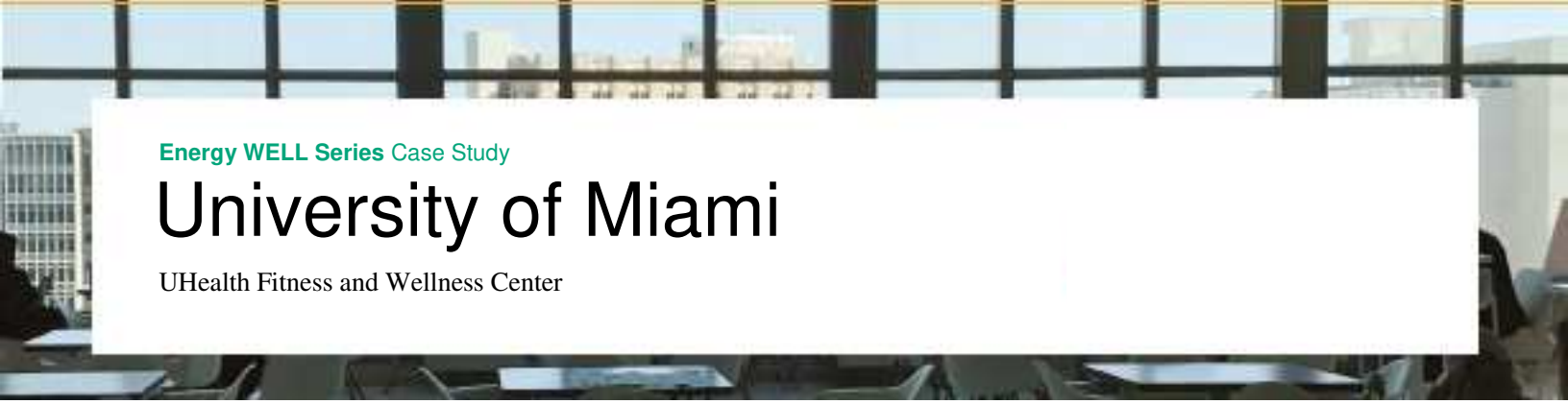

Energy WELL Series Case Study

University of Miami

UHealth Fitness and Wellness Center

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.

36%
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 Challenge

The indoor air quality (IAQ) was not at the level the facilities management team desired. Fitness centers generate a lot of carbon dioxide (CO_2) from people exercising, and the equipment and mats can off-gas formaldehyde and volatile organic compounds (VOCs). 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

Figure 1: The Wellness Center occupies 60,000 square feet on the top two stories above a parking garage and operates from 5 a.m. to 9 p.m.on most days.

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

UNIVERSITY OF MIAMI

Deployed: July 2015

Location: Miami, Florida

Climate Zone: 1A

Industry: Higher Education

Enrollment: 16,000 students

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

Solution: Energy WELL Modules 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

Results:

- ***36% average reduction in total HVAC energy consumption saving $19,500 per year***
- ***41% peak HVAC capacity reduction***
- ***75% average reduction in outside air***
- ***Estimated water savings of $9,200 per year***
- Better indoor air comfort: relative humidity decreased 10% and air temperature reduced 2.5˚C
- Improved air quality: Reduced TVOCs to 780 µg/m3, formaldehyde to 29 µg/m3, CO_2 to 753 ppm, and reduced particulate matter from the neighboring highway

Energy WELL Series, powered by Enverid is committed to improving energy efficiency and indoor air quality in buildings worldwide through innovative, award-winning HVAC Load Reduction solutions. Technology enables immediate capital cost savings on new HVAC systems and provides up to 30% energy savings and superior indoor air quality. The modules are deployed in commercial, academic and government buildings globally. Energy WELL series, powered by Enverid is ASHRAE and LEED compliant.
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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 Building

Located at the University of Miami Miller School of Medicine in downtown Miami, this 13-story building (figure 1) opened in October 2006. The UHealth Fitness and Wellness Center occupies the top two stories and spans 60,000 ft_2.

The facility (figure 2) 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, and Central Table Restaurant which serves fresh and healthy cuisine daily.

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 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 installation excluded AHU-1 and the pool area since this area requires special handling and is served by a separate AHU.

In June 2015, Energy WELL System and Johnson Controls installed three of Energy WELL modules in the mechanical rooms serving the Wellness Center.

