

# Educational Facilities

FALL EDITION





# Importance of Student Learning Environments

**S**tudent academic and extracurricular performance, safety, health and comfort are impacted by the quality of their indoor learning environments, given that **students can spend over 90% of their time indoors.**<sup>1</sup> In school buildings, indoor environmental conditions are affected by multiple factors, including occupant density and indoor air quality parameters such as temperature, humidity, CO<sub>2</sub>, PM2.5, volatile organic compounds (VOCs), etc. <sup>1</sup>

For example, student stress level is increased when classrooms are windowless and artificially lit, which interferes with adolescent hormone production.<sup>2</sup> An optimal learning environment may be able to support students to manage stress levels. “Left unaddressed, the negative effects of stress can disrupt a student’s behavior, physical and emotional well-being, school success and friendships.”<sup>2</sup>

## Measurable Outcomes of Optimized Learning Environments

- 1. Elevated Occupant Academic Performance, Productivity & Well-being:** Leading learning environments enable maximum cognitive function for students and teachers, which can positively impact student test scores and teacher effectiveness. Higher quality learning atmospheres optimize indoor environments for performance, including thermal

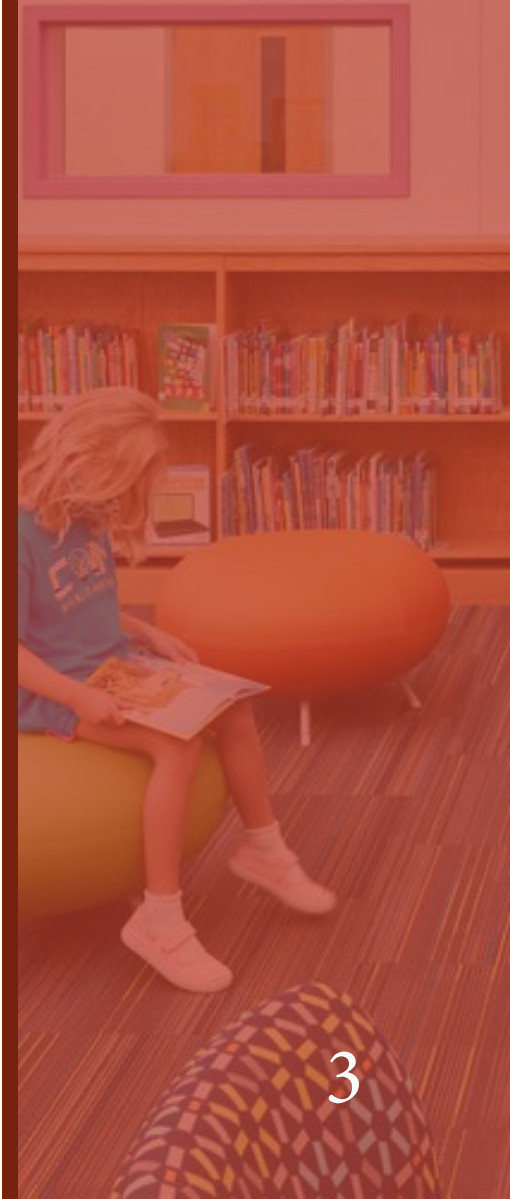
quality, unwanted noise and building condition, which have correlated with better academic and educational performance for school occupants.<sup>3</sup>

Occupant satisfaction and well-being refers to the feeling of fulfillment when student needs are met and the state of being healthy and comfortable. Building or school occupant satisfaction can be measured through satisfaction surveys, student and teacher feedback or other health measures. Some survey criteria can include indoor air quality (IAQ), thermal comfort, noise level and building cleanliness. According to studies, comfortable temperatures have a marked impact on student academic performance.<sup>4</sup> One study showed a span of test scores among “high school students scored an average of 76 percent when it was 61F, and did worse when it was 81F, scoring an average of 72 percent. When it was 72F, what most people would consider a comfortable temperature, students’ average scores went up to 90 percent.”<sup>4</sup>

**2. Enhanced Occupant Health & Reduced Absenteeism:** Indoor environments can support the health of students, teachers and staff, including physical, mental and overall well-being. Elements that make a school building healthier include IAQ, access to clean drinking water and exposure to daylight. Healthier schools support healthier occupants.

For example, poor IAQ in schools may cause the symptoms listed below, which can be mitigated by removing pollutants in the air.<sup>5</sup>

- Irritation of the eyes, nose and throat
- Headaches



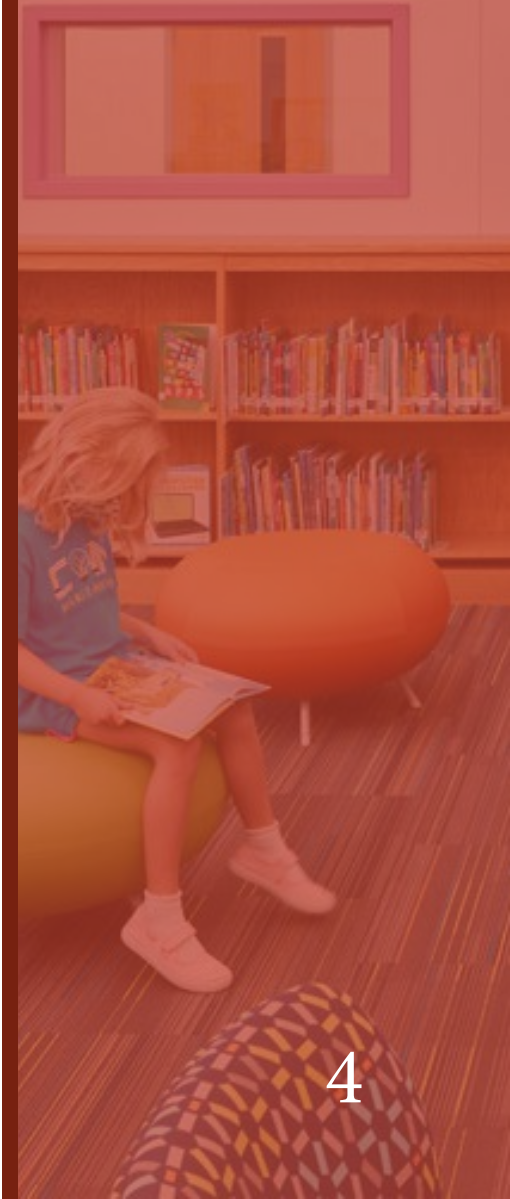
- Dizziness
- Fatigue<sup>15</sup>

Improving IAQ can also support reduced absenteeism. A study on absenteeism and air pollution of Salt Lake City schools summarized a statistically significant relationship between particle matter (PM)<sub>2.5</sub> levels and absenteeism in K-12 schools, indicating “PM2.5 and ozone exposure are associated with subsequent day absences from elementary, middle, and high schools, even at low pollution levels.”<sup>6</sup>

