor comfort: Relative humidity decreased 10% and air temperature reduced 2.5 ^{0}C
- Improved air quality: Reduced TVOCs to 780 µg/m^3, formaldehyde to 32 µg/m^3, CO_2 to 753 ppm, and reduced particulate matter from the neighboring highway.

*Energy savings would have been higher if indoor temperature and humidity had been kept constant when HLR was On vs Off. Outcomes measured during summer.

More than 12 million individuals have walked through the Wellness Center doors since it's opening 20 years ago. Each day, approximately 2,500 people take advantage of the facilities.

The center includes a 15,000 ft^2 fitness floor with over 100 pieces of state-of-the-art cardio and strength equipment, four group fitness instructional classrooms including a dedicated studio cycling room, pool, indoor courts, restaurant and instructional kitchen.

The building is connected to the neighboring clinical research building by a walkway on the 12th floor. The first 11 stories of the building are a parking facility and were therefore out of scope for this project.

Air quality is an important aspect of health and was therefore a priority to the Wellness Center. In addition, the university has a strong commitment to the environment and energy efficiency is a priority.

The Challenge

The indoor air quality (IAQ) was not at the level the facilities management team desired. Fitness centers not only generate a lot of carbon dioxide (CO_2) from people exercising, but the equipment and mats can off-gas volatile organic compounds and formaldehyde. Using increased outside air ventilation to improve the air quality inside was attempted, but it made it difficult for the HVAC systems to maintain a comfortable indoor temperature and humidity. Further, the energy consumption of the HVAC equipment was already quite high and adding more hot, humid outside air ventilation would cause a significant increase in utility costs. Finally, increased outside air ventilation would result in an increase in fine particulate matter coming from the neighboring highway.

The Project

The center is served by four air handling units (AHUs) and a pool dehumidification system. The AHUs are connected to a central chilled water system that serves the medical campus. The scope of this HVAC Load Reduction (HLR®) installation excluded AHU-1 and the pool area since this area requires special handling and is served by a separate AHU.

In June 2015, enVerid and Johnson Controls installed three of enVerid's HLR modules in the mechanical rooms serving the Wellness Center.

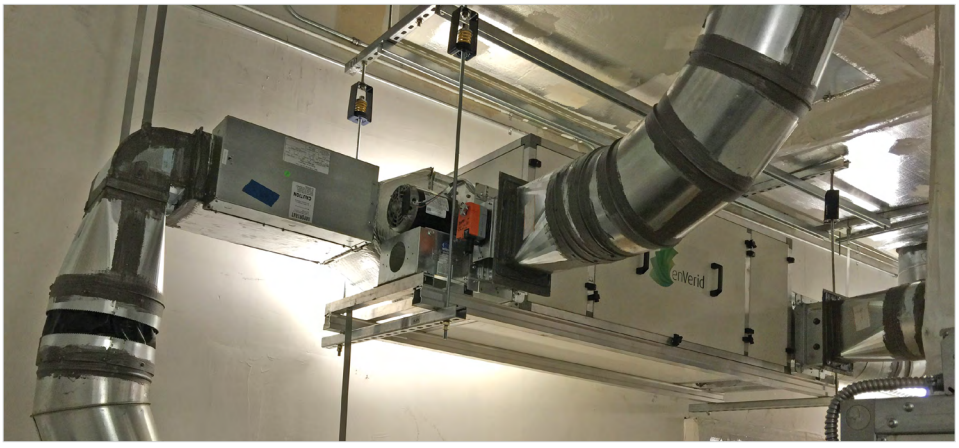

Figure 3: HLR installed at the University of Miami

> **Marcelo Bezos, Director of Energy Management Systems, University of Miami:** We consider our facilities management processes best-in-class. When we identified issues at the Wellness Center, we immediately looked for a solution that addressed both air quality and energy efficiency simultaneously. HLR technology was the only real choice, and gives the added benefit of future reductions in HVAC capital expenditures.

The project was led by enVerid Systems along with three facilities management leaders from the university: Ron Bogue, Vice President for Facilities and Services, and his staff including, Marcelo Bezos, Director of Energy Management Systems, and Carl Thomason, Energy Manager. In addition, the National Renewable Energy Lab (NREL) was contracted to perform independent measurement and verification (M&V) of energy savings and indoor air quality (IAQ).

