Energy WELL Series Case Study

ArcBest

Corporate Headquarters Building Increases Occupant Density by 50%

About ArcBest

ArcBest℠ is a multibillion-dollar logistics company delivering integrated solutions primarily under the ArcBest brand. Our offerings include less-than-truckload services via the ABF Freight® network, ground expedited solutions through Panther Premium Logistics®, household moving under the U-Pack® brand and vehicle maintenance and repair from FleetNet America®. From Fortune 100 companies to small businesses, our customers trust and rely on ArcBest for their transportation and logistics needs.

With a relentless focus on meeting our customers' needs and unique access to guaranteed transportation capacity, we create solutions to even the most complex supply chain challenges. We are focused on providing the best customer experience possible with seamless access to a broad suite of logistics capabilities, including truckload, LTL, ocean and air, ground expedite, managed transportation and warehousing.

Our over 13,000 employees deliver knowledge, expertise and a can-do attitude with every shipment and supply chain solution, residential move and vehicle repair. Headquartered in Fort Smith, Arkansas, ArcBest has significantly expanded our total service offerings to include both asset-based and asset-light solutions to meet any customer need.

No matter the job, ArcBest finds a way.

Figure 1: The five-story ArcBest Corporate Headquarters Building, has approximately 190,000 ft² of office space divided into two primary zones per floor.

Customer: ArcBest (NASDAQ: ARCB)

Climate Zone: 3A

Deployed: June, 2016

Location: Fort Smith, Arkansas

Industry: Freight Transportation and Logistics

Employees: Over 13,000

Annual Revenue: $2.67 billion (Year Ended December 31, 2015)

Challenges: Building was designed for 850 people, but now supports 1200. As a result, increased ventilation is required causing drafts in the building during both winter and summer.

Solution: 10 Energy WELL modules - two installed on each floor, one per wing - to scrub air of contaminants and reduce the amount of outside air ventilation required.

Results:

- **273 tons reduction in HVAC cooling peak load**
- **$63,709 energy cost savings annually**
- **65% average reduction in outside air (IAQP using Energy WELL modules vs VRP)**
- $11,535 in water and wastewater savings
- $66,900 utility rebate
- Extended filter life
- All contaminants of concern maintained at a healthy level
- Better indoor air comfort

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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The Challenge

Originally designed to support an occupancy level of 850 people, the corporate headquarters has grown to now have 1,085 people plus visitors. Ten percent of the people work at night, requiring 24/7 conditioning of air. The increase in occupancy drove a need to introduce more outside air to maintain air quality. All of this outside air had to be conditioned, increasing electrical energy costs. In addition, the extra outside air caused draftiness on cold winter days, and during the summer the extra outside air flow through the air handlers resulted in some parts of the building getting too cool. "I previously got calls from people that they were cold during the summer, which was a direct result of having to introduce so much chilled air into the building to meet the appropriate CO_2 levels," said Richard Rieske, Director of Corporate Facilities at ArcBest. "Likewise, they felt drafts during the winter due to all the outside air that was being used to ventilate the building. When the Energy WELL modules are running, our people are more comfortable."

The Building

The Corporate Headquarters Building is in Fort Smith, Arkansas, a warm and humid city in the Southeastern United States. The 190,000 ft^2 building (see Figure 1) has five floors of office space separated into two wings (east and west primary zones). Two staircases connect all building floors.

The building has a central core (bathrooms, coffee rooms) and a peripheral open office plan. There is a computer room on the 1st floor and executive offices and conference rooms at the southern side of the 4th and 5th floors.

Each wing is served by a dedicated air handling unit (AHU). Building return air is an open plenum suspended ceiling type while air is ducted to line diffusers. Building pressurization is regulated on each floor by return air mounted exhaust fans.

Figure 2: ArcBest lobby.