The project was led by Energy WELL 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 Energy WELL modules, ours team assessed the HVAC

Figure 3: Energy WELL module installed at the 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. Energy WELL technology was the only real choice, and gives the added benefit of future reductions in HVAC capital expenditures.*
>
> **Marcelo Bezos**
> Director of Energy Management Systems, University of Miami

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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, ours 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 Energy WELL Internet-of-Things (IoT) cloud-based platform for 24/7 monitoring. Each Energy WELL module underwent its own acceptance test, and final acceptance tests for the building were completed after all modules 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 Energy WELL modules went live on July 2015. Each Energy WELL module includes Energy WELL-developed synthetic sorbents housed in cartridges that adsorb CO_2, formaldehyde and VOCs. The Energy WELL module also has a set of sensors measuring temperature, relative humidity, CO_2 and VOCs. The Energy WELL system interprets the output of these sensors using control algorithms to actively and automatically manage indoor air quality and outside air volumes.

> *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 Energy WELL technology. Energy WELL team has been great to work with, and we plan to do more deployments of their Energy WELL modules.*
>
> **Carl Thomason**
> Energy Manager, University of Miami

The Energy and Air Quality Measurement Methods

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

Measurements were taken on July 11, 2015 and were completed on September 5,

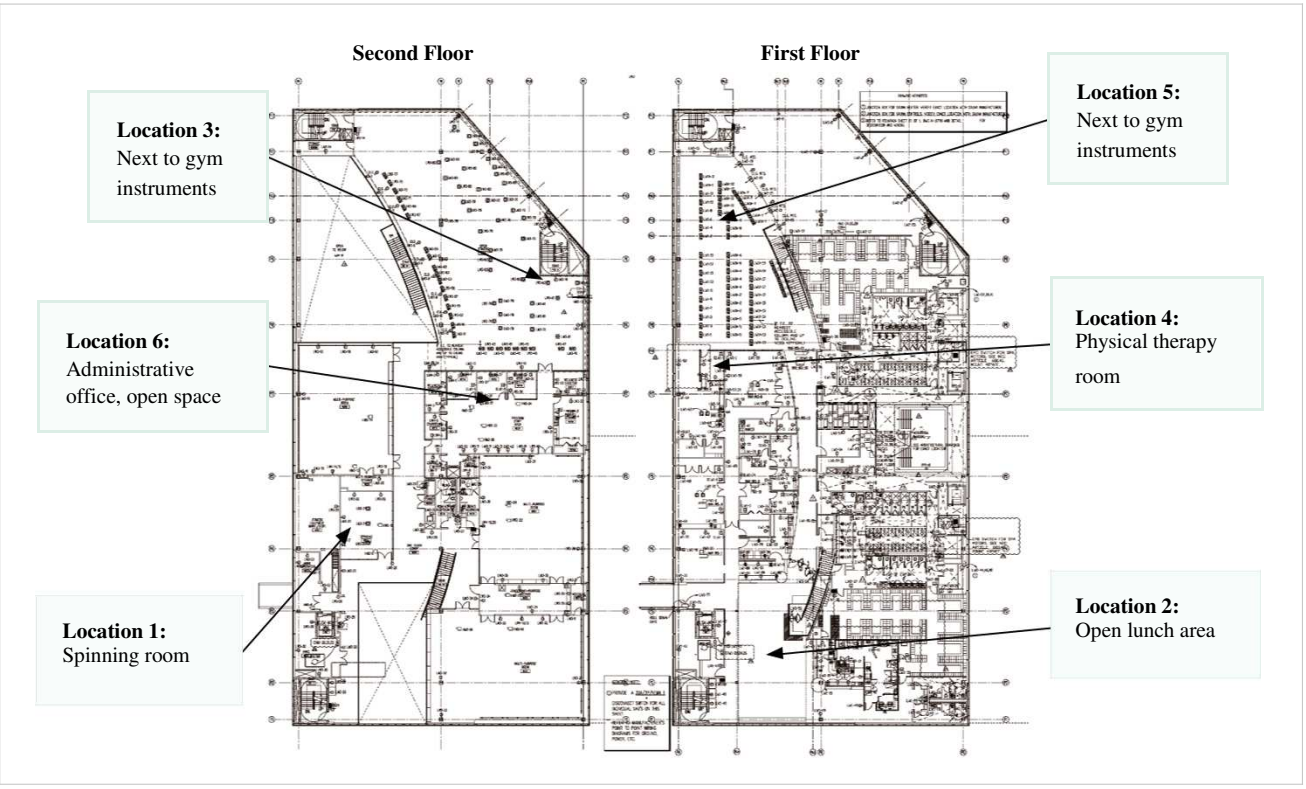

Figure 4: First and second floor layouts, with air quality testing locations identified.