Before shipping the HLRs, the enVerid project team assessed the HVAC mechanical environments, provided a detailed installation plan and obtained necessary permits. They developed an energy metering and monitoring plan, and collected and analyzed air samples for baseline indoor air quality.

In the installation phase, the enVerid project team selected and supervised electrical and mechanical subcontractors with the customer's approval. Installation was completed with no disruption in HVAC service to building occupants.

Installation included wireless Internet connectivity to feed air quality data into the enVerid Internet-of-Things (IoT) cloud-based platform for 7x24 monitoring. Each HLR underwent its own acceptance test, and final acceptance tests for the building were completed after all units were tested individually. Finally, an air test and balance was conducted by a third party, Air Balance and Diagnostic Company, to measure and adjust the outside air delivered to each zone.

The three HLR units went live on July 2015. Each HLR unit includes patented sorbents housed in proprietary cartridges that adsorb CO_2, formaldehyde and volatile organic compounds (VOC). The HLR also has a set of sensors measuring temperature, relative humidity, CO_2 and volatile organic compounds. The HLR system interprets the output of these sensors using control algorithms to actively and automatically manage indoor air quality and outside air volumes.

> **Carl Thomason, Energy Manager, University of Miami:** We wanted to improve the indoor air quality at the Wellness Center, as well as reduce total energy consumption. Given that other air cleaning products like bi-polar ionization are not ASHRAE-compliant, we decided to use HLR technology. enVerid has been great to work with, and we plan to do more deployments of their HLR modules.

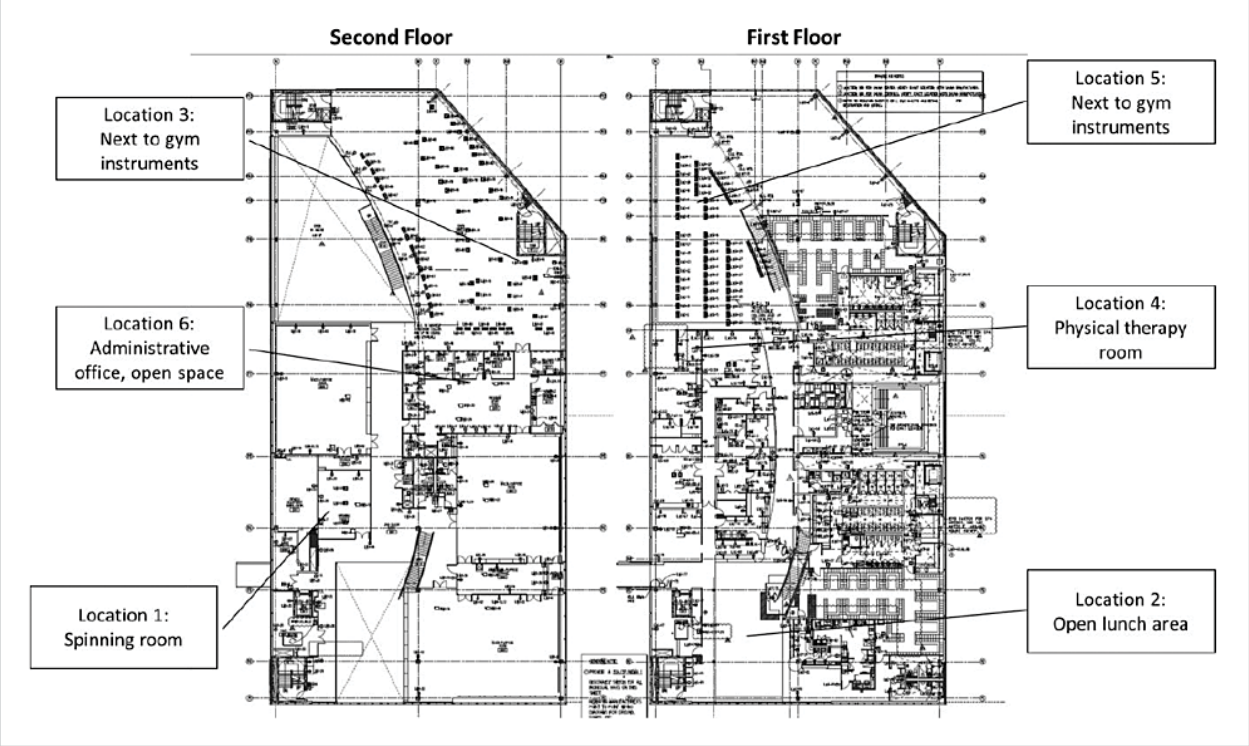

Figure 4: First and second floor layouts, with air quality testing locations identified.

