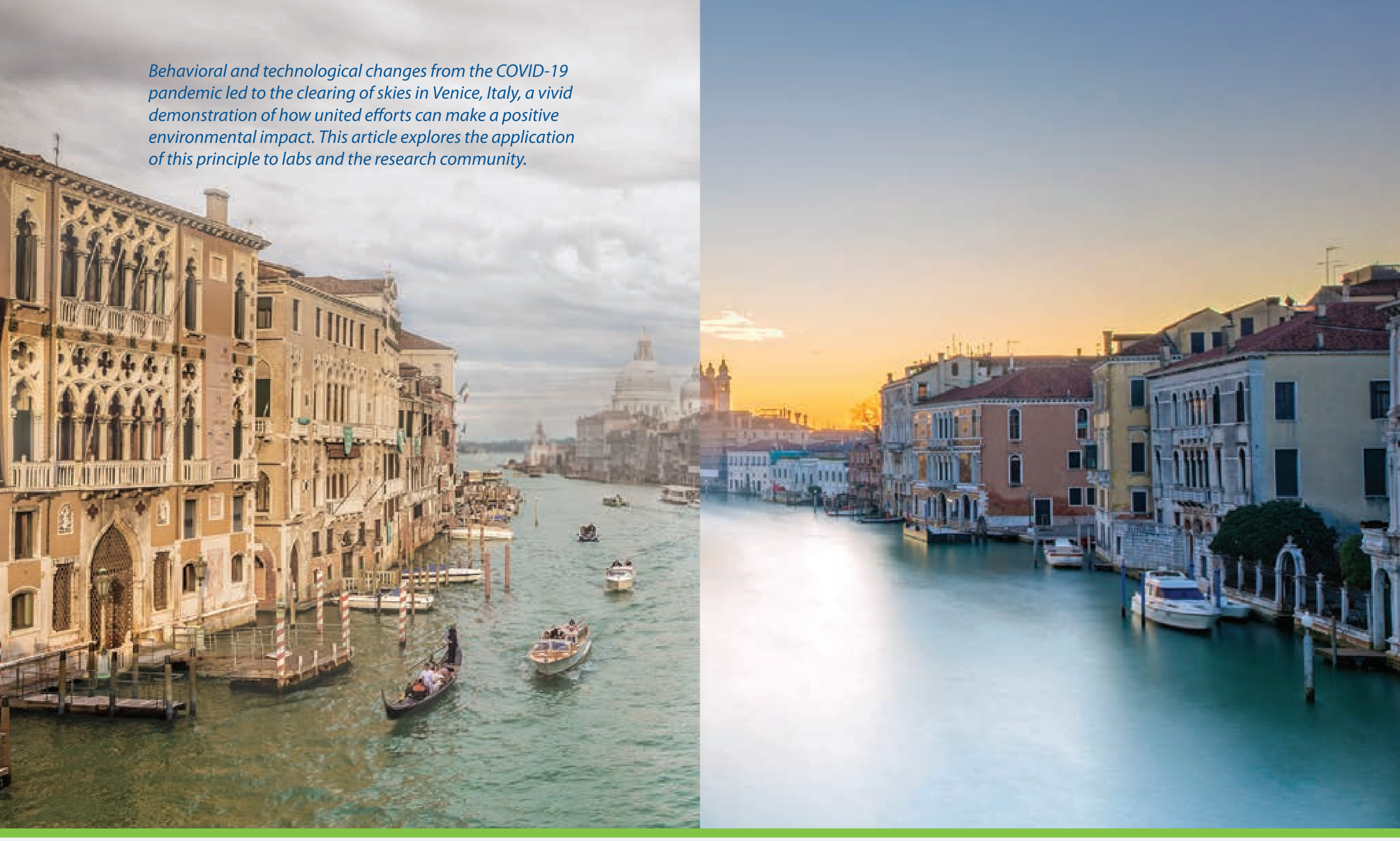

Behavioral and technological changes from the COVID-19 pandemic led to the clearing of skies in Venice, Italy, a vivid demonstration of how united efforts can make a positive environmental impact. This article explores the application of this principle to labs and the research community.