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41% reduction in peak HVAC capacity

2015. In order to further confirm the savings, energy consumption was measured again in 2016, this time starting on August 14th until September 21st, and then again in 2017 from June 6th until September 27th. Energy consumption was measured using an energy meter installed by the building facility management. Chilled water consumption and outdoor conditions were also monitored.

Without Energy WELL modules, ventilation rates were set according to the Ventilation Rate Procedure (VRP; ASHRAE Standard 62.1-2013). When the Energy WELL system was in use, outside air volume was reduced by 75% based on the Indoor Air Quality Procedure (IAQP; ASHRAE Standard 62.1-2013).

For indoor air quality, contaminant concentrations were measured prior to the Energy WELL module operation, then again after the Energy WELL technology 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, CO_2, speciated (separated by species) volatile organic compounds (VOCs) and total VOCs (TVOC), formaldehyde, and particulate matter with aerodynamic size of less than 2.5 µm ($PM_{2.5}$). These include all the contaminants of concern typically found in buildings. The investigation included sampling at six 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 Energy WELL system realized 36% energy savings while improving the air quality in the space.

Peak HVAC Capacity Reduction: 58 tons

Peak HVAC capacity is calculated to be 58 tons lower (19 tons saved per Energy WELL module), which corresponds to roughly a 41% decrease in peak 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 measured peak load reduction was lower than 58 tons, which was due to two factors:

- The indoor temperature and relative humidity were not kept constant, as explained in figure 6.
- The chiller set-points and parameters, were not yet optimized for Energy WELL operation, so energy consumption would spike and trough in a cyclical manner. These unnecessary spikes lower the realized reduction in peak load.

Reduced Water Consumption: $9,200/year

University of Miami uses a central chiller plant, so specific water savings for the Wellness Center is difficult to confirm, but are calculated to be $9,200 annually based on the cooling load and annual cooling hours.

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Energy Savings: 36%

Using the Energy WELL modules, the University of Miami's Wellness Center is now using 75% less outside air and saving 988 Ton-hrs per day of cooling – a 36% 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. By decreasing unnecessary exhaust, savings increased to 36% in 2017.

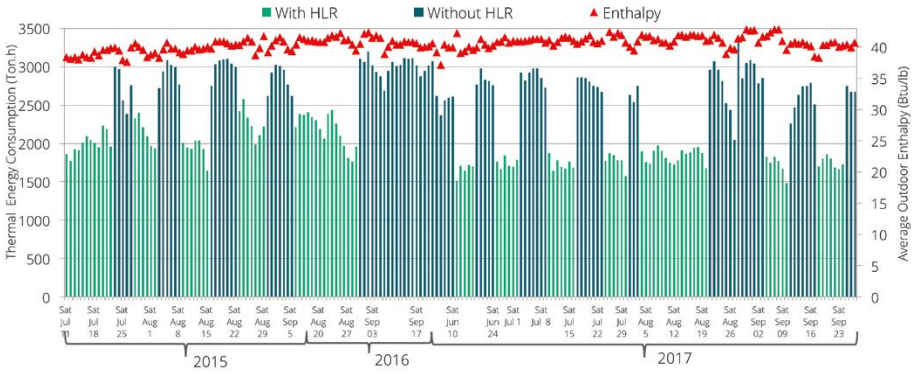

Figure 5: Daily HVAC energy consumption comparison.

The energy savings would have been higher if indoor temperature and humidity inside the building were kept constant with and without Energy WELL technology. In Figure 6, the indoor temperature and humidity are charted for when Energy WELL technology was On and Off. When the Energy WELL system is Off, indoor humidity is 10% higher, and temperature also was a couple degrees higher. This condition was observed consistently during the measurement and verification period.

