LIGHT PROGRESS
UV-C Technology Solutions since 1987

UV-FACTS
ARTICLE SERIES
SEPTEMBER 2023

The ABCs of IAQ:

WHY INDOOR AIR QUALITY MATTERS FOR SCHOOLS

Indoor air quality (IAQ) refers to the condition of the air inside a building, such as a school, and how it affects the health, comfort, and performance of the occupants. IAQ depends on many factors, including the sources of pollutants, the ventilation system, the design and maintenance of the building, and the activities and behaviors of the people inside.

THE BENEFITS OF IAQ FOR STUDENTS, TEACHERS, AND SCHOOL BUDGETS

Schools are places where students and staff spend a significant amount of time, typically more than six hours a day. Therefore, **the quality of indoor air has a direct impact on their overall well-being and learning and performance outcomes**.

Poor IAQ in schools can cause or exacerbate several health problems, including asthma, allergies, respiratory infections, headaches, fatigue, nausea, and eye, nose and throat irritation.

These health effects can lead to **increased absenteeism, decreased concentration and productivity, lower test scores, and higher medical costs**.

Poor IAQ can also lead to **higher operating costs** and even damage to school buildings and equipment, resulting in higher maintenance and repair costs.

NUMBERS DON'T LIE: SOME FACTS AND RESEARCH

Scientists who study virus transmission see a big lesson in the recent pandemic school closures: **if indoor air had been cleaner and safer, they may have been preventable.**

Studies and research during the recent coronavirus pandemic show that **the incidence of COVID** - an airborne threat - was about **40% lower in schools that improved air quality**.

Schools that combined better ventilation with filtration had 48% fewer cases.

A study in Italy measured IAQ in more than 10,000 classrooms and estimated that students in classrooms equipped **with ventilation systems or devices that provide clean air had at least a 74% lower risk of infection than** students in classrooms **with only open windows**.

A survey last year found that **70% of 420 schools had evaluated their ventilation systems**, although many had made only low-cost improvements such as opening doors or windows; one in three school districts had begun or planned to improve air quality, and **more than a quarter had installed or planned to install air purifiers**.

But until recently, **it wasn't even clear to school officials how clean the air in school buildings should be**, and we were asking school districts and facilities to make decisions and investments they didn't really understand.

Several guidelines make it clear that in order to mitigate "infected" indoor air, we need to have a significant outdoor air exchange or equivalent air exchange (eACH) per hour.

The latest standard recommends that classrooms get **at least 6 ACH**, or six air changes - the equivalent of replacing all the air in a room - per hour.

A major study underscores that **the probability of infection from spending 6 hours in a classroom is higher than being hospitalized for 24 hours**, yet there is no clear understanding of the risk of sending students to school without a specific, structured strategy to protect them from this threat.

Scenario	ACH	Exposure time (h)	Infection Probability (%)
Hospital	3	24	0.8
	6		0.4
	9		0.3
	12		0.2
Classroom	3	6	1.5
	6		0.8
	9		0.5
	12		0.4

Source: "The impact of heating, ventilation, and air conditioning design features on the transmission of viruses, including the 2019 novel coronavirus" Journal of Public Health

WHY YOU SHOULD CARE ABOUT CO2 AND IAQ MONITORING

CO2 monitoring is a useful way to estimate the ventilation rate in a building and can **help assess whether or not the ventilation rate is adequate** for the occupancy level and activity type in a building.

If the **CO2 level is too high**, it indicates that the **ventilation rate is too** low and more outdoor air should be brought in to dilute indoor pollutants and pathogens. If the **CO2 level is too low**, it indicates that **the ventilation rate is too high and energy could be saved** by reducing the outdoor air supply.

So CO2 first, but **what else should you monitor**?

It would be wise to monitor several metrics, such as carbon dioxide (CO2), particulate matter (PM), and volatile organic compounds (VOCs), even though they do not reflect the presence or absence of airborne pathogens.

