BUILDINGS AND PEOPLE: MANAGING HEALTH AND SAFETY DURING A PANDEMIC

GREENER U

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INTRODUCTION

The coronavirus pandemic is the largest global health crisis of the past century. The American death toll hit a terrifying 100,000 milestone on May 27, 2020. While the curve is gradually flattening and businesses are reopening, history shows that resurgences can create new waves of outbreaks, leading to more periods of shutdown and delayed economic recovery.

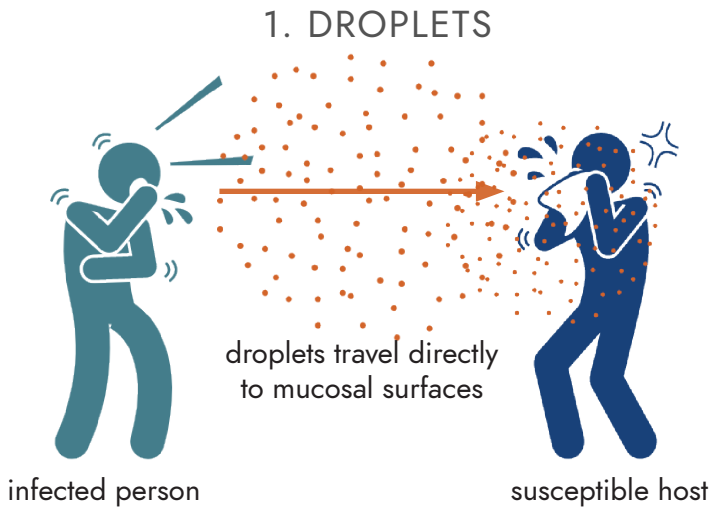
This paper offers the following:

1. An overview of how COVID-19 is transmitted—to the best of our current understanding
2. Suggested behavior change methods to communicate, contextualize, and motivate students, faculty, and staff to remain vigilant while returning to campus during the covid pandemic
3. Methods of preventing the transmission of COVID-19 via building operations
4. Short-term strategies to prevent the transmission of covid before reoccupying spaces
5. Longer-term strategies to prevent the transmission of covid in occupied spaces