The Energy and Air Quality Measurement Methods

The National Renewable Energy Lab (NREL) validated and confirmed the energy savings of the HLR. Energy consumption of the HVAC system was measured, day by day, to compare days with the HLR operating versus when the HLR was off.

Measurements started on July 11, 2015 and were completed on September 5, 2015. Energy consumption was measured using an energy meter installed by the building facility management. Chilled water consumption and outdoor conditions were also monitored.

When the HLR was in use, outside air volume was reduced by 75%. The HLR OFF test was done while ensuring that the ventilation rates were set according to the Ventilation Rate Procedure (VRP; ASHRAE Standard 62.1 - 2013). In order to further confirm the savings, energy consumption was measured again in 2016, this time starting on August 14th until September 21st.

For indoor air quality, contaminant concentrations were measured prior to the HLR operation, then again after the HLR had been installed and running for at least one week. Indoor air quality monitoring was performed per EPA Standards and the results were analyzed by a third party certified lab (Prism Analytical Technologies).

This investigation included environmental and indoor air quality sampling of temperature, relative humidity, carbon dioxide (CO_2), 31 speciated (separated by species) volatile organic compounds (VOCs) and total VOCs, formaldehyde, and particulate matter with aerodynamic size of less than 2.5 (PM2.5). These include all the contaminants of concern typically found in buildings. The investigation included sampling at different locations in the center. To prevent instrumentation-based discrepancies, we tracked the instruments used for each type of measurement, along with the manufacturer reported detection principle, resolution, and uncertainty.

The Impact

The HLR system realized 28% energy savings while improving the air quality in the space.

Energy Savings:

Using the HLR modules, the University of Miami's Wellness Center used about 75% less outside air and thereby saved 828 Ton-hrs per day of cooling – a 28% reduction in total HVAC energy consumption. As a result, the building is saving $19,500 each year in energy consumption.

The individual daily measurements and corresponding outdoor enthalpy is shown in Figure 5, covering July and August 2015, and August and September 2016.

The energy savings would have been higher if indoor temperature and humidity inside the building were kept constant when the HLR was On and Off. In Figure 6, the indoor temperature and humidity are charted for when HLR was On and Off. When HLR is Off, indoor humidity is 10% higher, and temperature also was a couple degrees higher.

41% reduction in peak HVAC capacity

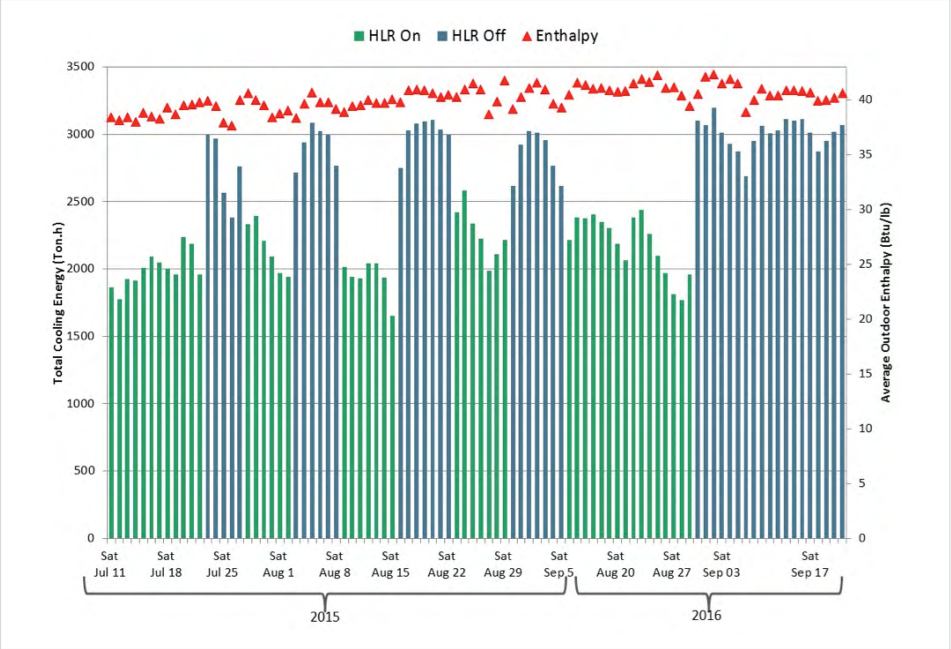

Figure 5: Daily HVAC energy consumption comparison

Peak HVAC Capacity Reduction:

The HLR reduced peak HVAC load by 56 tons, which corresponds to roughly a 41% decrease in total HVAC load. This savings impacts the "demand charges" on their utility bill, which in many locations, has a major impact on the overall cost of electricity. In addition, when the Wellness Center replaces the HVAC equipment in the future, the peak capacity required will be 41% less, providing significant capital expense savings.

The peak load reduction would have been even higher if the indoor temperature and relative humidity had been kept constant, as explained above.

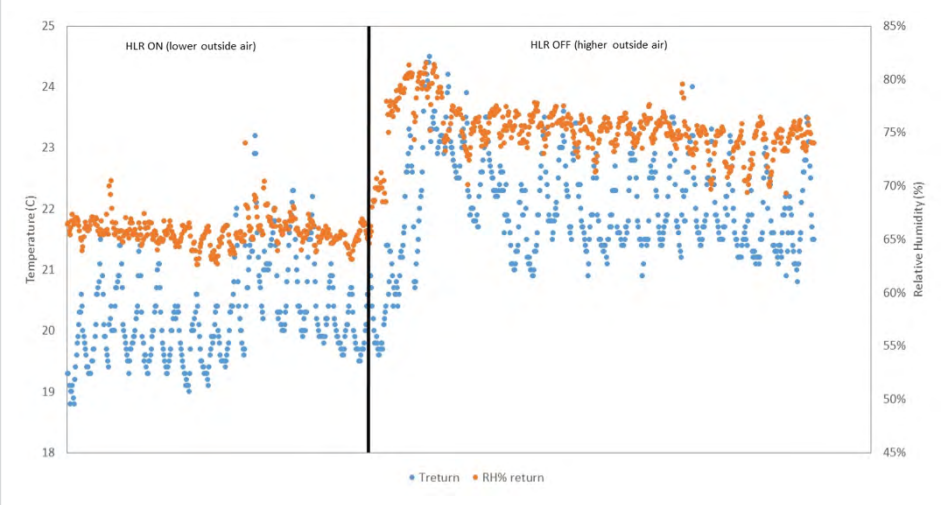

Figure 6: Average hourly indoor temperature and relative humidity from August 14th – September 21st, 2016. HLR was turned Off on August 30th, represented by the vertical black line.

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Ron Bogue, Vice President for Facilities and Services, University of Miami: University of Miami is committed to the environment, energy efficiency, and providing a healthy environment for our faculty and students. We have used enVerid's HLR technology to achieve a 30% savings in total HVAC energy consumption and a 40% peak capacity decrease. To achieve this while improving indoor air quality demonstrates this is truly disruptive technology for the HVAC industry.

Additional savings:

- **Filters:** A 75% reduction in outdoor air can double the lifetime of the outside air filters. Given that the University of Miami Wellness Center is next to a major highway, reduced filter changes can save hundreds of dollars each year.
- **Reduced water consumption:** University of Miami uses a central chiller plant, so specific water savings for the Wellness Center is difficult to confirm, but these savings could be thousands of dollars annually.
- **Reduced Corrosion:** A reduction of outdoor 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.
- **Improved indoor air quality (IAQ):** ***The air quality in the building was improved when using the HLR modules.*** Using enVerid HLR units, the minimum ventilation rate and results from IAQ (pollutant concentrations) showed compliance to ASHRAE Standard 62.1 IAQP. Contaminants (i.e., aldehydes, speciated volatile organic compounds, and carbon dioxide) were successfully maintained below their established threshold values. Figure 7 shows the specific measurements of each key contaminant of concern. In addition, by reducing the amount of outside air, less particulate matter is brought into the building from the neighboring highway, providing a further improvement in air quality. A growing number of studies show that living near highways increases your chance of cardiovascular disease.