**3. Improved Building Operations Efficiency and Sustainability:** Not only should learning environments benefit students and school staff, but improvements should be done in a way to also benefit ongoing operations, budget efficacy and the environment. Building sustainability refers to operating schools and making investment decisions in a way that minimizes negative environmental and societal impacts, including reducing energy usage or waste. Sustainability is key in learning environments to minimize environmental impacts while creating opportunities for operational savings. Schools spend \$12.5 billion a year on utility costs, yet one-fourth (approximately \$3.1 billion) of these costs, could be saved through improved energy efficiency.<sup>11</sup> Reducing fossil fuel usage and energy consumption in schools are a few ways schools can achieve building sustainability.<sup>6</sup>

### COGfx Cognitive Function Building Study

The COGfx study series from the Harvard T.H. Chan School of Public Health’s Center for Health and the Global Environment showed the dramatic impacts of ventilation on cognitive function. In study 1, the research team evaluated the economic and



environmental costs against the health and productivity benefits of enhanced ventilation in buildings, studying three ventilation strategies and four different heating, ventilating and air conditioning (HVAC) systems across seven U.S. cities. They found that the health and productivity benefits far outweigh energy costs and that environmental impacts, which can be mitigated through a variety of readily available strategies.<sup>8</sup>

### Technologies to Enable Good Learning Environments

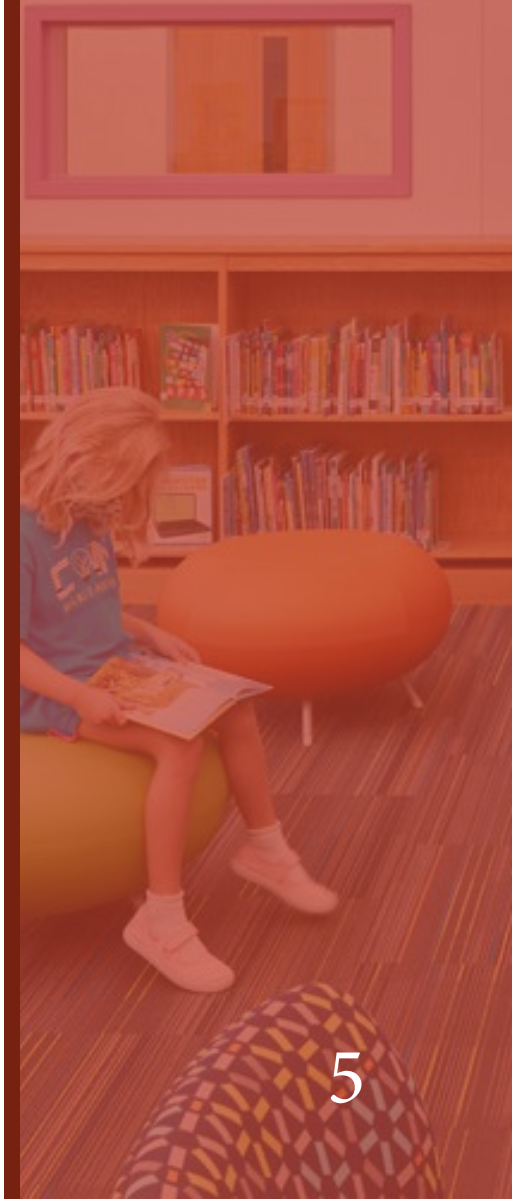
The quality of the air inside K-12 classrooms and other indoor spaces has never been a more critical issue. It is imperative to evaluate, and if necessary, upgrade and improve essential aspects of a school's current HVAC and controls system to make sure it delivers the high level of IAQ needed to support key wellness initiatives.

- **Filtration and Purification:** Filtration refers to the use of filters and other filter technologies to reduce solid particles, and in some cases odor and gaseous pollutants, from the air. Minimum Efficiency Reporting Value (MERV) rates the ability to filter particles. The higher the MERV filter rating, the more efficient the filter and the cleaner the air. The CDC recommends MERV -13 or higher filters for K-12 schools wherever possible.<sup>9</sup>
- **Ventilation:** Ventilation is the exchange or replacement of air in indoor environments. Bringing in more fresh outdoor air to replace indoor air can help

"It is time we move away from ventilation designed for merely acceptable indoor air quality and move towards design for optimal indoor air quality. We have been presented with the false choice of energy efficiency or healthy indoor environments for too long. We can and must have both."

**Dr. Joseph Allen**

*Assistant Professor of Exposure Assessment Science at the Harvard T.H. Chan School of Public Health, Director of the Healthy Buildings Program at the Center for Health and the Global Environment at Harvard Chan School, Principal Investigator for the study*

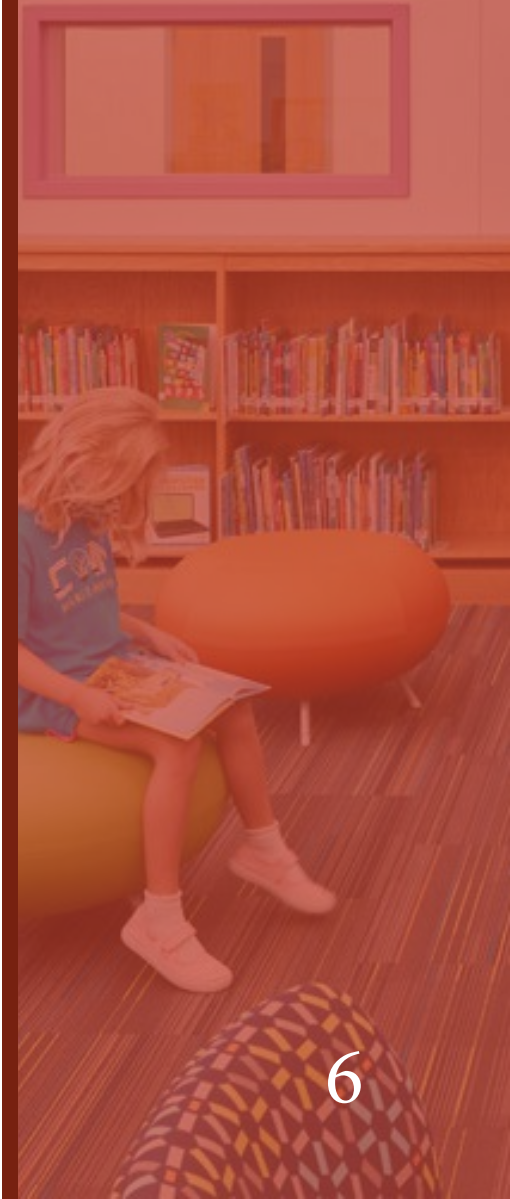


reduce the concentrations of airborne pathogens and other contaminants. Solutions like rooftop units, dedicated outdoor air systems and air handling units can support continuous air flow and usage of outdoor air.

- **Humidity Control:** Humidity is a measure of the quantity of water vapor in the air. Keeping relative humidity within the recommended range of 40% to 70% can minimize the effects of bacteria and allergens.<sup>10</sup>
- **Remote Airside Management:** Remote Airside Management services provide continuous validation of IAQ parameters, periodic checks of equipment health and continuous airside commissioning, enabled by a 24x7 command center.
- **Remote Energy Management:** Remote Energy Management services for HVAC and other building systems provide analytics that help optimize energy efficiency, equipment uptime and operational productivity.
- **IAQ Monitoring and Digital Solutions:** Continuous IAQ monitoring can identify issues with air quality and provide metrics and insights via digital platforms to help confirm IAQ over time.