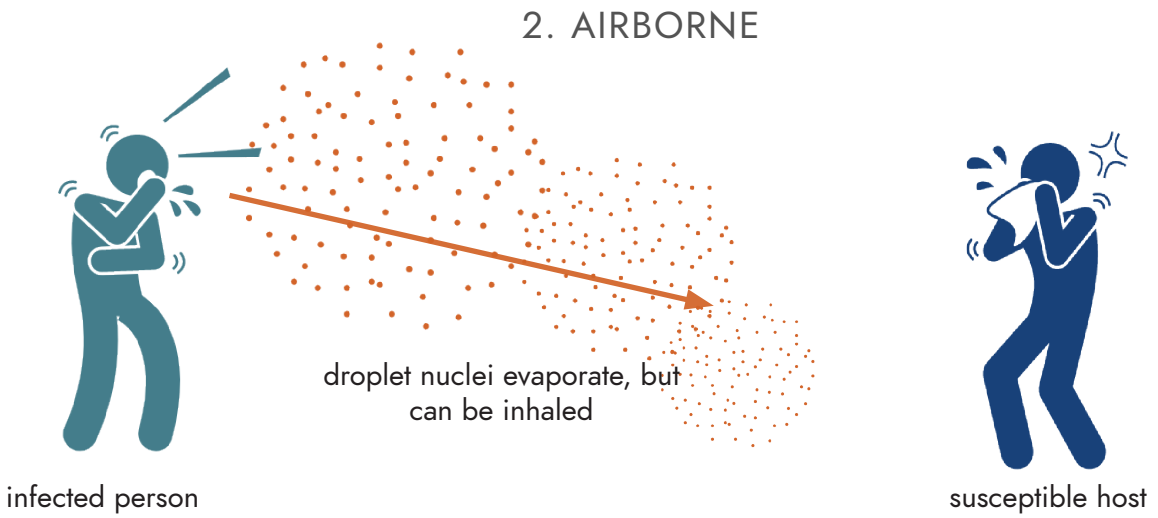
MODES OF TRANSMISSION

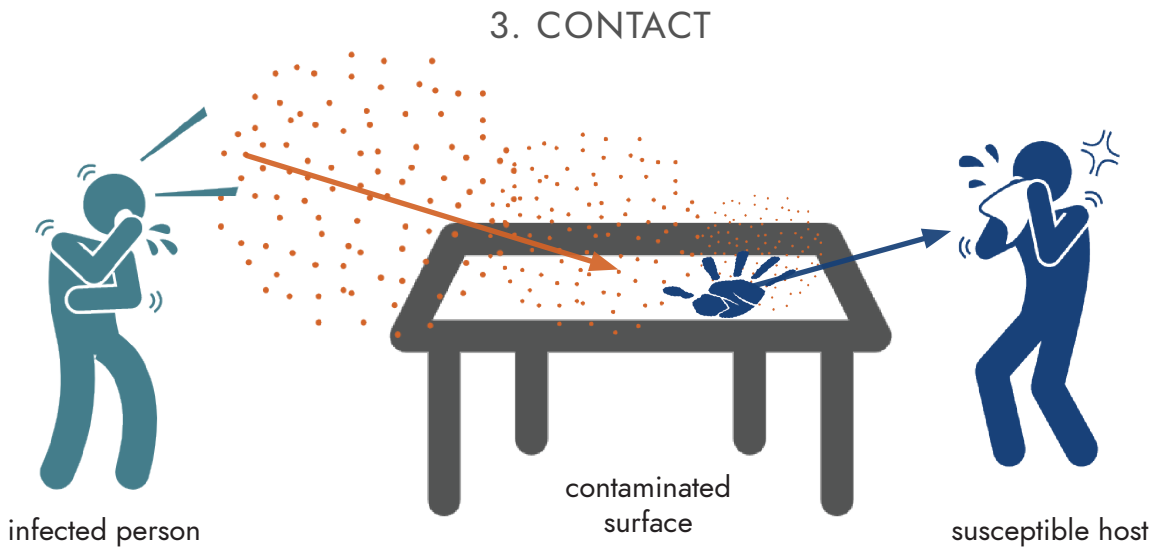
Respiratory droplets are generated when a person coughs or sneezes, etc., and are of sufficient size that they travel only a certain distance before falling to the ground. Airborne transmission refers to droplets that are sufficiently small (and are referred to as droplet nuclei or aerosolized particles) which can remain suspended in the air and can travel further distances.

The World Health Organization shares three main ways the disease COVID-19 is known to be transmitted between people:[1]



1 "Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations," World Health Organization scientific brief, March 29, 2020, https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations





Many facilities operators are taking precautions against the third mode of transmission—contact—by changing cleaning and sanitization procedures, installing touchless faucets and door openers, etc. But it's the first two modes—airborne nuclei and droplets—that are of most concern with respect to HVAC systems and what we can do to manage them.

Droplet transmission is thought to be a major culprit in the spread of the disease. What is less clear is the role played by airborne transmission. The same WHO paper referenced above states, "According to current evidence, COVID-19 virus is primarily transmitted between people through respiratory droplets and contact routes." It also cautions careful interpretation of evidence regarding airborne transmission. The Centers for Disease Control discusses the spread of COVID-19 as being mainly through contact and droplets, not mentioning airborne transmission.[2]

That said, the New England Journal of Medicine researchers described how aerosolized coronavirus particles can remain viable for up to three hours in the air, meaning they could infect a person hours after being expelled. The letter's authors sampled the air for just three hours, meaning the virus could potentially remain viable for longer.

2 Centers for Disease Control, "How COVID-19 spreads," https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html

OCCUPANT BEHAVIOR

COVID-19 is likely to present a unique challenge in the fall for campuses planning to welcome the return of students, faculty, and staff: vigilance in complying with health and safety behaviors. Among adults aged 18-29, just 26% saw the COVID-19 outbreak as a threat to their personal health, compared to 49% among adults aged 65 and older.[1]

Once students, faculty, and staff return to campus, institutions face unique challenges in continuing to enforce health and safety measures to prevent the spread of COVID-19. Campus environments are inherently social. The ability to gather with, learn from, and bond with other students is a fundamental aspect of the college experience. Thus, reinforcing messages of caution will be particularly challenging as students begin to feel fatigued by constant vigilance.