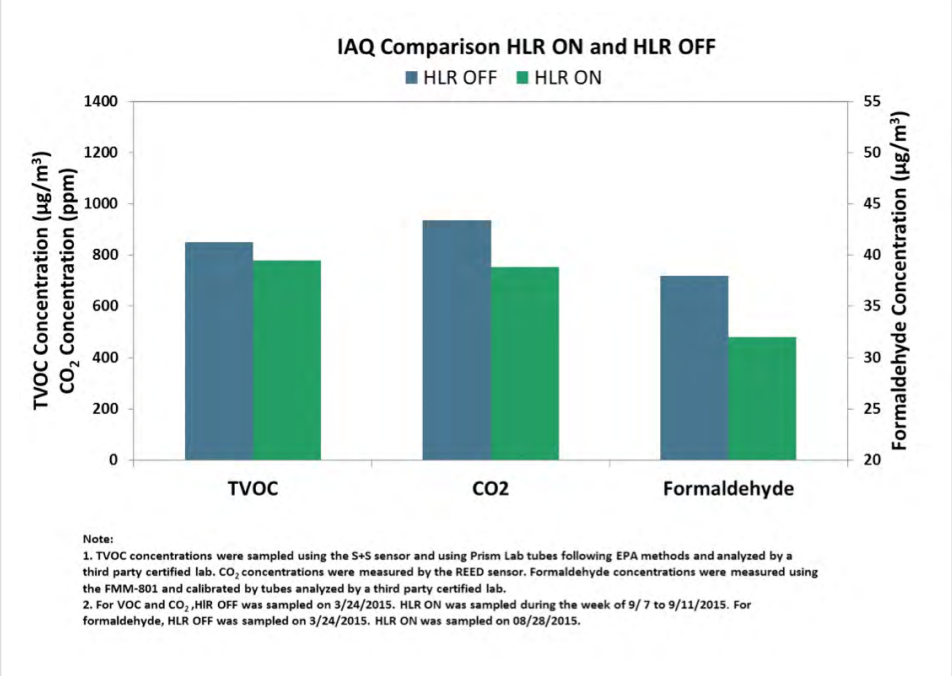

Figure 7: Comparison of total VOCs, CO2, and formaldehyde with and without HLR on.

75% reduction in outdoor air can double the lifetime of the outside air filters

Conclusion

The Patti and Allan Herbert Wellness Center has defined wellness for the University of Miami community. Since opening its doors in 1996, the premier fitness and recreation facility continues to engage students, faculty, staff and alumni in its many programs and services – with approximately 2,500 people using the facility each day.

Faced with higher than desired energy costs and a commitment to high air quality and comfort, the Wellness Center turned to enVerid for help. The enVerid project team assessed the HVAC mechanical environments, provided a detailed installation plan and obtained necessary permits.

In the installation phase, the enVerid project team selected and supervised electrical and mechanical subcontractors with the customer's approval. Installation of three enVerid HLR systems was completed with no disruption in HVAC service.

Results: Improved Energy Efficiency and Indoor Air Quality (IAQ):

- 28% average reduction in total HVAC energy consumption ($19,500 savings/year)
- 41% peak HVAC capacity reduction
- 75% average reduction in outside air
- Better indoor comfort: Relative humidity decreased 10% and air temperature reduced 2.5 ^{0}C
- Improved air quality: Reduced TVOCs to 780 µg/m^3,formaldehyde to 32 µg/m^3, CO_2 to 753 ppm, and reduced particulate matter from the neighboring highway.

As a result of this successful implementation, enVerid was selected for another University of Miami project at the Richter Library.

28% reduction in total HVAC energy consumption

About enVerid Systems

enVerid Systems offers a proven, game-changing technology that significantly lowers HVAC energy consumption, delivering 20-40% cost savings and improving air quality. enVerid's HVAC Load Reduction (HLR™) modules remove molecular contaminants from indoor air including CO_2, formaldehyde and VOCs, thereby reducing the amount of outside air required to maintain indoor air quality. HLR modules can be easily retrofitted to any existing commercial building or incorporated in new construction. The HLR's innovation and massive energy saving potential have been recognized by the U.S. Department of Energy, the U.S. General Services Administration's Green Proving Ground Program, the U.S. Green Building Council, trade groups and industry analysts. For more, please visit www.enverid.com.