> *I previously got calls from people that they were cold during the summer, which was a direct result of having to introduce so much chilled air into the building to meet the appropriate CO_2 levels. Likewise, they felt drafts during the winter due to all the outside air that was being used to ventilate the building. When the Energy WELL modules are running, our people are more comfortable.*
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> **Richard Rieske**
> Director of Corporate Facilities, ArcBest

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At the start of the project, the building's central plant on the ground floor had two packaged hermetic centrifugal liquid single-speed chillers (375 tons each). On warm days, the second 375-ton chiller was required, but now with the Energy WELL modules they typically only need a single chiller as the peak HVAC cooling capacity has been reduced by about 273 tons.

All outside air intake for the HVAC system is demand control ventilation (DCV) dependent (controlled by space CO_2 sensors). The outside air damper is actuated based on an averaged CO_2 value on a per floor section basis. Each floor has about ten CO_2 sensors strategically distributed throughout the floor. CO_2 sensors residing in the eastern section on each floor were averaged separately from those in the western section. CO_2 set point is observed by the BMS to actuate outside air damper position.

"Running a second chiller significantly increased our energy utility costs" per Tom Daigle, Manager of Building Systems at ArcBest. "By using the Energy WELL modules, we are not conditioning as much outside air and we are projected to save $63,709 annually.

The building has a Carrier iVu Building Management System (BMS) running BACnet over MSTP which can optionally be integrated with Energy WELL's module BACnet to control the outside air (OA) damper. The following registers are available in the system:

- Outside air temperature and relative humidity [°F, %]
- AHU VFD [%]
- Return air exhaust fan VFD [%]
- CO_2 values [ppm] per sensor and averaged values
- Cooling coil valve position [%]
- Supply air temperature and set point [F]
- Mixed air temperature [F]
- Supply/return water temperature [F]
- OA Damper position [%]
- Object mapping

The Project

The kickoff began with a site survey by ours team of the building mechanical layout, an Indoor Air Quality (IAQ) assessment and identification of potential locations for integrating the Energy WELL systems. The number of Energy WELL modules needed and the resulting outside air reduction were calculated according to ASHRAE Standard 62.1 Indoor Air Quality Procedure (IAQP) for a typical office building.

The site survey assessed the spaces that are cooled and heated (including stairways and closeted spaces), and documented the existing hydronic systems, power meters and all DCV, VAV and AHU interactions in the building, including dampers, sensors and exhaust systems.

The survey measured and planned for the positioning and installation of the Energy WELL modules, ensuring that they would fit and could be easily moved into position. In this phase, the team also checked for wireless connectivity options and suggested connection points to the BMS.

> *We are reducing approximately 273 tons of HVAC cooling capacity.*
>
> **Tom Daigle**
> Manager of Building Systems, ArcBest

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Lastly, the team took snapshot baseline measurements of CO_2, energy use and other air quality indicators. This information was shared with the facilities management team.

The Central Plant Mechanical Room (see figure 3) on the first-floor houses two AHUs: one which conditions the western side of the first floor and the other that conditions the computer UPS room – which is isolated and separated from the office space. The computer room was not included in the Energy WELL system retrofit as the outside air intake is fixed at a low level. The Eastern Mechanical Room contains the AHU that conditions the eastern side of the first floor.