As most of us are well aware by now, the Centers for Disease Control and Prevention suggest four main ways to prevent the spread of coronavirus:[2]

1. Maintain good social distance (about 6 feet). This is very important in preventing the spread of COVID-19.
2. Wash your hands often with soap and water. If soap and water are not available, use a hand sanitizer that contains at least 60% alcohol.
3. Routinely clean and disinfect frequently touched surfaces.
4. Cover your mouth and nose with a cloth face covering when around others.

Some lessons from behavior change research and psychology can suggest some methods to developing a culture of responsible behavior on college campuses. According to Nature Human Behavior, people tend to cooperate when they believe others are cooperating.[3] This suggests that peer leadership and norming can contribute to behaviors on campuses that can either help or hurt efforts to contain the spread of the virus.

GreenerU's change management team worked on a pilot study with Brown University in 2011 to show how behavior change mechanisms could reduce the rate of students opening windows in dormitories during the winter months. The study found that using a combination of energy-efficiency measures—including the installation of adjustable thermostatic radiator valves—and a number of other engagement strategies, there was a 75% reduction in window opening when compared to similar buildings with neither efficiency improvements nor engagement strategies.

Thus, based on an analysis of pro-environmental behaviors, we can extrapolate similar behavior change mechanisms that could apply to the primary safe and healthy COVID-19 behaviors, namely pro-environmental attributes from Hines, et al. (1986-1987) (see Table 1).

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1 "Experiences with the COVID-19 outbreak can vary for Americans of different ages," Pew Research, https://www.pewresearch.org/fact-tank/2020/06/16/experiences-with-the-covid-19-outbreak-can-vary-for-americans-of-different-ages/
2 "How COVID spreads," Centers for Disease Control and Prevention, https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html
3 Van Bavel, Jay et al., "Using social and behavioural science to support COVID-19 pandemic response," Nature Human Behavior, https://www.nature.com/articles/s41562-020-0884-z

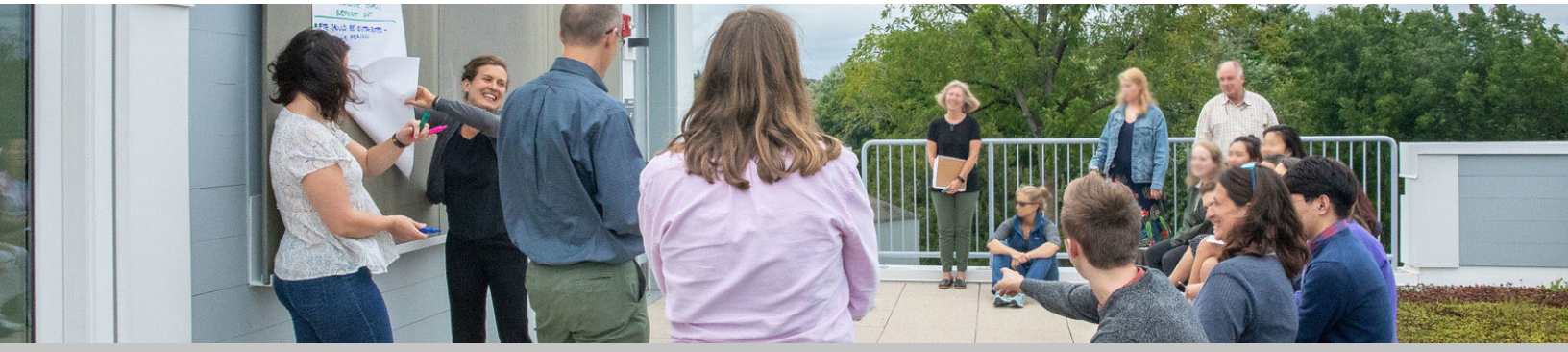

Table 1. — Pro-environmental attributes (extrapolatable to attributes to help foster the prevention of COVID)[4]