### The Current State of U.S. Schools

There is work to be done to promote the health and ideal learning environment of students by improving school facilities, and that can begin with investments in HVAC. Public schools are the second largest U.S. infrastructure sector, but as of 2021, 41% of public-school districts were needing “HVAC systems upgrades or replacements in at least half of their schools.”<sup>11</sup>



The American Society of Civil **Engineers rated the condition of America's public schools an overall grade of D+**, for many reasons, including roof leaks, old HVAC systems, pest infestations, presence of asbestos and more. In fact, the average age of a school building in America is 50 years old, with some dating back to World War II.<sup>11</sup>

However, funding was made available to address this critical need through the Elementary and Secondary School Emergency Relief Fund (ESSER) program. ESSER has granted America's schools \$190 billion to invest in infrastructure improvements and prevent pandemic learning loss.<sup>11</sup> Schools may use these funds to achieve outcomes like minimizing the spread of airborne infectious diseases and helping students and staff stay safe, through investments in equipment.<sup>11</sup>

### What is ESSER Funding?

ESSER funds are a set of stimulus funds granted by the U.S. government to support schools with pandemic learning loss by re-opening and maintaining the health and safety of America's schools. In addition to deadlines, ESSER funds have required guidelines about how funds are spent. Many schools are choosing to invest in building systems and equipment, infrastructure, new energy sources, new modern technologies and staff hires.

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**54%**

Percentage of U.S. school districts that need to update or completely replace multiple building systems in their schools

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**36K**

Number of U.S. school buildings that need to update or replace their HVAC systems (1/3 of schools)

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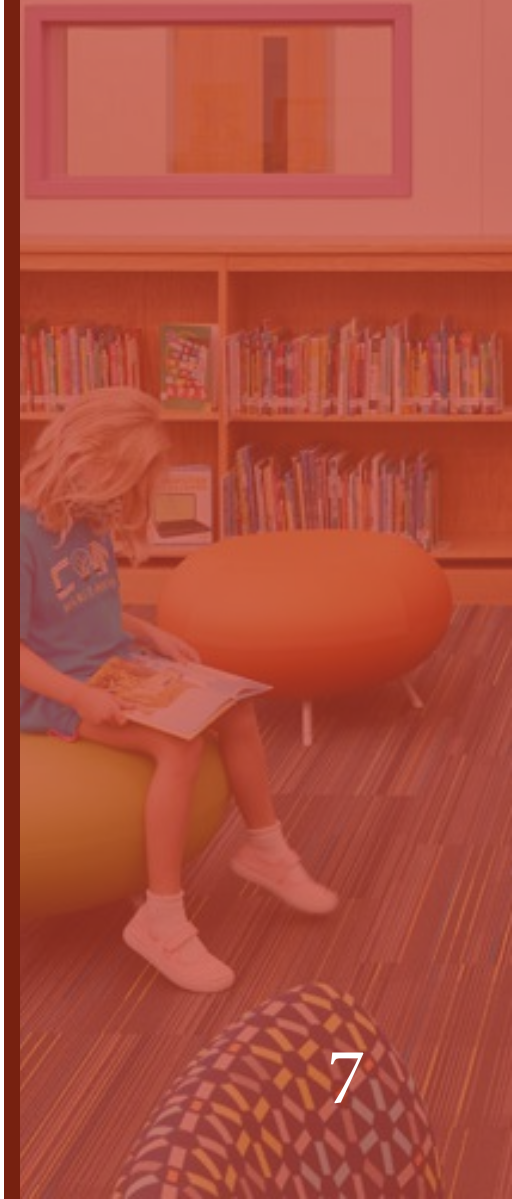
**\$85B**

The amount by which national spending for K-12 school buildings falls short each year

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**\$1.1T**

Estimated cost of modernizing and replacing obsolete school buildings and systems over the next decade



### ESSER Deadlines

- ESSER II – a part of the Coronavirus Response and Relief Supplemental Appropriations (CRRSA) Act.<sup>12,16</sup>
  - Funding Amount: \$54.3 billion
  - Allocation Date: December 2020
  - Spend Obligation Date: September 2023
  - Spend Liquidation Date: January 2024
- ESSER III - a part of the American Rescue Plan (ARP) Act.<sup>12,16</sup>
  - Funding Amount: \$123 billion
  - Allocation Date: December 2021
  - Spend Obligation Date: September 2024
  - Spend Liquidation Date: January 2025

### HVAC is a Priority for Schools for ESSER Spend

HVAC is a priority investment category for schools leveraging ESSER funds because HVAC improvements can both improve building infrastructure and operations, contribute to healthier outcomes for occupants and reduce energy spend. Investing in IAQ solutions can help schools:





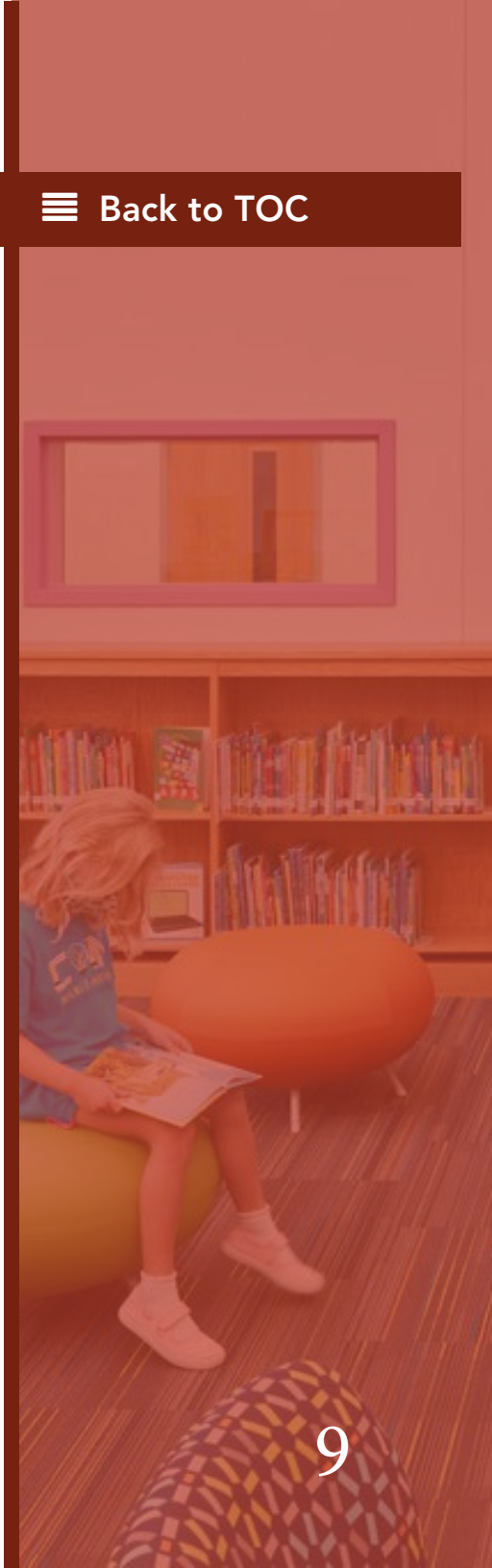
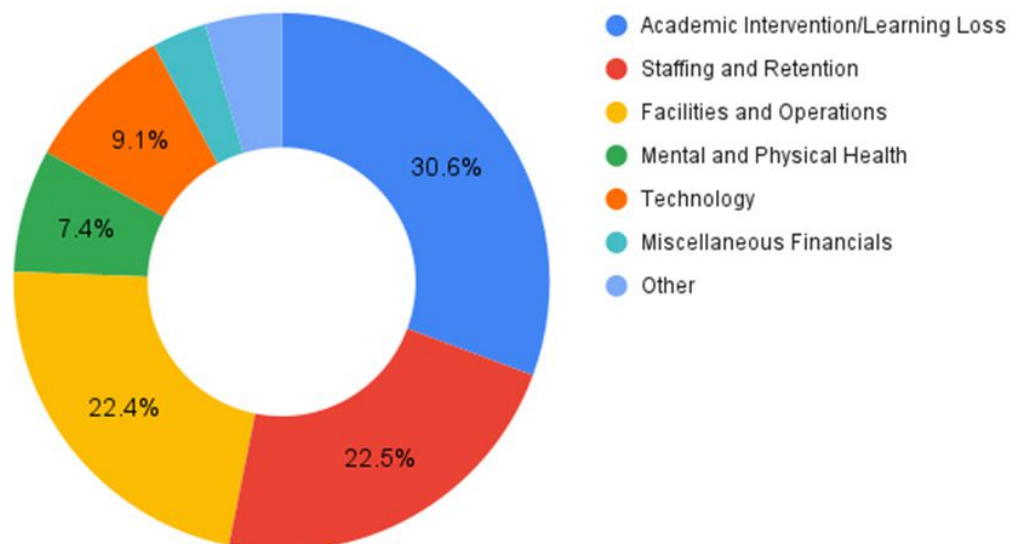
## Importance of Student Learning Environments

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- Enhanced student health and academic performance
- Increased teacher retention and productivity
- Improved building operations and resilience

Half of schools are choosing to allocate ESSER III spending to HVAC systems is because HVAC investments can be costly.<sup>13</sup> According to details from ASHRAE's Epidemic Task Force, "replacing an HVAC system in an older school facility could cost between \$30 and \$50 per square foot."<sup>13</sup> Schools, especially smaller districts, or those in low-income areas with less taxpayer funding, typically lacked funding for large-scale HVAC capital investments prior to ESSER. Of the districts that have reported planned ESSER III spend, the small to medium districts have "reported more spending per school on facilities categories" than larger districts.<sup>13</sup>

**ESSER III Planned Spending by Category**



### How Carrier Helps Schools Optimize ESSER Spend

It is recommended that schools plan comprehensively, act early and leverage third parties as needed to avoid or mitigate known issues with spending ESSER funds. Carrier experts are here to support schools in overcoming challenges to realize results that matter for students, staff and the community. Choosing Carrier means schools have access to unparalleled expertise and technologies needed to help schools achieve desired outcomes. Wherever a school is in the journey, Carrier partners to prioritize funds for school improvement projects.

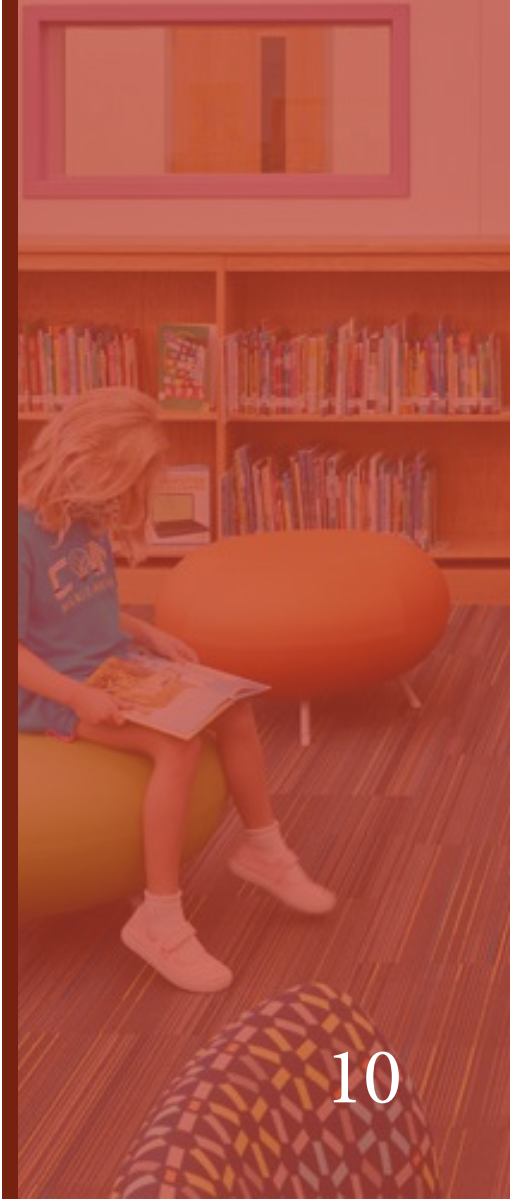
### ESSER Funds for Johnston County Public Schools

Johnston County Public Schools (JCPS), located in Smithfield, North Carolina, chose Carrier to improve energy efficiency and comfort at five of its schools. JCPS used money from ESSER funds to replace a dozen chillers. The school district selected Carrier's AquaSnap® 30RB, an air-cooled liquid chiller offering an effective all-in-one package that is easy to install and maintain. The new equipment replaced chillers that were between 20 and 25 years old.

JCPS appreciates that Carrier's AquaSnap Greenspeed® intelligence technology provides best-in-class part-load efficiency with quiet part-load operation. The school district needed the reliability of the aluminum fin copper tube condenser coils and the simplicity of the scroll compressor technology to handle compressor repairs in-house. Many of the schools also have older piping infrastructure so they preferred the shell and tube evaporator as it is less susceptible to fouling and clogging up from dirty piping systems.

"Carrier is working with school districts across the country to implement layered HVAC replacement and retrofit solutions that improve learning environments. With solutions tailored to each schools' needs, Carrier is committed to helping foster the long-term well-being of students and staff and encourage the use of ESSER funds to make critical improvements that will impact generations of student."