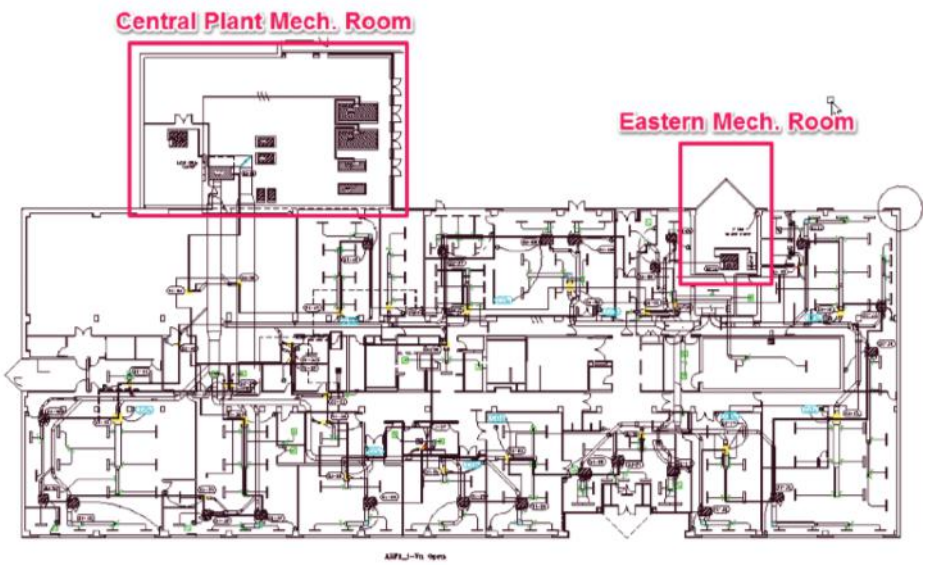

Figure 3: 1st floor mechanical rooms.

Inside the mechanical rooms each AHU has their supply air (SA), return air (RA), and outside air (OA) ducted. Each mechanical room has an outdoor air inlet ducted from a louver on the mechanical room north-east exposure. A return air exhaust fan (separated from the return air duct with a gravity damper) is connected to a louver on the mechanical room north-west exposure.

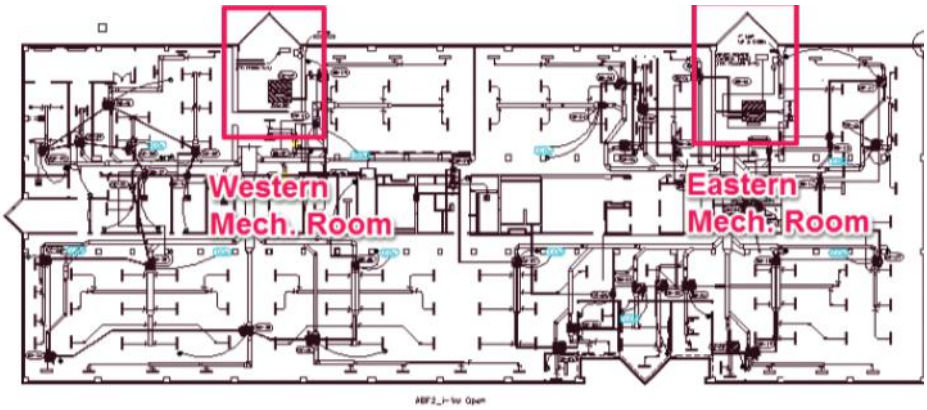

Figure 4: 2nd, 3rd, 4th and 5th floor mechanical rooms.

Outdoor Air Reduced
65% from
41,240 CFM (using VRP) to
14,600 CFM (using Energy WELL module and IAQP)

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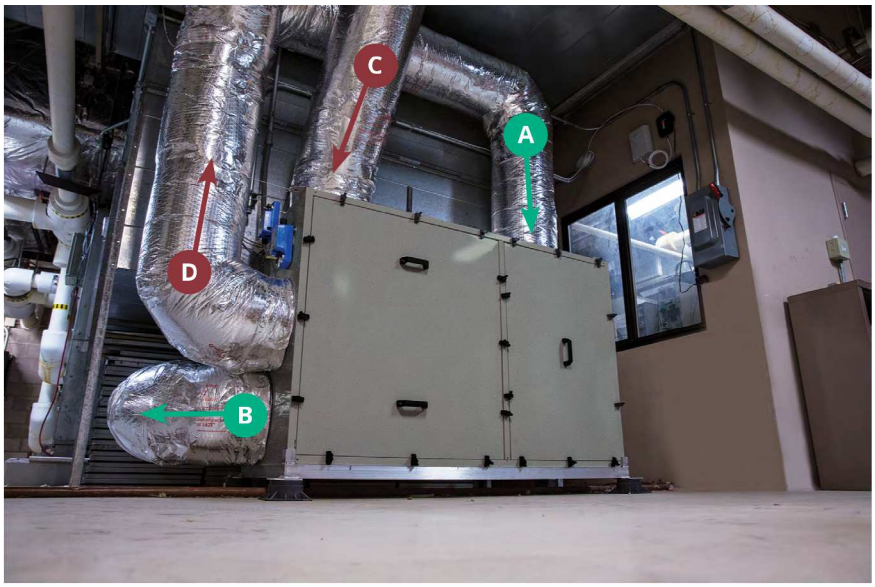
In the installation phase ours project team selected and supervised electrical and mechanical subcontractors with the customer's approval. 10 Energy WELL modules, installed in each of the building's mechanical rooms, will cover all spaces within the building. A slip-stream of return air from AHU is ducted through the Energy WELL module to be cleaned. Outside air used for regeneration and regeneration exhaust from modules are ducted to the louvered outside air in each mechanical room. Figure 5 shows an example of adsorption (A, B) and regeneration paths (C, D). Figure 6 shows a schematic of HLR module by-pass connection to the AHU.