Knowledge of issues	— a person is familiar with the problem and its causes
Knowledge of action strategies	— a person knows how to act to lower their impact on the problem
Internal locus of control	— whether an individual perceives they have an ability to bring about change through their behavior, with a strong internal locus of control indicating a perception that their actions are significant
Pro-environmental attitudes	— people with strong pro-environmental attitudes were found to be more likely to engage in pro-environmental behavior, though the relationship between attitudes and actions proved to be weak
Verbal commitment	— a communicated willingness to take action was also indicative of a person's willingness to engage in pro-environmental behavior
Individual sense of responsibility	— people with a greater sense of responsibility are more likely to engaged in environmentally responsible behavior

Given the central role and experience of campus sustainability personnel on the role of motivating sustainable behavior (in a broader sense), sustainability offices can serve a key function on campus by employing similar techniques as they would in developing sustainability communications campaigns. GreenerU's work with Brown developed a series of engagement activities to coincide with pro-environmental attributes.[5]

WHAT MIGHT A COVID-19 VIGILANCE CAMPAIGN LOOK LIKE? GreenerU offers the following recommendations:

CREATE A CULTURE OF RESPONSIBLE BEHAVIOR through a facilitated process of group consensus across a broad spectrum of stakeholders. Develop a clear, cohesive presentation to indicate the risks of non-compliance and invite stakeholders—students, faculty, staff, and the broader community—to weigh in on developing campus-wide solutions.

MAXIMIZE THE SALIENCE OF COVID-19 by developing clear, memorable communication from leadership. Strong, compassionate leadership will be crucial in helping students, staff, and faculty remember the urgency of the issue through crisply worded key messages and multiple delivery methods.

DEVELOP A REWARDS SYSTEM. COVID-19 will be a marathon, not a sprint. Students will likely benefit from engaging in creative, well-timed events at intervals that encourage and reward responsible behavior. Contests, humor, trivia, and other games can be effective ways to keep relaying the message about preventing the spread of coronavirus.

4 Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1986-1987). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. The Journal of Environmental Education, 18(2), 1–8.
5 GreenerU and Brown University, "Brown University Dorm Energy Efficiency Program," https://drive.google.com/file/d/0B3ZP4qRlwUfAUWFWVFZtNV9HTzA/view

WE DON'T YET KNOW WHAT EFFECT HVAC SYSTEMS HAVE ON COVID-19 TRANSMISSION.

In a letter published in March in the New England Journal of Medicine, researchers described how aerosolized coronavirus particles can remain viable for up to three hours in the air, meaning they could infect a person hours after being expelled.[1]

The letter's authors sampled the air for just three hours, meaning the virus could potentially remain viable for longer. Until scientists learn more about the true viability of the virus in a variety of settings and conditions, they have to consider all potential routes of transmission in their attempts to slow transmission.

There is great concern about the real possibility of transmission through the air of various pathogens, especially SARSCoV-2, among staff and administration in healthcare facilities, office workers, retail workers and patrons, manufacturing workers, and residents in private and public facilities and the general public in outdoor settings and in public transportation.

While there is much to learn about how COVID-19 travels through air, we know it's possible—which is enough to take caution. ASHRAE, through its Environmental Health Committee, created an Epidemic Task Force and has issued the following statements:[2]

> Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. **Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures.** … 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. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating, and air-conditioning systems is not a recommended measure to reduce the transmission of the virus.

A well-publicized study of a restaurant in China demonstrated that a wall-mounted AC unit probably contributed to transmission in the vicinity of an infected diner.[3] The authors concluded that the most likely cause of transmission in this case was by droplets, prompted by airflow from the air conditioning unit.

Thus, airflow can cause droplets produced from coughs, sneezes, etc. to travel further than they otherwise would. But how far can aerosolized droplets travel through an HVAC system? How can this inform how to operate HVAC systems in our buildings?