**Steve Ribaldo**  
Vice President, North America  
Commercial HVAC, Carrier



## Carrier's Abound™ Suite of Connected Solutions

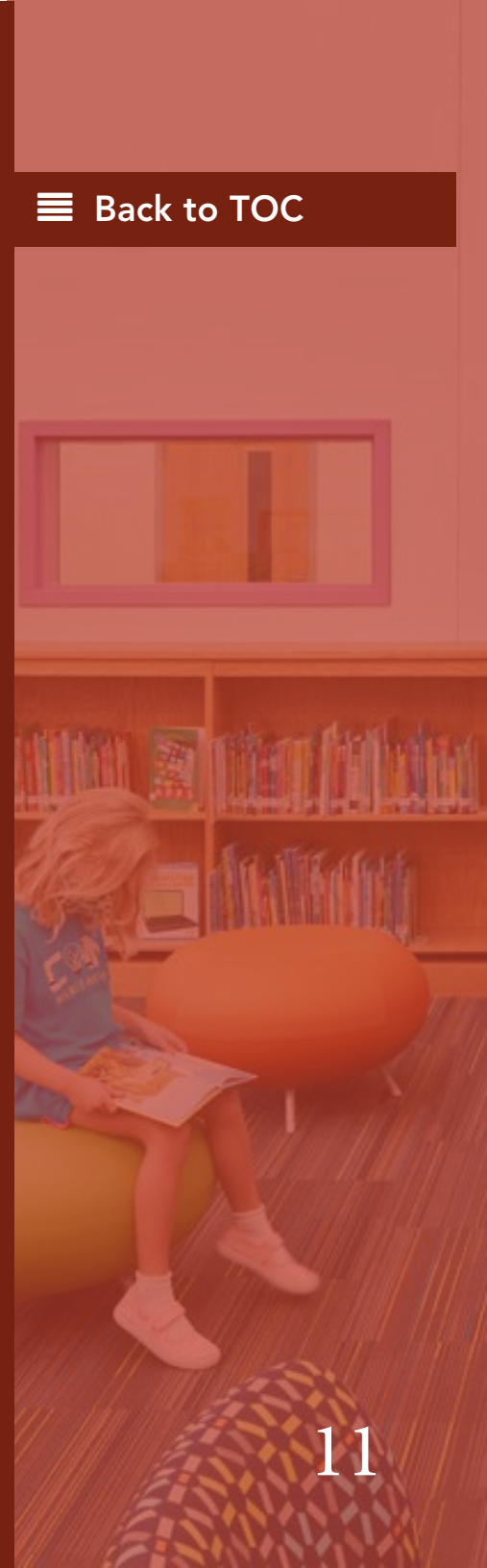
Abound gathers real-time performance data from disparate systems, equipment and sensors and presents it in a smart, user-friendly interface allowing school facility staff to make quick assessments and confident decisions.

- **Visualize:** Provides a clear view of all the school building systems across your entire building portfolio in one intuitive interface.
- **Analyze:** Unites disparate data and identifies anomalies in real time to resolve issues quickly.
- **Optimize:** Provides actionable insights and recommended solutions to take action to make learning environments more efficient, comfortable, sustainable and provide occupants with increased confidence in their indoor environments.

People spend <b>~90%</b> of our time indoors <sup>15</sup>	Indoor air can be <b>3-5x</b> more polluted <sup>15</sup>
Buildings account for <b>~40%</b> Of greenhouse gas emissions <sup>17</sup>	<b>1 in 5</b> existing buildings retrofitted to meet net-zero emissions by 2050 <sup>17</sup>
<b>&gt;4 billion</b> connected IoT devices in commercial buildings by 2028 <sup>18</sup>	Integrated smart building systems can reduce energy use <b>~10%- 20%</b> <sup>19</sup>

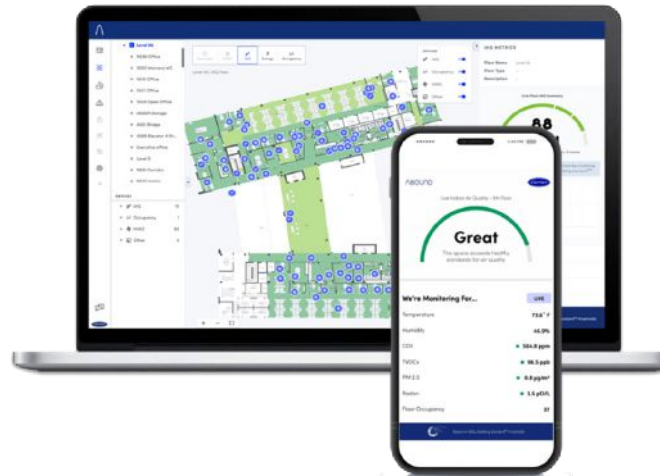
## Abound's Suite of Connected Solutions Healthy Air – Air Quality Monitoring

- **IoT Sensing:** Our internet-of-things, wireless IAQ sensors are easy to install, monitor and measure multiple air quality indicators. Monitor real-time and historical IAQ data, including temperature, humidity, CO<sub>2</sub>, PM<sub>2.5</sub>, VOCs, and radon by room, floor, building or for an entire portfolio of buildings. Detailed insights and suggestions help to optimize IAQ.