Energy Cost
Reduced
$63,709
Annually



A Return air from AHU
B Clean air from module ducted back to AHU
C Outside air for regeneration
D Regeneration exhaust from module

Figure 5: Installation of an Energy WELL module in a mechanical room at ArcBest.

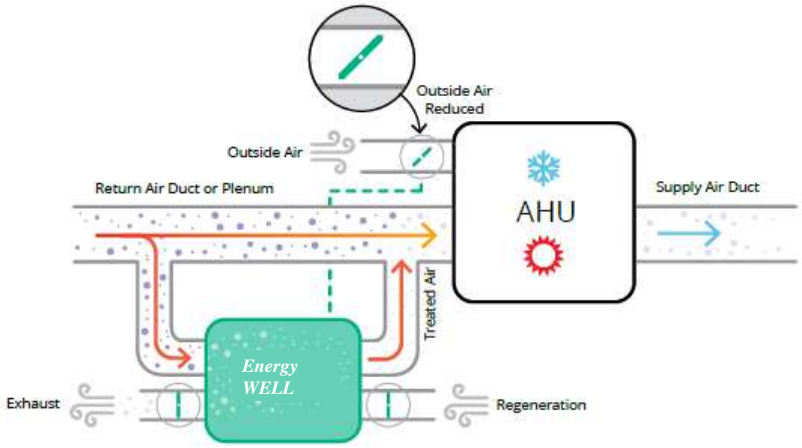


Figure 6: Schematic of Energy WELL module connected to AHU.

Additionally, ours project team continues to work with ArcBest's Facilities Management post-installation to optimize energy, IAQ and environmental comfort. ArcBest data continues to be captured for the National Renewable Energy Laboratory (NREL), to provide documented consumption information to the US Department of Energy.

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Energy and Air Quality Measurements

Using Energy WELL technology, ArcBest could take advantage of ASHRAE 62.1 Indoor Air Quality Procedure (IAQP) and use 65% less outside air compared to using the ASHRAE 62.1 Ventilation Rate Procedure (VRP). As a result, the annual energy savings for heating and cooling are calculated to be $63,709.

For indoor air quality (IAQ), contaminant concentrations were measured prior to the Energy WELL module operation, then again after the Energy WELL module had been installed and running for at least one week. Indoor air quality 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 (CO_2), full scan of speciated (separated by species) volatile organic compounds (VOC) and total VOC, aldehydes (e.g., formaldehyde), and particulate matter with aerodynamic size of less than 2.5 µm ($PM_{2.5}$). These include all the contaminants of concern found in office buildings. The investigation included sampling throughout the building at 10 different locations for CO_2, and two different locations for VOCs. Instruments used were calibrated before each use and functioned within the limits of performance specifications appropriate for pollutants measured in indoor environments.