An excellent white paper from industry leader Taylor Engineering in Alameda, Calif., provides a comprehensive review of scientific literature and makes some common sense recommendations. Some of the key takeaways are quoted below:

> "Can our building's HVAC systems, perhaps with some enhancements, make our buildings safe to occupy as they were before the pandemic? Taylor Engineering's opinion: absolutely not. … But can our HVAC systems, perhaps with some enhancements, mitigate disease transmission? Taylor Engineering's opinion: Perhaps, but most likely not in a significant way."[4]

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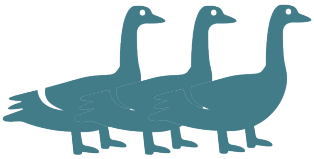
1 "To the Editor: Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1." New England Journal of Medicine 382:1564-1567, April 16, 2020, https://www.nejm.org/doi/10.1056/NEJMc2004973.
2 "Message from ASHRAE President Darryl Boyce," ASHRAE.org, https://www.ashrae.org/technical-resources/resources.
3 Lu, Jianyun, et al., "COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China," 2020 Centers for Disease Control and Prevention, https://wwwnc.cdc.gov/eid/article/26/7/20-0764_article
4 Taylor Engineering, COVID-19 white paper, updated June 2, 2020, https://taylorengineers.com/wp-content/uploads/2020/05/TE-COVID19-White-Paper.pdf

HVAC RECOMMENDATIONS: OVERALL

GreenerU offers the following recommendations for overall HVAC preparedness as students, faculty, and staff return to campus.

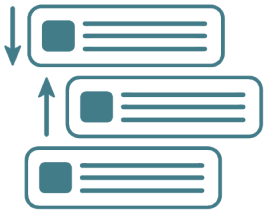


GET ORGANIZED.

Make a plan. A reasonable place to start is by taking stock of your equipment, to make sure you understand what you have and how it works. This is a good opportunity to take a (likely overdue) hard look at the design, condition, and functionality of your systems. Perform a comprehensive survey of your systems. Then work with your institution to understand what operating scenarios are on the table and how each building will be impacted.

LET THE HVAC DO ITS JOB.

Remember that your building's HVAC was designed to maintain a comfortable indoor environment for occupants. This itself is an important component of occupant health. Don't expect your air handler to solve all your worries about transmission—it is just one component of a multi-faceted approach to risk management.



PRIORITIZE.

Even if you wanted to, you wouldn't be able to transform your buildings' systems overnight. Focus on buildings or areas with the most likely usage. Determine what adjustments are manageable within time and budget constraints, but will make a significant impact.

MAKE REASONABLE ADJUSTMENTS.

In the near term, work with what you have. Make adjustments to controls systems. Consider filtration upgrades or in-room units.

PLAN FOR THE FUTURE.

As you learn more about the future of your institution's operating plans, you will likely be facing the need for longer-term modifications. Weigh your options for system improvements by identifying risk impacts and operational and maintenance costs.

HVAC: SHORT-TERM RECOMMENDATIONS

Following are short-term building preparedness strategies for the return of students, faculty, and staff to campus during the COVID pandemic.

CONTINUE WITH REGULAR MAINTENANCE.

- Maintain your regular maintenance schedule for filters, grease, etc.
- Run hot water or chilled water systems normally. Or, at minimum, circulate water at full flow with all respective valves open once per week to prevent rust buildup.
- Now that it's summer, follow similar procedures. If you haven't already, get your cooling systems ready as if it was business as usual.

PREPARE FOR REGULAR OCCUPANCY.

- Per ASHRAE 189.1, treat buildings like new construction: ventilate for at least 14 days. (This is not required; just a suggestion.)
- If regular maintenance has not been followed:
- Change filters before students arrive
- Make sure heating and cooling coils are clean
- Check operation of all moving components, such as damper and valve actuators, etc.
- Ensure any overrides are released and automatic reset routines will operate normally
- Check schedules and modify as needed

TAKE SHUTDOWN OPPORTUNITY TO GET WORK DONE.

- Perform maintenance items that can only be performed with equipment shut down (belts, motors, greasing dampers, etc.)
- Perform point-to-point checks:
  - Check dampers, mixed air, calibration of controlled variables
  - Valve stroke
  - Perform VFD maintenance
  - Make sure to modify or add alarming for monitoring high temperature/humidity/CO2—now may be a good time to visit alarming/trending and maintain databases, make changes, etc.
  - Consider what options to implement regarding system operations for buildings based on age, air-tight/new

ADJUST YOUR CONTROL SETTINGS.