Behavior and Technology Changes Must Be Part of Lab Sustainability Efforts

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Labs consume a massive amount of energy due to their energy-intensive equipment, continual operations, often 100% outside air requirements and high airflow rates. After data centers, laboratories consume more energy per square meter than any other sector.

Unexpected Lessons From the Global Pandemic

And while labs around the world have made sincere efforts to reduce their carbon footprint and combat climate change, the recent global response to the coronavirus pandemic has revealed a new perspective on how changing behaviors and adopting new technologies can have a profound impact on our environment. Stay-at-home policies contributed to lower carbon emissions and less air pollution the world over.

Technology was the main driver for professionals to stay productive while working remotely. Companies across several industries adopted digital tools like cloud-based applications that enabled collaboration to support this new way of working. Schools incorporated online learning management systems, video conferencing tools and messaging platforms to facilitate distance learning.

Despite its tragic and continuing impact on global health, the pandemic has surprisingly offered a blueprint that shows how modifying behaviors and adopting new technologies can have a positive effect on the environment.

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Changing Behaviors in the Lab

Labs seeking to curb their environmental footprint should start by educating staff on positive behavioral changes that can reduce their energy use. One place labs can begin is by emphasizing correct behaviors related to the use of fume hoods.

Why fume hoods? Around 93% of labs have at least one fume hood, and many labs have multiple units. Considering fume hoods consume up to 21,900 kWh of electricity per year and produce up to 60 pounds (27.2 kilograms) of CO_2 per day, ensuring staff practice correct fume hood behaviors can have a significant impact on a lab's energy consumption and CO_2 production.[1]

Modern fume hoods typically use variable air volume (VAV) fans, which change speed depending on how far the sash (door) is open. VAV fans have to work harder the wider the sash is open. Even when closed, these units operate continually to prevent the buildup of dangerous fumes, but they operate on a much lower level than when open.

A fume hood's total energy use is directly related to the day-to-day habits of lab staff. If they operate the fume hood with the sash open more than needed or if they leave the sash open after they finish using it, they are wasting energy. Simply keeping fume hoods closed when not in use can save a substantial amount of energy.

Many universities have explored behavioral interventions specifically for fume hood closure and found something as small as placing stickers on fume hoods reminding staff to close them when not in use have been successful in changing behaviors. One university instituted a campaign that used surprise fume hood sash inspections, incentives and a variety of tools to raise awareness of positive sash behaviors. Before the campaign, only 3.1% of hoods were closed when unoccupied, but during the campaign, the figure rose to 61.3%.[2]

Waste Stream Mitigation Behaviors

While fume hood habits represent only one example of positive behavioral changes labs should emphasize to reduce their energy use and carbon footprint, there are many other sustainable behaviors to consider, especially those related to the waste stream, including:

- Ordering from suppliers with sustainable supply chains
- Reducing single-use plastics in favor of autoclavable glassware than can be reused
- Exploring ways to recycle the single-use materials you continue to use
- Switching from water baths to environmentally sustainable bead baths
- Consolidating orders or eliminating unnecessary shipments to reduce waste and related carbon emissions from deliveries

Laboratory fume hood

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Understanding Your Lab's Carbon Footprint

There are several human activities that release greenhouse gases, CO_2 and methane, with potentially harmful impacts to the atmosphere. And yet, the burning of fossil fuels for electricity, heat and transportation is the world's leading contributor to carbon footprint, posing the greatest threat to our planet's climate. The prevalence of fossil-fueled power generation in most regions of the world makes electrical power consumption a key determinant of carbon footprint for many aspects of our daily work and life.

This also stands true for your research laboratory. While a lab's carbon footprint equals the total amount of greenhouse emissions generated from its operation, including various activities of lab personnel, the greatest impact and pathway to reducing carbon footprint runs through the electrical grid.

Of course, one way to limit climate impact is by using alternative energy sources that don't burn fossil fuels. Perhaps your lab is located in an area where electricity is largely supplied from hydroelectric, solar, wind or even nuclear generation sources. Because ready access to alternative and renewable energy is still out of reach for many labs, there is an even better way to reduce your laboratory's carbon footprint.