The Impact

273 tons Peak HVAC Load Reduction

The Energy WELL System reduced peak HVAC load by 273 tons, which corresponds to a 36% decrease in total HVAC load. On warm days, ArcBest's second 375-ton chiller was required, but now with the Energy WELL modules they typically only need a single chiller. This savings impacts the "demand charges" on ArcBest's utility bill, which in many locations, has a major impact on the overall cost of electricity. In addition, when ArcBest replaces the HVAC equipment in the future, the peak capacity required will be 36% less, providing significant savings in capital expense.

Energy Savings of $63,709 per Year

Based on sensible and latent energy calculations, the energy savings for reducing outside air by 26,640 CFM equates to $63,709 annually using a standard energy model as applied to Fort Smith, AR, outside temperature and relative humidity data downloaded hourly from 2009 to 2013 (see figure 7).

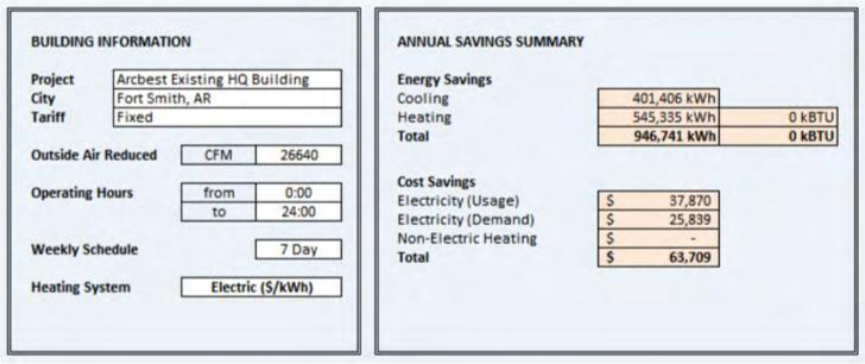

Figure 7: A VRP-compliant design requires 41,240 CFM of outside air. The HLR IAQP-compliant design requires 14,600 CFM of outside air, 26,640 CFM less than VRP.

Water Cost
Reduced
$11,535
Annually

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Water Savings of $11,535 per Year

ArcBest was also able to conserve on cooling tower water but a separate water meter wasn't available so this information was not included in the overall project savings. However, based on standard calculations, ArcBest is saving 2.175 million gallons of water and saving $11,535 in water and wastewater charges.

Earned a One-Time Energy Rebate of $66,900

The local electric utility, Oklahoma Gas & Electric, offers rebates for energy efficiency projects. The rebate of $6,690 per Energy WELL module, funded a substantial portion of the deployment

Maintained Indoor Air Quality

CO_2 levels vary throughout the day but are maintained at levels below 1,000 ppm see (Figure 8).

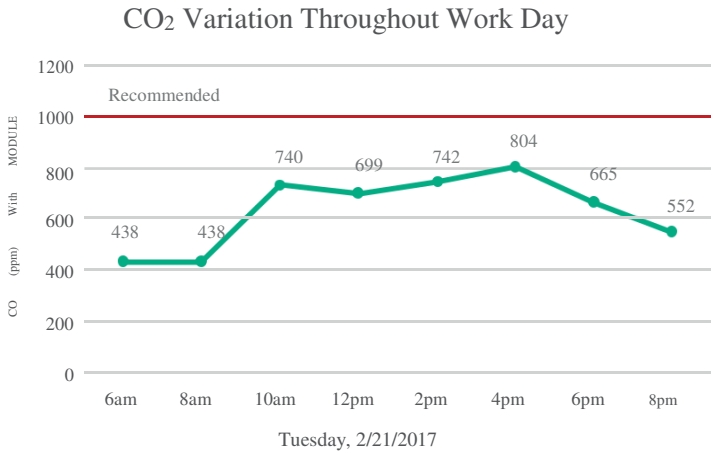

Figure 8: Energy WELL Cloud System CO_2 readings for unit located on the first floor in the west wing. CO_2 rises when employees are in the office. CO_2 levels are below the recommended target of 1,000 ppm (700 ppm + local outdoor concentration.