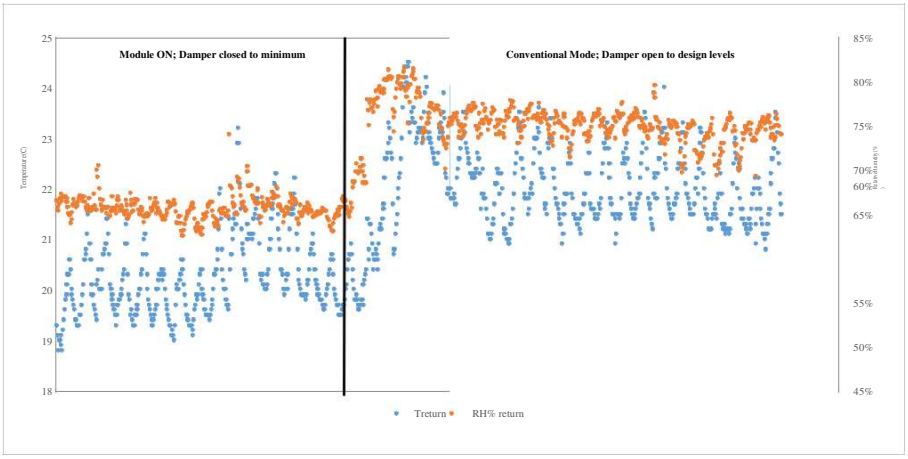

Figure 6: Average hourly indoor temperature and relative humidity from August 14th – September 21st, 2016. Energy WELL system was turned Off on August 30th, represented by the vertical black line. This behavior was observed during the summer of 2017 as well, and therefore the measured savings and peak load reductions would have been larger if the T and RH were kept constant.

University of Miami is committed to the environment, energy efficiency, and providing a healthy environment for our faculty and students. We have used Energy WELL technology to achieve a 36% savings in total HVAC energy consumption and a 41% peak capacity decrease. To achieve this while improving indoor air quality demonstrates this is truly disruptive technology for the HVAC industry.

Ron Bogue
VP for Facilities and Services,
University of Miami

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Additional Savings:

- **Filters:** A 75% reduction in outdoor air can double the lifetime of the outside air filters. Given that the UHealth Fitness and Wellness Center is next to a major highway, reduced filter changes can save hundreds of dollars each year.
- **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.

75% reduction in outside air

can double

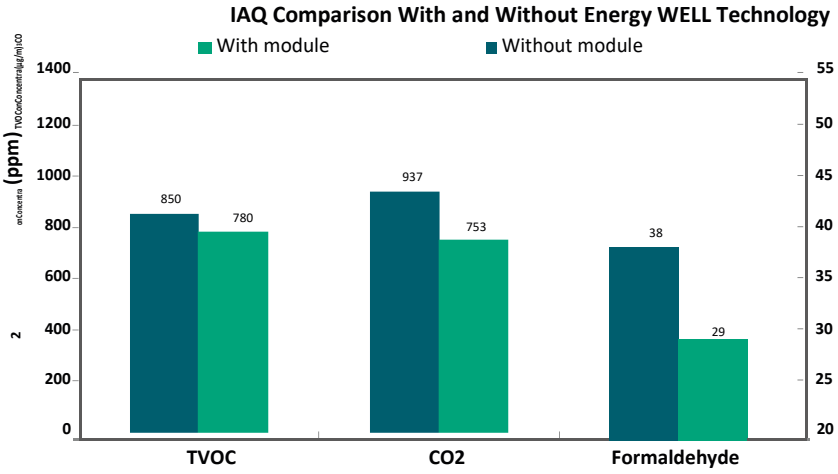
the lifetime of the outside air filters

Improved indoor air quality (IAQ)

The air quality in the building was improved when using the Energy WELL modules.

Using Energy WELL modules and a reduced ventilation rate, the building was compliant to ASHRAE Standard 62.1 IAQP. Contaminants (i.e., aldehydes, speciated VOCs, and CO_2) were successfully maintained below their established threshold values. Figure 7 shows specific measurements of key contaminants of concern.

In addition, by reducing the amount of outside air, less particulate matter and hazardous chemicals are brought into the building from the neighboring highway and airport, providing a further improvement in air quality. Studies show that living near highways increases your chance of cardiovascular disease.



