

## DEFICIENT INDOOR AIR QUALITY: A SERIOUS THREAT TO SCHOOLS

### Cleaner and healthier indoor air achieved via energy recovery ventilation improves the health, cognitive function, productivity and wellbeing of school occupants

By Nick Agopian

School buildings are extremely vulnerable to deficient indoor air quality (IAQ). This is especially true with improved energy-efficient air-sealing methodologies on the rise that not only trap in air but also numerous internally generated contaminants.

The best way to enhance IAQ is with increased ventilation, but conventional HVAC systems waste energy and therefore lead to additional costs. So how can IAQ be enhanced energy-efficiently, cost-effectively and sustainably in order to support the health and wellbeing of school occupants? The answer is through increased and balanced ventilation via energy recovery ventilators (ERVs). Let's take a look at why this is the case.

### The Challenge

#### Deficient IAQ Threatens School Buildings

With [buildings becoming increasingly air-sealed to improve energy efficiency](#), a consequence is a rise in deficient IAQ. This is a serious—yet often unnoticed—threat to occupant health, cognitive function, productivity and general wellbeing. Deficient IAQ is especially concerning because people are indoors about 90% of the time (the elderly 95%). Moreover, the Environmental Protection Agency (EPA) found that indoor air may be two to five times, and occasionally greater than 100 times, more polluted than outdoor air.<sup>1</sup>

Schools suffer considerably from deficient IAQ. The EPA determined that the typical school has approximately four times as many occupants as office buildings for the same amount of floor space.<sup>2</sup> This means that more carbon dioxide (CO<sub>2</sub>)—which is considered an indoor air contaminant—is exhaled into the air. What's more, the EPA found that about 50% of school buildings have problems linked to poor IAQ.<sup>3</sup>

Further, experts agree that the primary transmission route of SARS-CoV-2,



*Deficient IAQ threatens the health, cognitive function, productivity and wellbeing of school occupants*

the coronavirus that causes COVID-19, is through the air. Thus, due to their high-occupant densities, schools are quite vulnerable to the spread of airborne viruses that can lead to deadly diseases. This is especially true in school transient areas where occupant density is at its peak.

#### Deficient IAQ has Many Adverse Effects on School Occupants

[Deficient IAQ has numerous adverse effects](#) on all indoor occupants. Specific to schools, these include:



<sup>1</sup> All EPA facts from this paragraph are sourced from: "Why Indoor Air Quality is Important to Schools," EPA, <http://www.epa.gov/iaq-schools/why-indoor-air-quality-important-schools>.

<sup>2</sup> "Reference Guide for Indoor Air Quality in Schools," U.S. Environmental Protection Agency (EPA), <https://www.epa.gov/iaq-schools/reference-guide-indoor-air-quality-schools>.

<sup>3</sup> "50% of Schools Have Poor Indoor Air Quality: How Does Your Child's School Measure Up?," American Lung Association, August 22, 2018, <https://www.lung.org/media/press-releases/50-of-schools-have-poor-5>.