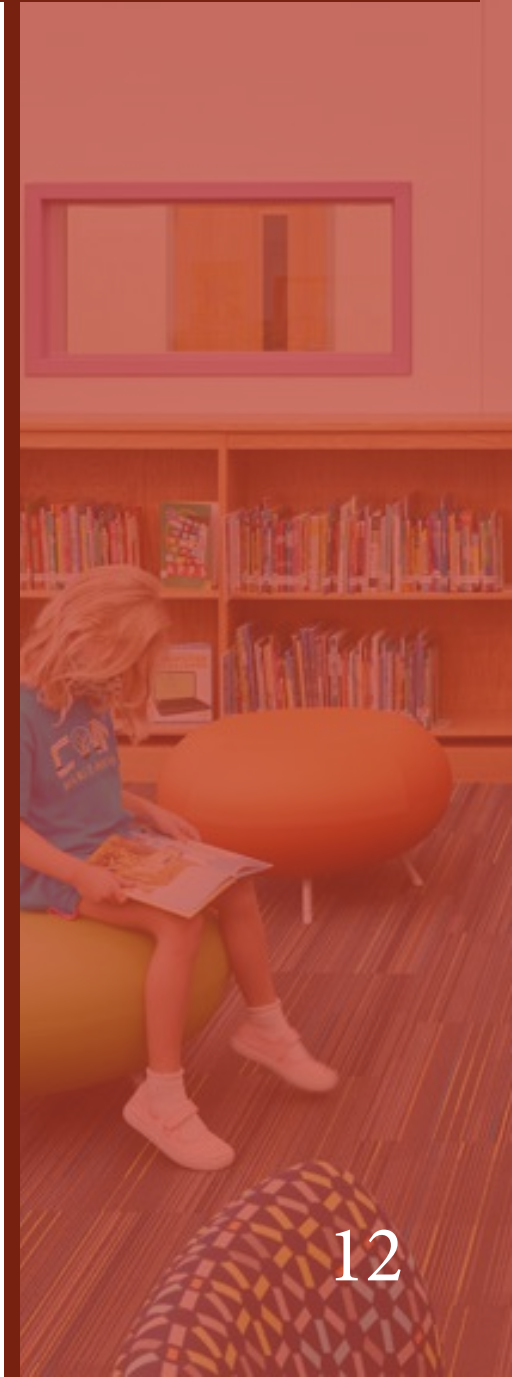


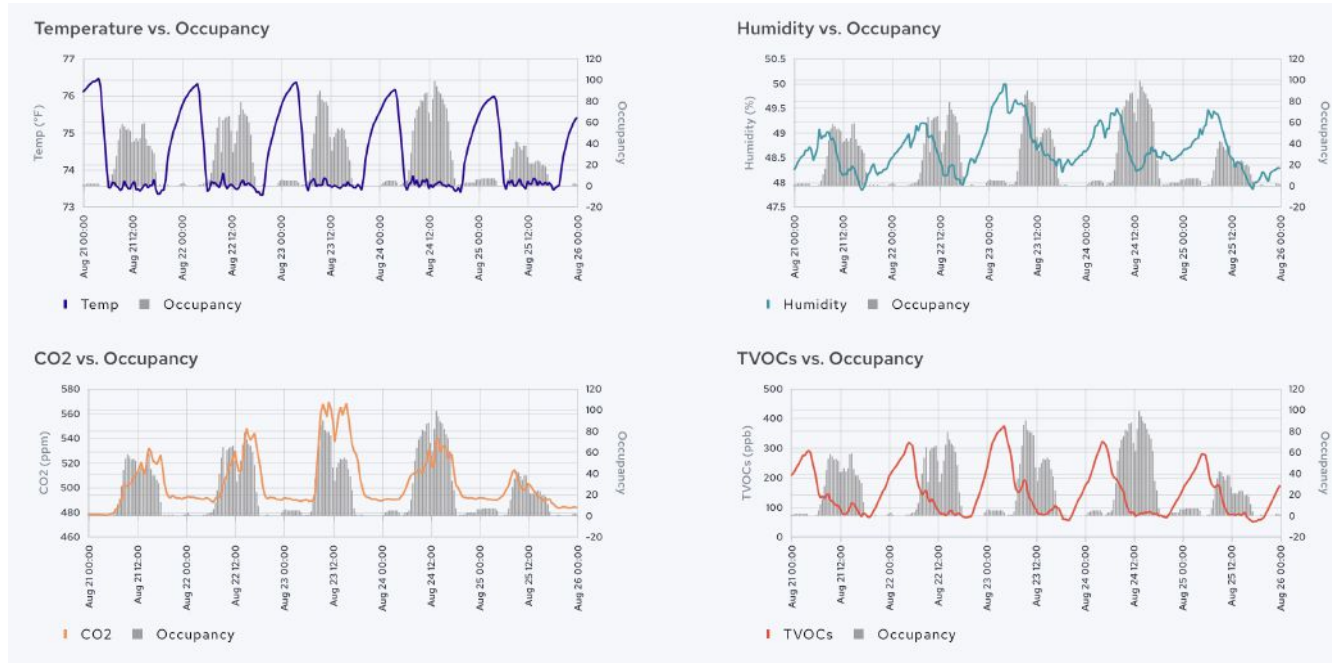
- **Health and Comfort Visualization:**

Get a real-time, unified view of all sensor readings. Easily monitor the IAQ of a building's spaces and floors with a color code system based on real-time data. Dark green means great, light green means good, yellow means caution and red denotes critical IAQ. These help build confidence in the quality of indoor spaces for students, teachers and staff.



- **BMS Integration:** Integrate new or existing IAQ sensor and HVAC equipment data from building management system (BMS).
- **Comparative Health Scores:** Compare IAQ readings to the International WELL™ Building Standard. Benchmark IAQ numbers within your spaces to gain further insights about your buildings.
- **Alerts & Analysis:** Receive notifications when IAQ levels move outside normal ranges. Alerts provide the location of the issue, possible solutions to the problem, and make it easy to share this information via email with other school personnel. Allowing issues to be corrected quickly.
- **Reporting:** Comprehensive template reports that can be customized to view specific metrics, building spaces, date ranges, etc. to help manage building efficiencies and IAQ.



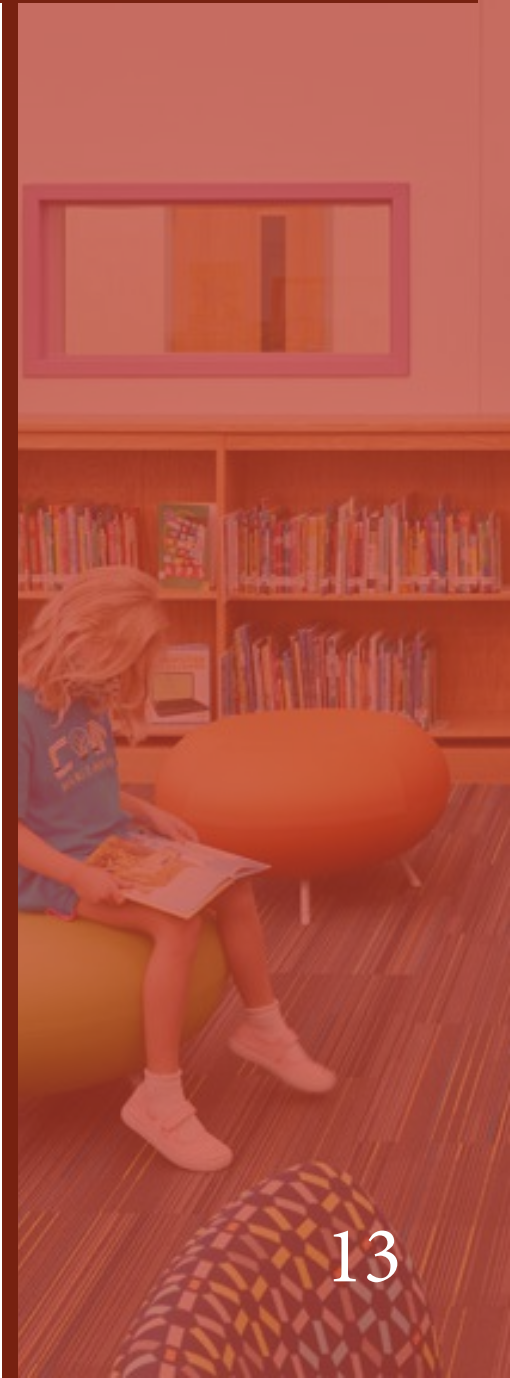


## Density Monitoring

Knowing when people are in the building, when they came and when they left, allows school building operators to adjust the building's HVAC system to meet the needs of occupants, help prolong equipment and provide energy savings management that is based on real-time data for individual spaces or an entire building. It also allows for understanding space utilization against healthy, sustainable and operational goals.