But what would be really interesting is to imagine a **system that**, **after monitoring**, **also triggers actions** and consequences in real time **to optimize ventilation consumption with the goal of achieving high IAQ standards**.

KNOWING YOUR BUILDINGS: HOW TO INCREASE IAQ WITHOUT INCREASING ENERGY USE

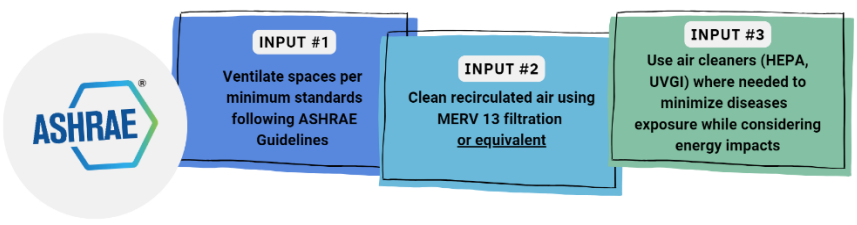
To improve IAQ in school buildings, we must first understand **how ventilation works** in these facilities.

If there is **no mechanical** system, **windows and/or fans may be used**; if there is a **mechanical system**, it is often **only for temperature and not for ventilation** (i.e., radiators).

If a **heating/cooling system is present**, it may be **decentralized** (with or without filters and with or without outdoor air mixing); a **centralized system** (100% recirculation or recirculation + ventilation) serves several rooms and heats and cools recirculated air or mixes outdoor air with recirculated air during heating and cooling. They typically have a filtration stage (i.e., AHU and RTU unit).

It is widely agreed that **ventilation**, which brings fresh outdoor air indoors and dilutes pathogens, is an **effective countermeasure to prevent disease transmission**, but it is recognized that **additional outdoor air is not always possible and trade-offs must be considered** (ASHRAE 2021).

Typical **schools are designed for 3 ACH**, but often, due to lack of investment and proper maintenance, the **value drops to half of that**, far from the 5/6 ACH in the guidelines.



Furthermore, in many of the climates of interest, **it is difficult to economically provide outdoor air** above the minimum for much of the year.

The outdoor air is simply too cold, too hot, or too humid**.**

IAQ OPTIONS	BUILDING SYSTEM TYPE				
	Radiators, no Conditioning	Unit Ventilator	Decentralized heating/cooling	Central System serving one or multiple Rooms / Areas	
				100% Recirculation	Recirculation + Ventilation (fresh air)
Ventilation: Mechanical		✓			✓
Ventilation: Natural (windows)	✓		✓	✓	
HVAC Filtration		Depending on pressure drop, might need to increase filters	Depending on pressure drop, might need to increase filters	Depending on pressure drop	Depending on pressure drop
In-Room HEPA Air Cleaners	✓	✓	✓	✓	✓
Upper Air GUV	✓	✓	✓	✓	✓
In-Duct GUV				✓	✓

Source: "The Center for Green School" Indoor Air Quality Fact Sheets see USGBC here www.usgbc.org

If the goal is to remove pathogens from where they come from (the classroom) and ventilation is natural, once you have received an alarm about rising Co2 levels the only solution is to open windows.