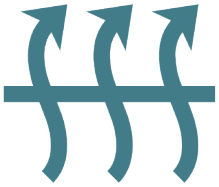
- For unoccupied buildings during warm weather, schedule occupancy for overnight with relaxed setpoints
- Tighten relaxed setpoints for time periods when custodians are active
- Monitor systems when they are operating, tune control loops, and look for inefficiencies
- Document changes so that when normal operation returns, systems revert back
- When preparing for re-occupancy, focus on individual spaces or buildings set to be occupied first and perform in order in which buildings should be ready

HVAC: LONG-TERM CONSIDERATIONS

Following are longer-term building preparedness strategies for the return of students, faculty, and staff to campus during the COVID pandemic.

FILTRATION

Refer to ASHRAE recommendations on upgrades to filtration systems. Consider increasing to MERV-13, but beware of static pressure drop and effects on system performance. Where increased filtration is deemed necessary, but not possible at the air handler level, consider in-room filtration systems. When considering an upgrade in filtration, it may be worth doing a cost comparison of disposable filters versus other active filtration systems, which require less ongoing maintenance and total life cycle cost.



OUTDOOR AIR & VENTILATION

ASHRAE guidance recommends both increasing outdoor air as much as systems allow, but also following Standard 62.1 on ventilation. GreenerU recommends keeping with 62.1 standards, provided adequate filtration is in place. As a short-term strategy, disable or set back CO_2-based demand controlled ventilation (DCV) sequences, which reduce outdoor air intake based on CO_2 levels.

ULTRAVIOLET (UV)

UV is a proven technology for inactivating viruses. The UV-C wavelength is most effective, but is harmful to humans under direct exposure. Applications include in-room (also called upper-room, safely away from human eyes and skin), or within air-handling units. The challenge with air handling units, however, is achieving adequate exposure time for an airborne virus, given the high velocity of air movement through an AHU. Strategies around this include increasing UV intensity and the use of filtration to "capture" virus-laden particulates in the airstream.

DISCLAIMER

GreenerU believes educational institutions are uniquely positioned to lead the world in mitigating climate change.

Our mission is to help them.

COLLABORATIVE SOLUTIONS, EFFECTIVE RESULTS.

GreenerU, Inc. works with educational institutions to implement turnkey solutions to energy challenges. Our unique approach integrates building system improvements with behavioral programs in a customized way for each campus. We pride ourselves on helping our clients overcome a variety of barriers, going beyond analysis and planning to deliver desired outcomes.

We are a small business with a strong culture of passion for our work, developing innovative solutions, and collaboration.

OUR UNIQUE APPROACH

GreenerU is a multidisciplinary firm with extensive technical expertise in energy efficiency engineering and project delivery, as well as behavior and organizational change management. Our approach to climate action and sustainability strategic planning therefore integrates a range of perspectives. We understand the complexities of navigating higher education institutions and the different stakeholders involved—no two schools are alike, and our work reflects a highly customized approach to helping colleges and universities identify and accomplish their own unique goals.

Because GreenerU is skilled in the full spectrum of sustainability—from strategic planning and stakeholder engagement to energy-efficiency planning and project management—we can offer the unique perspectives of understanding pragmatic and innovative approaches to greenhouse gas reduction from our work with more than 50 colleges, universities, independent schools, and other institutions.

AN EXPERIENCED TEAM

GreenerU's team of energy engineers, project managers, and sustainability specialists bring expertise in engineering, construction management, facilitation, and engagement. We have a proven track record of success, underscored by the long-term relationships we maintain with many of our clients.

GreenerU can help you with COVID-related building and change management solutions. Services we provide include:

- Performing an HVAC systems review, inventory, and condition assessment
- Retrocommissioning HVAC and controls systems
- Providing recommendations for short-term and long-term system changes for building operations during a pandemic
- Designing and implementing HVAC solutions that improve health, safety, and energy performance
- Facilitating teams managing changes to building usage and operating plans
- Supporting the development of a communication strategy based on your new operational plans

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