## Abound Predictive Insights – Equipment Monitoring:

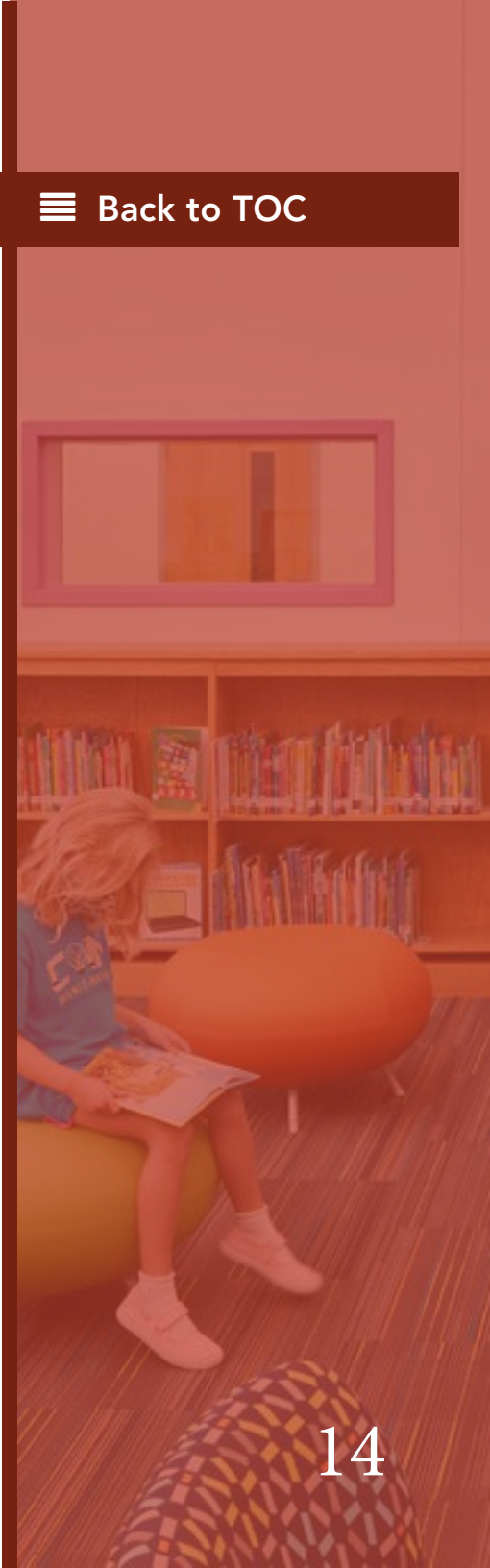
- **Track and analyze:** Examine real-time and historical data for critical building systems, including chillers, rooftop units, variable air volume (VAV) systems, refrigerated cases, freezers/coolers, unit heaters, air source and water source heat pumps, air handling units and boilers.



- **Leverage AI for predictive maintenance:** Easy to use data comes directly from the BAS and delivers recommendations to service technicians that are actionable.
- **Reduce operational costs of BAS and HVAC assets:** Obtain insights before alarms go off. Capture inefficiencies that lead to capital expenditures and proactively prepare facilities for replacement when needed.

### Abound Net Zero Management – Energy Usage and Greenhouse Gases (GHG) Emissions Monitoring

- **Track:** Consistently track and report real-time and historical energy usage data of an entire building portfolio, or drill down into individual school building metrics, to optimize energy spend and meet environmental, social and governance (ESG) goals with this award-winning offering.
- **Measure:** Collect utility billing data automatically and easily integrate submeter data installed at properties to get in-depth insights into usage and demand. Calculate GHG emissions based on regional emission factors across an entire school property portfolio.
- **Evaluate:** Accurately report on energy consumption, spend, and Scope 1 and 2 GHG emissions in an individual building, across multiple sites or benchmark against a set of buildings.
- **Take Action:** Make energy and emissions data readily accessible to school facility managers and administrators by generating consistent and timely reports, and downloading data and graphs. Identify underperforming equipment or



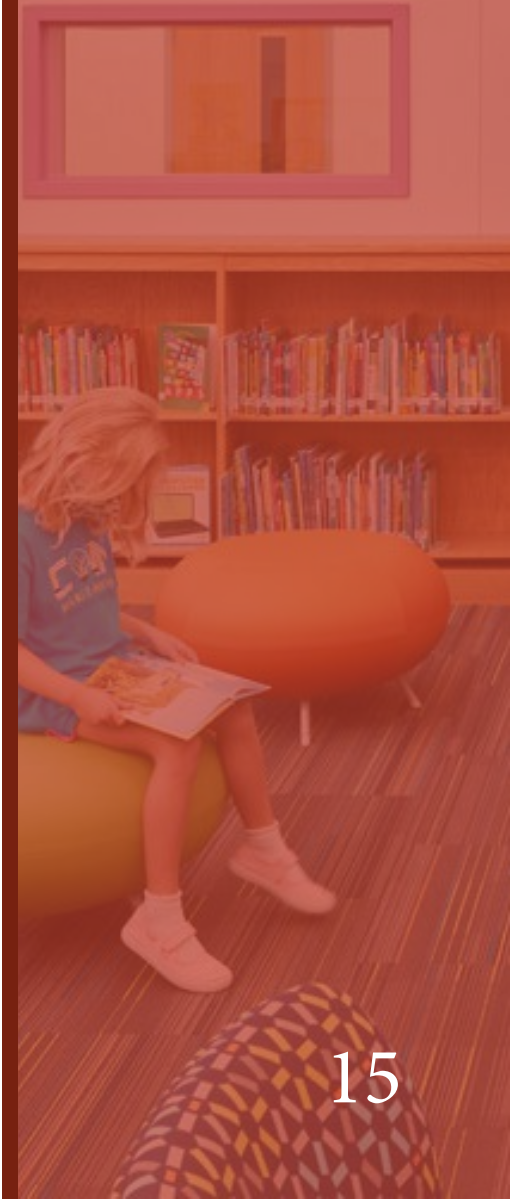
buildings, fix operational issues, such as inefficient scheduling, and institute new energy and carbon reduction initiatives to help reduce costs, mitigate risks and align with emerging regulations and ESG goals.

### Can Abound Work in Any School Building?

- 1. Introduce:** If the school doesn't currently have a BMS, Carrier Abound is the perfect way to start monitoring data from an entire building portfolio so that facility managers and administrators can gain important insights.
- 2. Enhance:** If the school or district already has a BMS, Abound Predictive Insights acts as an overlay so facility managers can see more information, extract valuable insights and enhance their value by allowing them to address issues more proactively.
- 3. Integrate:** As an open platform, the Carrier Abound platform integrates the current BMS. While it complements BMS systems made by Carrier, including Carrier i-Vu® and Automated Logic WebCTRL®, Abound's use of open protocols allows for seamless integration with many building systems from a variety of manufacturers.

### Southeastern School Monitors IAQ with Abound Platform

- 1. Challenge:** A school district, in the southeastern U.S., sought to enhance and more closely monitor air quality and environmental conditions in one of their schools.
- 2. Implementation:** The district partnered with Carrier to implement the Abound platform in one building that covers 260,000 square feet. Abound complements



the school's BMS system and provides a more granular view of key air quality metrics, such as temperature, humidity, CO<sub>2</sub>, PM<sub>2.5</sub> and displays it on the Abound dashboard.

- 3. Result:** Abound provides facility staff with real-time insights about the health of a school's indoor spaces. Whenever air quality data is outside the WELL Building Standard's normal ranges, facility operators can make quick assessments and confident decisions to optimize their building's HVAC equipment in support of the health and well-being of all occupants.