Note:
1. TVOC concentra ons were sampled using the S+S sensor and using Prism Lab tubes following EPA methods and analyzed by a third party cer fied lab. CO_2 concentra ons were measured by the REED sensor. Formaldehyde concentra ons were measured using the FMM-801 and calibrated by tubes analyzed by a third party cer fied lab.
2. For VOC and CO_2, without module was sampled on 3/24/2015. With module was sampled during the week of 9/ 7 to 9/11/2015. For formaldehyde, without module was sampled on 3/24/2015. With module was sampled on 08/28/2015.

Figure 7: Comparison of total VOCs, CO_2, and formaldehyde with and without Energy WELL technology.

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In addition, Our Energy WELL Team collected air samples from six locations (figure 4) in the Wellness Center and tested them for all speciated VOCs. The results from an independent lab, shown in figure 8 below, demonstrate the air scrubbing effect of the Energy WELL technology.

VOCs	CAS	Measured Results (µg/m3)	Exposure Limit (µg/m3)
Acetaldehyde	75-07-0	25	140[1]
Acetone	67-64-1	15	590,000[2]
Benzene	71-43-2	1	3[1]
Bromoform	75-25-2	0.6	5,000[2]
Butane (C 4)	106-97-8	5	1,900,000[2]
sec-Butylbenzene	135-98-8	0.2	Exposure limit not established
C10-C12 Hydrocarbon	N/A	31.4	Exposure limit not established
C15-C17 Hydrocarbon	N/A	13.5	Exposure limit not established
Carbon Tetrachloride	56-23-5	0.4	40[1]
Chloroform	67-66-3	0.8	300[1]
1,4-Dichlorobenzene	106-46-7	0.4	800[1]
Dodecane (C 12)	112-40-3	4	Exposure limit not established
Ethanol	67-17-5	170	Exposure limit not established
Ethylbenzene	100-41-4	0.7	2,000[1]
Gamma-Terpinene	99-85-4	8.5	Exposure limit not established
Hexamethylcyclotrisilox	541-05-9	8	Exposure limit not established
Hexanal	66-25-1	4	920.3[3]
Hexadecane (C 16)	544-76-3	6	Exposure limit not established
Isopropanol	67-63-0	55.5	7,000[1]
p-Isopropyltoluene	99-87-6	2.4	Exposure limit not established
Limonene	138-86-3 or 5989-27-5	325	150,000[4]
2-Methylbutane	78-78-4	8	350,000[2]
Methylene Chloride	75-09-2	0.2	400[1]
Myrcene	123-35-3	7	Exposure limit not established
Naphthalene	91-20-3	0.2	9[1]
Pentane (C 5)	109-66-0	5	350,000[2]
α-Pinene	80-56-8	8	450,000[5]
β-Pinene	127-91-3	23.5	Exposure limit not established
Styrene	100-42-5	0.8	900[1]
Toluene	108-88-3	4.7	300[1]
1,2,3-Trimethylbenzene	526-73-8	0.4	125,000[2]
1,2,4-Trimethylbenzene	95-36-3	1.1	125,000[2]
1,3,5-Trimethylbenzene	108-67-8	0.3	125,000[2]
Undecane (C 11)	1120-21-4	5	350,000[2]
m,p-Xylene	108-38-3; 106-42-3	2.3	700[1]
o-Xylene	95-47-6	0.9	700[1]

Figure 8: Measured results of individual VOCs collected from six locations are well below their established limits.

[1] Exposure limit source: USGBC
[2] Exposure limit source: NIOSH
[3] Exposure limit source: EU-LCI value
[4] Exposure limit source: IARC guideline
[5] Exposure limit source: German IAQ

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Conclusion:

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

Installation of three Energy WELL modules was completed without disruption in HVAC service.

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

- 36% average reduction in total HVAC energy consumption
- 41% peak HVAC capacity reduction
- 75% average reduction in outside air
- Per HLR module savings each year
  - »» $6,500 energy savings
  - »» $3,100 water savings
  - »» 19-ton reduction in peak HVAC load
- 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 29 µg/m^{3}, CO_2 to 753 ppm, and reduced particulate matter from the neighboring highway.

ASHRAE Compliance with ASHRAE 62.1 IAQP

As a result of this successful implementation, Energy WELL System has been selected for three additional projects at the University of Miami: a library, an administrative office building, and a medical office and classroom building.

36% reduction in total HVAC energy consumption

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