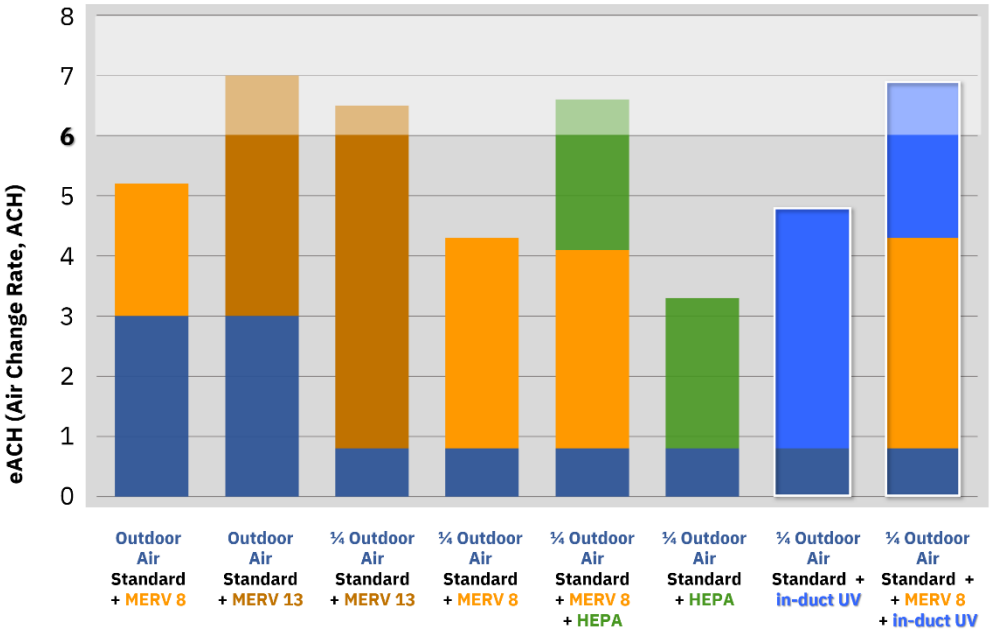
But are we sure that bringing in more outside air is always a good and effective idea?

Filtration is a good alternative solution. However, in-room filters such as **HEPA** can create hazardous waste and quickly lose their effectiveness by trapping dust and other contaminants.

In a ventilation system, ASHRAE recommends using **MERV 13 filters**, but they require larger and more powerful HVAC systems, which usually lead to a system upgrade. In addition, they may not be effective at diluting or removing airborne pathogens such as viruses or bacteria that can cause infection or disease.

If you look at the comparison made by ***Green Building***, many solutions or combinations of solutions can be good alternatives to get to the 6ACH required to have a good IAQ level in a school building.

Their suggestion is that sometimes **a combination of less efficient filters with GUV can provide better IAQ without the need for HAVC upgrades and more energy consumption**.



Source: "The Center for Green School" Indoor Air Quality Fact Sheets see USGBC here www.usgbc.org