"The Abound platform is very easy to navigate. Having a color-coded floor plan based on IAQ metrics, such as temperature, humidity, CO<sub>2</sub> humidity, or particulate matter, gives the team a much better view of the air quality in the building. Alerts on metrics that drift outside of the good health threshold are logged and can be sent to essential staff as they occur. Another great feature is that all of the IAQ data is trended and stored for future analysis.

*The Energy Management Control Specialist for the Southeastern School*

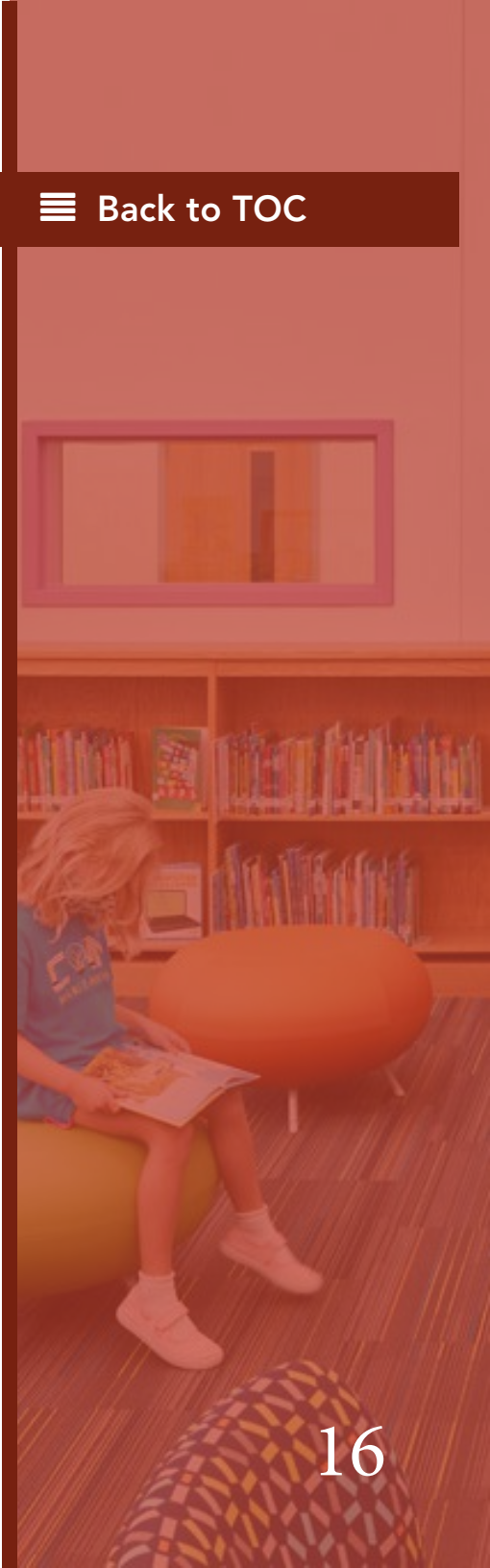
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### Center for Intelligent Buildings

The Carrier Center for Intelligent Buildings (CIB) is a first-of-its-kind showcasing the technology and innovation of Carrier's products and integrated systems, including Abound, BMS and HVAC equipment. It was designed and constructed with a healthy and sustainable focus, and it was the first commercial building in Florida to earn both Leadership in Energy and Environmental Design (LEED) and WELL Platinum designations. The 224,000 square foot building located in Palm Beach Gardens, Florida, features solutions and interactive displays from Carrier.

### Visit and Experience

The CIB is not simply meant to be visited; it's designed to be experienced. Customers from a variety of sectors, including school facility managers and administrators can observe the strength of Carrier's full suite of intelligent offerings in one integrated and interactive facility, and explore everything the Center has to offer:





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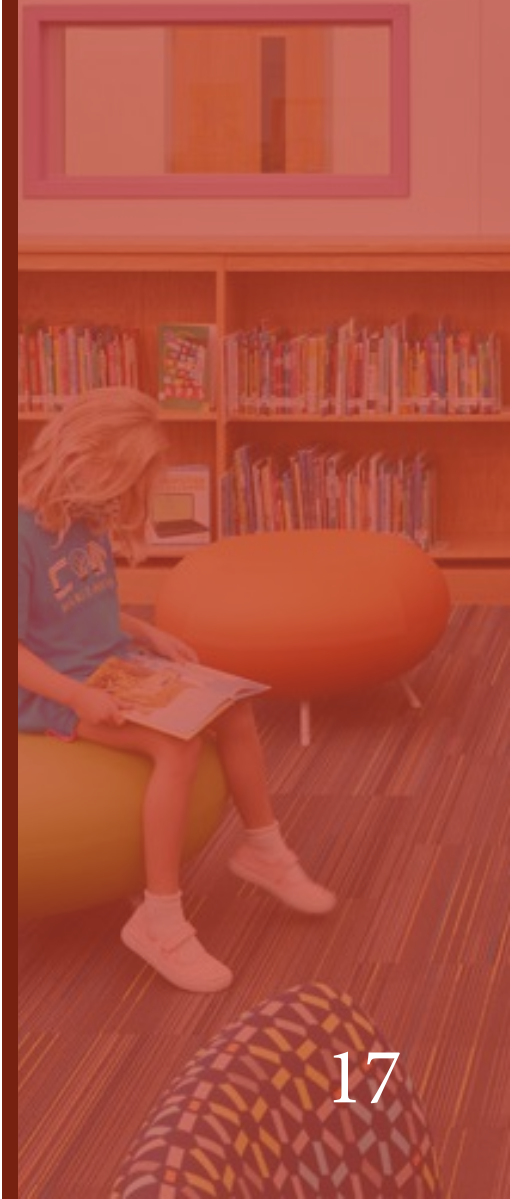
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- Best-in-class customer experience featuring immersive and interactive healthy and sustainable solutions
- State of the art briefing center and conference facilities
- Beautiful south Florida weather

### Citations

1. How To Reduce Student Absenteeism with Indoor Air Quality Improvements
2. APA Students Experiencing Stress
3. School Facility Conditions and Student Academic Achievement (escholarship.org)
4. The Effects of Classroom Temperature on Student's Performance | SitelogIQ
5. Indoor Air Quality in High Performance Schools | US EPA
6. Absenteeism in K-12 Schools: How Improving Indoor Air Quality Can Help | Sanalife (sanalifewellness.com)
7. What is Building Sustainability? (absa.net.au)
8. The Impact of Green Buildings on Cognitive Function
9. The Difference Between MERV and HEPA Air Filters
10. Indirect health effects of relative humidity in indoor environments
11. 2021 State of Our Schools
12. Understanding ESSER I, II and III Disbursements - MISBO
13. School Facilities Funding Pandemic ESSER III Planned Spending
14. Burbio School Tracker
15. Trends in Indoor Air Quality
16. ESSER Resources at School Outfitters
17. Buildings
18. IOT Devices in smart buildings
19. Smart Building Magazine

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