VOC measurements included TVOC and a full scan of speciated (separated by species) VOCs, identified by the USGBC as VOC contaminants of concern. The results, shown in Figures 9 and 10 below demonstrate the air scrubbing effectiveness of the Energy WELL technology.

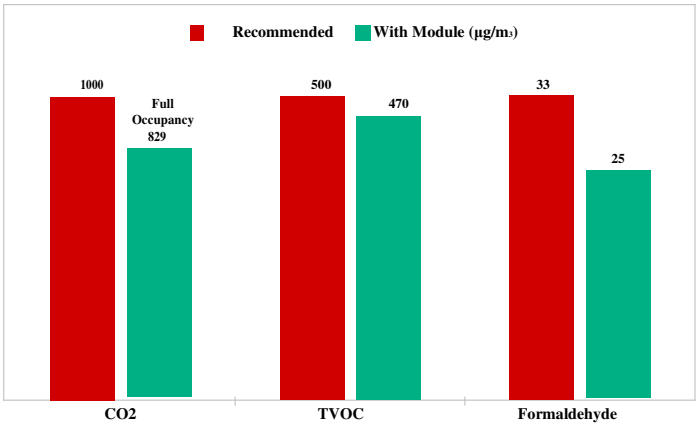

Figure 9: The Energy WELL Systems maintained safe levels for key COC, CO_2, TVOC, and formaldehyde. All values are averages from sampling on 2/21/2016. Recommendations are based on established limits by cognizant authorities as documented by LEED IAQP EQpc68 Pilot Credit.

By incorporating
Energy WELL modules,
ArcBest was able to obtain a **$66,900 utility rebate**

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VOC	CAS	Exposure Limit	Measured Results with HLR
		(µg/m3)	Average (µg/m3)
Acetaldehyde	75-07-0	140	8.1
Acetone	67-64-1	590,000	12.1
Benzene	71-43-2	3	0.43
Butane (C4)	106-97-8	1,900,000	5
Carbon tetrachloride	56-23-5	40	0.4
Dichlorobenzene (1,4-)	106-46-7	800	0.4
Ethylbenzene	100-41-4	2000	0.3
Formaldehyde	50-00-0	33	25
Hexane (C6)	110-54-3	7000	0.7
Isopropanol	67-63-0	7000	9.7
Limonene	138-86-3 or 5986-27-5	150,000	33.7
Methylene chloride	75-09-2	400	0.35
Styrene	100-42-5	900	0.75
Toluene	108-88-3	300	4.8
m,p-Xylene	108-38-3; 106-42-3	700	0.8
o-Xylene	95-47-6	700	0.37
Carbon disulfide	75-15-0	800	
Chlorobenzene	108-90-7	1000	
Chloroform	67-66-3	300	
Dichloroethylene (1,1)	75-35-4	70	
Dimethylformamide (N,N-)	68-12-2	80	
Dioxane (1,4-)	123-91-1	3000	
Epichlorohydrin	106-89-8	3	
Ethylene glycol	107-21-1	400	
Ethylene glycol monoethyl ether	110-80-5	70	
Ethylene glycol monoethyl ether acetate	111-15-9	300	
Ethylene glycol monomethyl ether	109-86-4	60	
Ethylene glycol monomethyl ether acetate	110-49-6	90	
Isophorone	78-59-1	2000	
Methyl chloroform	71-55-6	1000	
Methyl t-butyl ether	1634-04-4	8000	
Naphthalene	91-20-3	9	
Phenol	108-95-2	200	
Propylene glycol monomethyl ether	107-98-2	7000	
Tetrachloroethylene (Perchloroethylene)	127-18-4	35	
Trichloroethylene	79-01-6	600	
Vinyl acetate	108-05-4	200	

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All contaminants of concern are maintained at a

Healthy level

Figure 10: Measured results of COC samples, including all the LEED IAQP EQpc68 Pilot Credit VOC target contaminants, after one week of running the Energy WELL system. All contaminants are WELL below their established limits

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Mixtures of Concern (MOC), introduced as part of ASHRAE Standard 62.1-2016 IAQP, are two or more hazardous substances that have similar toxicological effect on the same target organ or system. Their combined effect should be considered additive as exposure to low concentrations of MOC may cause adverse effects to human health[1]. Figure 11 shows the identified MOC and the organ-impact related characteristics of each COC.