## Adverse Effects of Deficient IAQ on School Occupants

<b>Health problems</b>	<p>Deficient IAQ in schools can cause acute allergies, headaches, coughs, asthma, skin irritations and breathing difficulties, as well as chronic illnesses such as cancer, liver disease, kidney damage, nervous-system failure and even premature death. In fact, the EPA found that the presence of dampness and mold increases the risk of asthma and related adverse respiratory health effects by 30-50%.<sup>4</sup></p> <p>Further, the EPA determined that schools are at particular risk of experiencing deficient IAQ due to insufficient maintenance of facilities and HVAC systems. The problem is even worse in older buildings that need constant upkeep, including the majority of U.S. schools.<sup>5</sup> These facts are alarming considering more than 55 million school children and about three million adults in the U.S.—equaling 20% of the country’s population—enter the nation’s schools every day.<sup>6</sup> And the average child spends about 1,300 hours inside a school each year, while teachers and other employees spend even longer.<sup>7</sup></p> <p>Moreover, the onset of COVID-19 provided unique health challenges for school occupants, particularly from an IAQ perspective. For example, if the indoor air wasn’t ventilated sufficiently, airborne viruses could build up and cause diseases. Although children are less susceptible to serious illness from COVID-19, they can still suffer from long-COVID effects.<sup>8</sup> Further, during the pandemic, many school children missed or delayed preventive care appointments, thus creating potential long-term health issues. Additionally, the pandemic may have worsened children’s mental health or exacerbated existing mental health issues.<sup>9</sup></p> <p>Similar to SARS-CoV-2, another virus that spreads via droplets is Respiratory Syncytial Virus (RSV).<sup>10</sup> There is robust evidence supporting its airborne transmission, thus deficient IAQ due to lacking ventilation can increase its spread.<sup>11</sup></p>
<b>Problems magnified in children</b>	<p>Children are disproportionately vulnerable to the adverse effects of inhaling indoor air contaminants. According to the World Health Organization (WHO), children breathe more rapidly than adults, causing them to take in more pollutants.<sup>12</sup> What’s more, children’s immune systems are less developed and therefore provide a weaker defense.</p>
<b>Cognitive impairment</b>	<p>NASA, Harvard and the Lawrence Berkeley National Laboratory (LBNL) determined that deficient IAQ can cause cognitive impairment due to CO<sub>2</sub> exposure. This means that anyone inside a school building, including students, teachers and staff alike, is especially at risk because of the higher-than-average occupant density of schools, and hence the greater amount of CO<sub>2</sub>.</p> <p>In fact, Harvard found that, on average, a typical participant’s cognitive scores dropped 21% with a 400 parts per million (ppm) increase in CO<sub>2</sub>.<sup>13</sup> Such a rise isn’t hard to reach because even though the design standard for CO<sub>2</sub> levels in most buildings is 1000 ppm, LBNL found average CO<sub>2</sub> concentrations in elementary schools in California and Texas to be above 1,000 ppm, with a substantial proportion exceeding 2,000 ppm.<sup>14</sup></p>

*“Ventilation is one component of maintaining healthy environments and is an important COVID-19 prevention strategy for schools and childcare programs.”*

*-Centers for Disease Control and Prevention (CDC)*

<sup>4</sup> “How Does Indoor Air Quality Impact Student Health and Academic Performance?,” U.S. Environmental Protection Agency (EPA), <https://www.epa.gov/iaq-schools/how-does-indoor-air-quality-impact-student-health-and-academic-performance>.

<sup>5</sup> Sherry Everett Jones, PhD, MPH, JD, Nancy D. Brener, PhD, Tim McManus, MS, “Prevalence of School Policies, Programs, and Facilities That Promote a Healthy Physical School Environment,” American Journal of Public Health, September 2003, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1448012/>.

<sup>6</sup> “Healthy Schools: Environmental Factors, Children’s Health and Performance, and Sustainable Building Practices,” U.S. Environmental Protection Agency, October 8, 2013, [https://cfpub.epa.gov/ncer\\_abstracts/index.cfm/fuseaction/display.rfatext/rfa\\_id/568](https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.rfatext/rfa_id/568).

<sup>7</sup> Ibid.

<sup>8</sup> All information in this paragraph sourced from: Elizabeth Williams, Patrick Drake, “Headed Back to School: A Look at the Ongoing Effects of COVID-19 on Children’s Health and Well-Being,” Kaiser Family Foundation (KFF), August 5, 2022, <https://www.kff.org/coronavirus-covid-19/issue-brief/headed-back-to-school-a-look-at-the-ongoing-effects-of-covid-19-on-childrens-health-and-well-being/>.

<sup>9</sup> All information in this paragraph sourced from: Elizabeth Williams, Patrick Drake, “Headed Back to School: A Look at the Ongoing Effects of COVID-19 on Children’s Health and Well-Being,” Kaiser Family Foundation (KFF), August 5, 2022, <https://www.kff.org/coronavirus-covid-19/issue-brief/headed-back-to-school-a-look-at-the-ongoing-effects-of-covid-19-on-childrens-health-and-well-being/>.

<sup>10</sup> “RSV Transmission,” Centers for Disease Control and Prevention (CDC), <https://www.cdc.gov/rsv/about/transmission.html>.

<sup>11</sup> Wang et al., “Airborne transmission of respiratory viruses,” Science, August 27, 2021, <https://www.science.org/doi/10.1126/science.abd9149>.