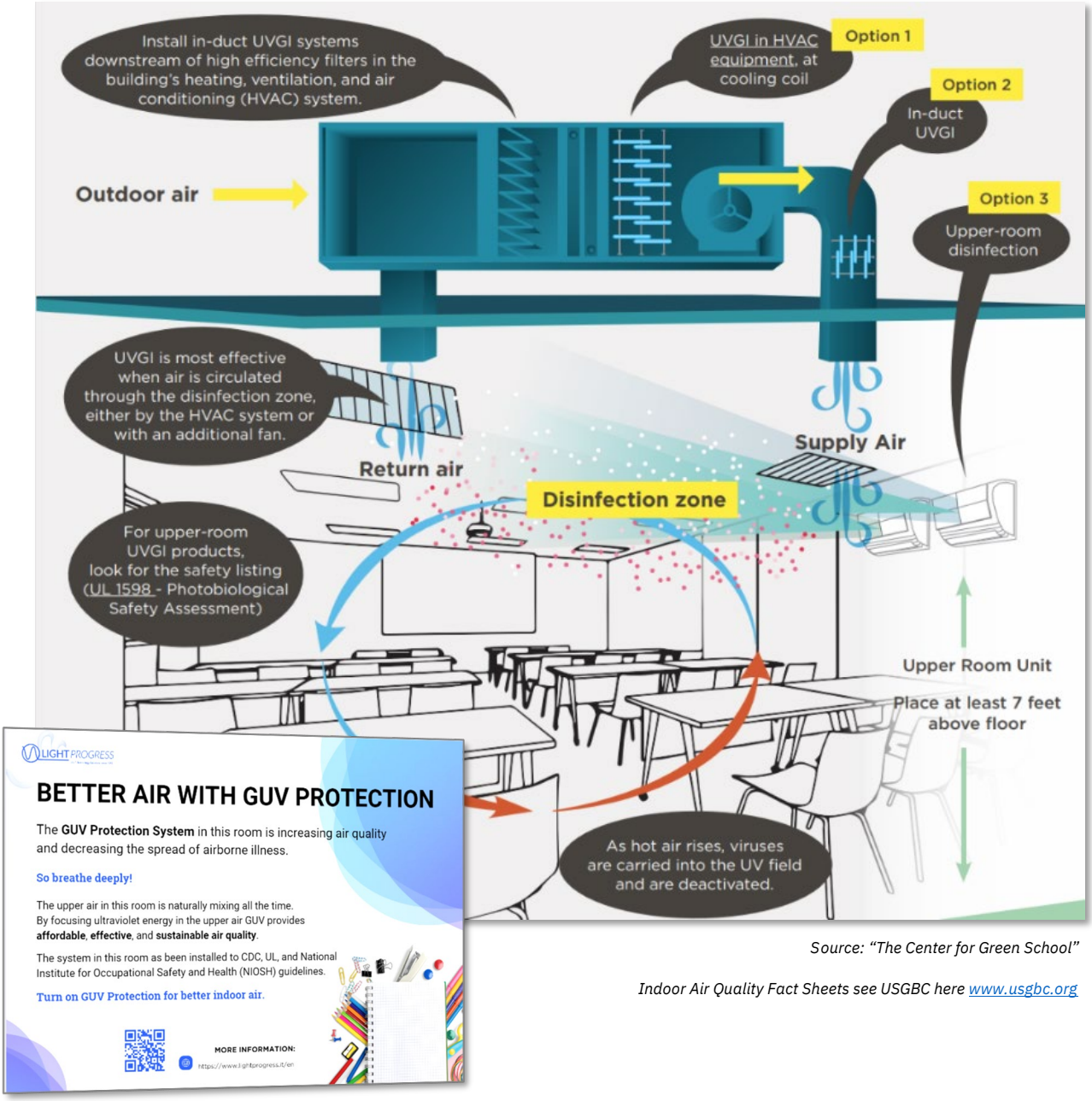
DIFFERENT APPLICATION OPTIONS OF GUV TECHNOLOGY FOR IAQ IMPROVEMENT

UV can be applied to improve indoor air quality by killing microorganisms and reducing pollutants.

There are **two common ways to use UV technology**: **inside the HVAC** or to perform **in-room disinfection**.

In HVAC, UV devices can treat the surface of the coil system or inside the duct network, treating the airstreams before it enter the occupied area.

For **In-room disinfection**, the choice is between a static or a dynamic GUV system. **Air purifiers** use a ventilator to collect the air and disinfect it inside a UV chamber, static disinfection is usually called **"upper air"** systems.



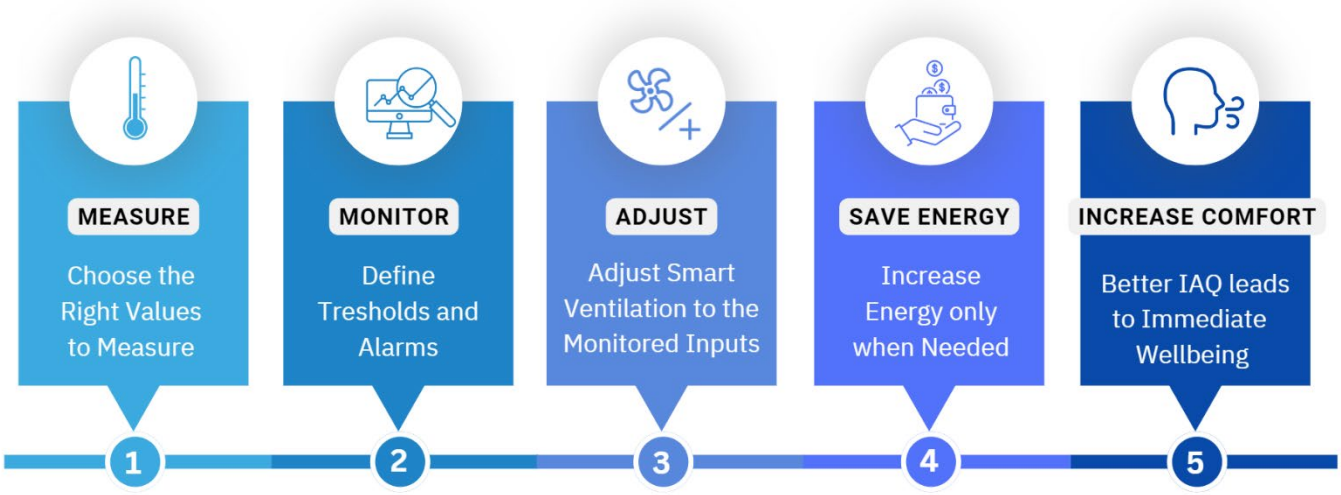
Source: "The Center for Green School"