To show compliance, the ratio of the measured concentration of each contaminant to its exposure limit is determined, and the sum of these ratios for each MOC group should not be greater than one. The result of these calculations is shown in the bottom row of Figure 11. The calculated values of each of the mixtures is below 1, therefore, it meets the limit of the MOC.

Adding Energy WELL modules **eliminates** **The overhead** of DCV systems.

MOC 1, Basis Upper Respiratory Tract	MOC 2, Basis Eye Irritation	MOC 3, Basis Kidney Damage	MOC 4, Basis Central Nervous System	MOC 5, Basis Liver Damage	MOC 6, Basis Fetal Damage
Acetaldehyde	Acetaldehyde	Dichlorobenzene (1,4-)	Acetone	Carbon tetrachloride	Chloroform
Acetone	Acetone	Ethylbenzene	Chloroform	Chloroform	Toluene
Diethyl phthalate	Dichlorobenzene (1,4-)		Hexane (n-)		
Ethylbenzene	Formaldehyde		Methylene chloride		
Formaldehyde	Hexane (n-)		Nonanal		
Naphthalene	Ozone		Octanal		
Octanal	Xylene (m/p-, o-)		Phenol		
Ozone			Styrene		
Phenol			Tetrachloroethylene		
Styrene			Trichloroethylene		
Xylene (m/p-, o-)			Xylene (m/p-, o-)		
0.818	**0.818**	**0.001**	**0.004**	**0.010**	**0.016**

Figure 11: All MOC are below a value of 1, and therefore below the threshold specified in ASHRAE 62.1-2016 IAQP.

DCV System No Longer Necessary

By incorporating Energy WELL modules and using IAQP to manage how much outside air is used for ventilation, ArcBest no longer needs to rely on its demand control ventilation (DCV) system. Using IAQP, Energy WELL modules enable reduction in outside air, a feature not available with DCV, because it provides IAQ management for all contaminants, not just people-related contaminants. Consequently, ArcBest is using the Energy WELL modules to control outside air dampers, thereby bypassing the DCV system. Additionally, by using the Energy WELL modules and IAQP, ArcBest is now managing ventilation based on all COC instead of just CO_2.

Additional Savings:

- **Filters:** A 65% reduction in outside air can extend the lifetime of the outside air filters by 2-4x and lessen the impact of coarse, fine and ultrafine particles.
- **Reduced Corrosion:** A reduction in outdoor air intake provides several secondary benefits that include extending the useful life of the existing mechanical equipment and ductwork.

[1] Cognizant Authority: American Conference of Governmental Industrial Hygienists (ACGIH), 2017, "TLVs and BEIs - Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices"

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"Energy WELL's people are Class A, top-notch and the Energy WELL system works as advertised," said Daigle.

Conclusion

ArcBest℠ is a logistics company with creative problem solvers who have The Skill and The Will® to deliver integrated logistics solutions. At ArcBest, We'll Find a Way to deliver knowledge, expertise and a can-do attitude with every shipment and supply chain solution, household move or vehicle repair.

The ArcBest headquarters building in Fort Smith, AR, was designed to support an occupancy level of 850 people which had grown to 1,085 plus visitors. The increase in occupancy drove the need for increased outside air ventilation, resulting in an increase in energy consumption and challenges in maintaining air temperature comfort throughout the building.

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

- 273 tons reduction in HVAC cooling peak load
- $63,709 energy cost savings annually
- 65% average reduction in outside air (IAQP using Energy WELL module vs VRP)
- $11,535 in water and wastewater savings
- $66,900 utility rebate
- Extended particulate filter life
- All COC and MOC are maintained at a healthy level
- Eliminated overhead of DCV system
- Better indoor air comfort

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