As originally postulated in the 1970s by chief scientist of the Rocky Mountain Institute, Amory Lovins, and since realized in myriad case studies, our capacity to reduce carbon emissions through adopting energy-efficient behaviors and technologies is far greater than any other sustainable energy source.[3] While not diminishing programs for recycling/waste stream reduction, green chemistry, renewable energy and the like, the most potent opportunity for reducing carbon footprint in the lab clearly points to improving efficiencies of high plug load equipment such as fume hoods and ultra-low freezers.

If you're looking to shrink your lab's carbon footprint, start by establishing a baseline for how much energy your equipment currently consumes. The EPA has evaluated the amount of power produced nationally, and you can use this data to determine an average of pounds of CO_2 produced per megawatt hour. This figure is 998.4 pounds (452.9 kilograms) of CO_2 per MWh (or 0.998 pounds/0.453 kilograms per kWh). Using this figure can help calculate average CO_2 emissions based on the amount of electricity your lab equipment uses.

If you want to dive deeper into your specific CO_2 emission rates, the EPA's Power Profiler tool can help. The tool also lets you estimate your emissions based on your geographic region.

Upgrade High-Energy Lab Equipment to Sustainable Technologies

Changing behaviors alone won't help labs meet their environmental objectives, but it's a start. To make sustainable labs a reality, research organizations must also bring the right equipment into their operation. When it comes to energy hogs, you'll find ultra-low temperature (ULT) freezer units near the top of the list. In 2015, My Green Lab published a report, "Market Assessment of Energy Efficiency Opportunities in Laboratories," that found a single ULT freezer consumes between 3,900 and 11,100 kWh/year.[4]

The report's ULT energy consumption figures only show part of the story. Unlike other high-energy use equipment, like fume hoods, ULTs have a direct effect on a lab's environment, because the harder they work to keep vital samples below -70°C, the more heat they release into the lab.

ULT energy use in a lab is directly proportional to the heat generated. As more ULTs are using high amounts of energy in a lab, an equivalent amount of rejected heat must be removed to keep surrounding spaces from becoming uncomfortably hot. Labs need to consider the HVAC energy cost required to remove that heat. ASHRAE guidelines suggest that an average of 29% of additional energy is required to remove the heat produced in this scenario.

By switching from standard compressor-powered ULTs to more energy-efficient units, labs can still meet strict sample safety and temperature performance guidelines while significantly reducing their carbon footprint. A conventional compressor-based ULT consumes up to 30.4 kWh/day and thus produces a little over 30.4 pounds (13.79 kilograms) of CO_2 per day (based on the EPA's carbon footprint calculation of one pound of CO_2 emission per kWh/day).[5] In contrast, a Stirling engine-powered ULT only uses 7.0 kWh/day.

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By replacing just one legacy model with a free-piston Stirling engine-powered ULT, labs can reduce their energy use up to 23.4 kWh per day (30.4 kWh/day – 7.0 kWh/day). This equates to a reduction of 4.3 tons (3.9 metric tons) of CO_2 per year. Given the effective life span of a Stirling ULT has been estimated at 12 years, that's a projected savings of 51.6 tons (46.8 metric tons) of CO_2 per unit over the freezer's operating life. Since Stirling engine-powered ULTs generate 70–75% less heat than legacy compressor-based models, labs can further realize energy and CO_2 savings from the reduction in HVAC use. These units also use natural, hydrocarbon refrigerants, which have less than 1/10,000th the global warming potential (GWP) of the refrigerants used in conventional ULT freezers.

Stirling Ultracold SU780XLE ULT freezer next to a competitor

Labs Can Advance Research, Operational and Sustainable Goals

The coronavirus pandemic has taken an emotional and economic toll on the world, but it has also shown us that behavior changes, combined with technology adoption, can have positive global impacts on the environment.

The good news for research communities is that adoption of environmentally sustainable practices need not disrupt your life's work and mission to cure disease or the financial and operational goals of your organization. In fact, adoption of energy-efficient technologies that reduce operational carbon footprint and climate impact of laboratories can advance research and operational goals even further. This sets the stage for all levels of the research organization to embrace behavioral and technical changes that are truly sustainable.

Learn more about laboratory sustainability or ask about an energy and carbon footprint audit at **www.stirlingultracold.com/solutions/sustainability-2.**

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