<sup>12</sup> “More than 90% of the world’s children breathe toxic air every day,” World Health Organization (WHO), October 29, 2018, <https://www.who.int/news/item/29-10-2018-more-than-90-of-the-worlds-children-breathe-toxic-air-every-day>.

<sup>13</sup> Joe Romm, “Exclusive: Elevated CO<sub>2</sub> Levels Directly Affect Human Cognition, New Harvard Study Shows,” Climate Progress, October 26, 2015, <https://archive.thinkprogress.org/exclusive-elevated-co2-levels-directly-affect-human-cognition-new-harvard-study-shows-2748e7378941/>.

<sup>14</sup> Ibid.

## Adverse Effects of Deficient IAQ on School Occupants cont.

<b>Diminished academic performance</b>	<p>The EPA determined that negative environmental factors, such as deficient IAQ, can harm students' ability to perform academically. Specifically, the EPA found that:</p> <ul style="list-style-type: none"> <li>When the school environment is unhealthy, which can occur with poor ventilation, children can be exposed to allergens, pollutants, chemicals and adverse classroom conditions that can cause their academic performance to suffer.<sup>15</sup></li> <li>Children in poorly ventilated classrooms tend to score lower on standardized tests in math and reading than children in classrooms with higher outdoor-air ventilation rates.<sup>16</sup></li> </ul>
<b>Increased absenteeism</b>	<p>According to the EPA, deficient IAQ in schools can result in absences because of respiratory infections, allergic diseases from biological contaminants or irritant reactions to chemicals used in virtually every part of the school. Some conditions in the school environment are closely associated with the incidence of Sick Building Syndrome (SBS) and asthma symptoms, and asthma-related illness is one of the leading causes of school absenteeism, accounting for over 10 million missed school days per year.<sup>17</sup></p>

## The Solution

### Energy Recovery Ventilation is the Best Choice for Enhancing IAQ

What's the best way to provide cleaner and healthier air inside school buildings? The answer is increased and balanced ventilation. As long as enough controlled and filtered fresh outdoor air is coming in and stale indoor air is exhausted out, interior spaces will enjoy high-quality air. In fact, the American Lung Association states that proper ventilation is essential for keeping the air fresh and healthy indoors.<sup>18</sup>

Further, to stop the spread of airborne viruses, cognizant authorities recommend a [layered approach with increased ventilation at its core](#). For example:

- The Centers for Disease Control and Prevention (CDC) advises using multiple mitigation strategies, including improvements to building ventilation, to reduce the spread of disease and lower the risk of exposure.<sup>19</sup>
- Regarding schools, the CDC states: "Ventilation is one component of maintaining healthy environments and is an important COVID-19 prevention strategy for schools and childcare programs."<sup>20</sup>
- ASHRAE states: "Ventilation and filtration provided by heating, ventilating and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air."<sup>21</sup>
- Regarding schools, ASHRAE states: "The underlying effort of the designer should be to mitigate risk of airborne pathogen transmission through a combination of strategies, including increased ventilation, better filtration, improved air distribution or use of other air cleaning or treatment technologies."<sup>22</sup>

Due to their high occupant density, cognizant authorities understand the risk posed by transient areas in schools. Standards, like increasing hallway

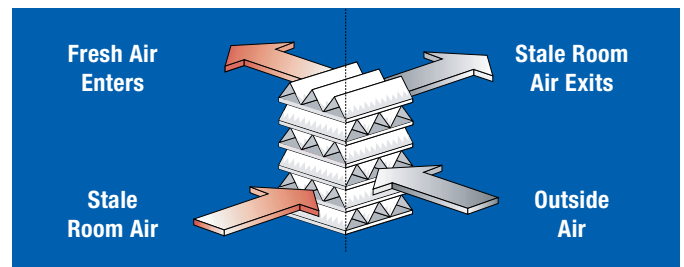
ventilation by 60%, are being developed to raise outdoor air rates in these high traffic and transient locations.

However, increasing ventilation rates in schools can also lead to higher energy consumption and costs. Thus, how can IAQ be enhanced while also optimizing energy efficiency and cost savings? The best way is via energy recovery ventilation, which [enhances IAQ while maximizing sustainability](#).