Indoor Air Quality Fact Sheets see USGBC here www.usgbc.org

BE SMART, BREATH BETTER; SPEND LESS.

A smart ventilation system is a **revolutionary solution that can optimize both IAQ and energy efficiency**. Unlike traditional ventilation systems that operate at a constant or fixed rate, a **smart ventilation system can adjust** the ventilation rate **according to your needs and preferences**, the **indoor and outdoor** conditions, and the **energy costs**.

A smart ventilation system can use **various sensors or signals**, such as CO2, humidity, TVOC, occupancy, outdoor temperature, etc., to monitor the IAQ and the ventilation demand. It can also use different strategies or algorithms to control the ventilation rate, such as averaging over short periods, scheduling, tracking energy performance, etc.



A **smart ventilation system** can provide **multiple benefits**, such as:

- → **Improved IAQ:** A smart ventilation system can reduce the pollutant concentrations, exposure levels, health risks, and discomfort levels in your indoor environment. It can also use filtration devices and germicidal ultraviolet (GUV) radiation to capture and destroy airborne contaminants, such as dust, pollen, mold spores, bacteria, and viruses.
- → **Energy savings:** A smart ventilation system can reduce the ventilation energy use and the heating and cooling energy use by adjusting the ventilation rate according to the actual demand. It can also use heat recovery ventilation to recover the thermal energy from the exhaust air and preheat or precool the incoming air.
- → **Cost savings**: A smart ventilation system can reduce the total energy cost by minimizing the energy waste and maximizing the energy efficiency. It can also reduce your maintenance cost by preventing biofilm growth on coils and ducts using GUV.

A smart ventilation system is a **smart investment** that can enhance **comfort**, **health**, **safety**, and **productivity**. It is also a smart choice that can **contribute to environmental sustainability and climate change mitigation**.

A smart ventilation system is the ultimate solution for the IAQ and energy efficiency needs.

References
B. Abboushi, G. Arnold, J. Tuenge, T. Salsbury: PNNL; J. DeGraw: Oak Ridge National Laboratory E. Nardell: Harvard Medical School Energy Implications of Using Upper Room GUV and HVAC Strategies to Combat SARS-CoV-2
The COVID-19 pandemic learning loss and recovery | McKinsey
This scientist says cleaning indoor air could make us healthier—and smarter | Science | AAAS Joseph Allen - Douglas Starr
Almaimani, A.; Alaidroos, A.; Krarti, M.; Qurnfulah, E.; Tiwari, A. Evaluation of Optimal Mechanical Ventilation Strategies for Schools for Reducing Risks of Airborne Viral Infection. https://doi.org/10.3390/buildings13040871
Air Disinfection for Airborne Infection Control with a Focus on COVID-19: Why Germicidal UV is Essential† Edward A. Nardell* Division of Global Health Equity, Brigham & Women's Hospital, Harvard Medical School, Boston, MA.
Design Guidance for Education Facilities: Prioritization forAdvanced Indoor Air Quality - Developed by ASHRAE Technical Committee 9.7, Educational Facilities