ERVs precondition the outdoor air coming in with the otherwise-wasted exhaust air's heat and humidity. This leads to substantial reductions in energy and equipment costs. Consequently, the EPA states that "ERVs provide excellent opportunities for saving energy, controlling humidity and providing sufficient outside air to promote IAQ."<sup>23</sup>

### Increased Building Ventilation Rates Bolster Occupant Health

In the post-pandemic new normal, a spotlight has been shown on the criticality of enhanced IAQ to safeguard occupant health. This can be achieved with greater amounts of fresh and filtered outdoor air that's ventilated indoors. With increased ventilation rates, aerosols and other indoor air contaminants are continuously diluted, reducing the intensity of exposure.



ERVs use otherwise-wasted total energy (heat and humidity) from the exhaust airstream to condition incoming outdoor air. Source: RenewAire

<sup>15</sup> "About the State School Environmental Health Guidelines," U.S. Environmental Protection Agency (EPA), <https://www.epa.gov/schools/about-state-school-environmental-health-guidelines>.

<sup>16</sup> "Evidence from Scientific Literature about Improved Academic Performance," U.S. Environmental Protection Agency (EPA), <https://www.epa.gov/iaq-schools/evidence-scientific-literature-about-improved-academic-performance>.

<sup>17</sup> "Indoor Air Quality and Student Performance," U.S. Environmental Protection Agency (EPA), <https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=100045VK.TXT>.

<sup>18</sup> "Ventilation: How Buildings Breathe," American Lung Association, <https://www.lung.org/clean-air/at-home/ventilation-buildings-breathe>.

<sup>19</sup> "Ventilation in Buildings," Centers for Disease Control and Prevention (CDC), June 2, 2021, <https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html>.

<sup>20</sup> "Ventilation in Schools and Childcare Programs," Centers for Disease Control and Prevention (CDC), Updated February 26, 2021, <https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/ventilation.html>.

<sup>21</sup> "ASHRAE Epidemic Task Force Filtration & Disinfection," ASHRAE, October 21, 2021, <https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-filtration-disinfection-c19-guidance.pdf>.

<sup>22</sup> "ASHRAE Epidemic Task Force Schools & Universities," ASHRAE, Updated 5-14-2021, <https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-reopening-schools-and-universities-c19-guidance.pdf>.

<sup>23</sup> "IAQ Building Education and Assessment Model (I-BEAM)," U.S. Environmental Protection Agency (EPA), January 19, 2017, [https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/text\\_modules\\_energy\\_efficiency.pdf](https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/text_modules_energy_efficiency.pdf).

In fact, ASHRAE recommended the following in its [Epidemic Task Force Building Readiness Report](#): “There is potential that building operators could increase their systems’ outdoor air ventilation to reduce the recirculation air back to the space. The guidance indicates that this should be done, if it is the selected mitigation strategy for this system, as much as the system and or space conditions will allow.”<sup>24</sup>

In addition, the market now demands buildings that are better for both occupant health and the environment. Standards are evolving to keep up, such as the forthcoming ASHRAE 62.1, Section 42P on “Enhanced Indoor Air Quality in Commercial and Institutional Buildings.” It’s still under review, but once approved it will recommend exceeding minimum building ventilation requirements for enhancing IAQ.<sup>25</sup>

What’s more, several green-building certifications require extra ventilation over code. These include:

- ♦ **LEED:** Requires increasing breathing zone outdoor air ventilation rates to

all occupied spaces by at least 30% above the minimum rates required by ASHRAE Standard 62.1-2007.<sup>26</sup>

- ♦ **WELL:** The Enhanced Ventilation feature of the WELL certification requires implementation of advanced ventilation strategies that can secure higher air quality levels. Projects exceeding outdoor air supply rates described in ASHRAE 62.1-2010 by 30% or 60% receive one or two points respectively. If CO<sub>2</sub> levels are kept at either 900 ppm, 750 ppm or 600 ppm, it’s worth one, two or three points respectively.<sup>27</sup>

## The Results

### Enhanced IAQ Improves the Health, Cognitive Function, Productivity & Wellbeing of School Occupants

Enhancing IAQ energy-efficiently, cost-effectively and sustainably through energy recovery ventilation results in numerous benefits for school occupants. These include:

Benefits of Enhanced IAQ for School Occupants	
<b>Better health for students, teachers and staff</b>	By breathing cleaner and healthier indoor air all day long at school, students, teachers and staff will experience fewer short- and long-term health problems.
<b>Reduced rates of airborne diseases, such as COVID-19</b>	Cleaner and healthier indoor air can be highly effective at decreasing the spread of airborne viruses that can cause harmful diseases. For example, the CDC found that the incidence of COVID-19 was shown to be 39% lower in schools that improved ventilation. <sup>28</sup>
<b>Strengthened cognitive function</b>	By removing contaminants from the indoor air, school occupants can improve their overall cognitive function. A Harvard study found that, on average, when compared to an indoor environment with deficient IAQ, cognitive scores were 61% higher in a simulated green-building environment and 101% higher in a simulated green-building environment coupled with doubling the outdoor-air ventilation rate from 20 CFM per person to 40 CFM per person. <sup>29</sup>
<b>Improved test scores</b>	The EPA found that children in classrooms with higher outdoor-air ventilation rates scored 14-15% better on standardized tests than children in classrooms with lower outdoor-air ventilation rates. <sup>30</sup>
<b>Reduced absenteeism</b>	The EPA found that raising classroom outdoor-air ventilation rates can reduce absenteeism by approximately five to 10 absences per 1,000 students for a 1,000 ppm decrease in the difference between indoor and outdoor CO <sub>2</sub> levels. <sup>31</sup>

## In Sum

Schools are at tremendous risk of suffering from deficient IAQ. Indeed, with increased air-sealing methodologies on the rise, the quality of indoor air is getting worse. On top of that, the risks of low-level IAQ were only amplified during the COVID-19 pandemic as the consequences can be severely detrimental to occupant health.

By enhancing IAQ through increased and balanced ventilation, the benefits to school occupants are numerous. These include improved health, cognitive function, productivity, wellbeing and peace of mind knowing you’re safeguarded from airborne viruses and other contaminants. And this can

all be achieved energy-efficiently, cost-effectively and sustainably through energy recovery ventilation.

*Nick Agopian is Vice President, Sales and Marketing at [RenewAire](#). For over 35 years, RenewAire has been a pioneer in improving people’s health, cognitive function, productivity and wellbeing by enhancing IAQ via energy recovery ventilation technologies. This is done energy-efficiently, cost-effectively and sustainably via sixth-generation, static-plate, enthalpy-core energy recovery ventilators (ERVs) and dedicated outdoor air systems (DOAS). For more information, visit: [www.renewaire.com](http://www.renewaire.com).*

<sup>24</sup> “Building Readiness,” American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), <https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-building-readiness.pdf>.

<sup>25</sup> “ASHRAE Guideline 42P, Enhanced Indoor Air Quality in Commercial and Institutional Buildings (Public Review Draft),” ASHRAE, July 2021, <https://docplayer.net/217513149-Enhanced-indoor-air-quality-in-commercial-and-institutional-buildings.html>.

<sup>26</sup> Increased ventilation, LEED, <https://www.usgbc.org/credits/eq13>.

<sup>27</sup> “Enhanced Ventilation,” WELL, <https://v2.wellcertified.com/v/en/air/feature/6>.

<sup>28</sup> J.C. Winck, S.M. Almeida, G. Correia, M.F. Gabriel, G. Marques, M.G. Silva, “A call for a national strategy for indoor air quality,” Pulmonology Journal, July - August 2022, <https://www.journalpulmonology.org/en-a-call-for-national-strategy-articulo-S2531043722000484>.

<sup>29</sup> Allen et al., “Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments,” Environmental Health Perspectives, October 26, 2015, <https://pubmed.ncbi.nlm.nih.gov/26502459/>.

<sup>30</sup> “About the State School Environmental Health Guidelines,” U.S. Environmental Protection Agency (EPA), <https://www.epa.gov/schools/about-state-school-environmental-health-guidelines>.

<sup>31</sup> “Frequently Asked Questions about Improved Academic Performance,” U.S. Environmental Protection Agency (EPA), <https://www.epa.gov/iaq-schools/frequently-asked-questions-about-improved-academic-performance#expect>.