IAQ Standards: Reflecting on A White House Summit

As I type, I have an air quality monitor on my desk. Actually, I have two. Combined, they cost less than my wife and I spent on dinner last night. CO_2 in my room is 1,350 ppm. PM_1 is 10 ug/m^3. PM_{10} is 20 ug/m^3. $PM_{2.5}$ is 15 ug/m^3. TVOCs are 0.004 ug/m^3. It's 68°F, and the RH is 60%. Now, that means this room doesn't meet the 2021 WHO guidelines mentioned in your [Brandon J. Burley Ph.D.'s] column, "Indoor Air Quality Standards: Reflecting on a White House Summit," in the December 2022 issue of *ASHRAE Journal*.

But, the more important thing is the technology. I can diagnose my air quality directly, cost-effectively, and in its native units.

The gap in ASHRAE's air quality tools is they breeze past this vital step of measurement. We're all engineers. We've all heard "You don't know what you don't measure," "You can't control what you don't measure," "In God we trust; all others must bring data," and the like. Engineers usually love measuring things. So, why is the measurement of air quality so rare?

You and I know ASHRAE's tools were born a generation ago. They evolved in an era when measuring air quality was expensive and impractical. In 1995, or 2005, I couldn't have afforded seven-variables of air quality monitoring. It would have cost more than a car! But, today, the cost of my personal air quality monitoring is less than the cost of a dinner date.

Hey, don't take my word. Go to your web browser, to your favorite search engine, and type in "air quality monitor shopping." Look at what's available. Look at the prices! While you're looking at the options, think back 25 years.

There's been a huge technological change. It is, in my opinion, a complete game-changer.

Now that air quality measurement is vastly more affordable and available, it should become commonplace among engineers. During initial commissioning, continuous commissioning and retro-commissioning, air quality experts should measure air quality. (It sounds so simple when you say it.) But, imagine this possible future: in 2030, if ASHRAE's tools still skip the measurement step and rely primarily on ventilation rates, filter efficiency prescriptions and equipment checklists, they'll hardly be the tools of air quality expertise.

The WHO, OSHA and other agencies already publish performance standards. In time, they'll become more and more easily measurable. People like me will have monitors on their desks. It'll be easier for users and enforcers to measure air than refer to HVAC guidelines, standards, checklists. (I bought $45 desktop air quality displays for all my staff, and for my brother, as holiday gifts! They're quite cute.)

Right now, ASHRAE's air quality tools rarely, if ever, tell us to measure air quality. We frequently breeze past the topic. Just for fun: look at how $PM_{2.5}$ is handled in ASHRAE's *Indoor Air Quality Guide* (2009). The guide warns us about the dangers of particulates and discusses resuspension. There's talk about emissions from photocopiers and computers.

It tells us to investigate regional air quality, specify filters, check for leakage, minimize thermal bridging, etcetera, etcetera. What it never says is: "Buy a $PM_{2.5}$ meter and measure $PM_{2.5}$ in the spaces." It's too bad it never says that. Today, in 2022, the simplest, most direct, cost effective, time effective, and repeatable thing to do is "buy a $PM_{2.5}$ meter and measure $PM_{2.5}$ in the spaces."

Side note—be cautious of placing too much stock in commissioning. There are two disclaimers commissioning buyers need beware. First, many commissioning efforts fall short of success. I can show you a stack of commissioning reports with lists of issues the team couldn't achieve or solve. "The systems didn't work as intended," they seem to say, "but at least we've documented it!" Documentation of issues is great, but it isn't the same as success.

Second, any commissioning process is only as good as its goals. If there aren't air quality goals, there won't be air quality commissioning. If achieving $PM_{2.5}$ below 10 ug/m^3 isn't a design goal, it won't a commissioning goal. If it isn't a commissioning goal, it won't be measured. And, if it isn't measured, it isn't assured.

Your conclusion, therefore—I'll paraphrase with the quote, "These documents form an excellent reference"—stands in jeopardy to the threat of time. Affordable air quality measurement is a threat to the viability of heavily prescriptive or prescriptive-only tools. That threat will grow in the next decade. It seems to me the most important thing ASHRAE could do, immediately, is to add the obvious step: measure the air.

Like the tools, your column also breezed past the topic of measurement. So, I'm interested in your opinion on the matter.

Travis R. English,
Member ASHRAE, Fountain

The Author Responds

Thank you for taking the time to read the column and for your thoughtful comments. When I first started writing the column I was focused on specifically addressing the criticisms of ASHRAE Standards and pointing out that all of the topics discussed at the White House Summit were already addressed by ASHRAE in some form and many were in the process of being developed into the standards.

You do make a good point that unless you follow the Indoor Air Quality Procedure, you are not compelled to measure air quality. From my perspective this is because the ventilation rates are based on achieving a vote of not unacceptable from 80% of the occupants; they are not intended to control specific contaminants to specific thresholds.

In terms of measurement, I think you are also breezing past some of the very real questions about how we should use indoor air quality measurements.

Let's start with the most basic design based on achieving a certain maximum level based on a design background condition. This is certainly achievable, but it requires several things. First, we have to identify the contaminants we are seeking to control. Second, we must gather data of background levels of those contaminants. Third, we must understand the sources of those contaminants. Finally, we must adopt limits from recognized regulating bodies that we can control to.

Let's look at your list of contaminants: we can certainly regulate any of the PM buckets; we could regulate CO_2, but there is significant debate on what an appropriate limit is; regulating TVOCs is perilous because it is an aggregate measurement, and even low levels of certain VOCs can be very harmful; we already have rules for humidity and temperature in ASHRAE Standard 55. So let's assume we establish limits for those air constituents we can.

Then we need to have a method of determining the background conditions and sources of those contaminants, similar to the climate database. There are weather stations with air quality readings, but this is not universal and we still need to aggregate and analyze the data. Even when we get this data we still have the issue of internal sources; are these understood well enough to design engineering controls around, and do those internal sources require different strategies than the external sources?

So having said all of this, I do think that developing design standards around obtaining limits is possible—the IAQP already allows this—but it is not nearly as simple as buying a desktop IAQ monitor.

Now let's take a look at the active control scenario. In this case you have your IAQ monitor and it reads an elevated level of a contaminant in your space. What is the control response to this information? Does the ventilation system increase air volumes? What if the source of the particulates is the ventilation air? Do we put safeties in place to cut off ventilation when the source is external, or do we alarm and continue to ventilate? What if there is an air cleaner? Should we mandate its priority relative to changes in ventilation rates?

It is not my intention to be dismissive, but rather to point out that these are all questions that need to be answered and agreed upon by the committee before we can change the standard. In fact some of these questions have been asked recently with respect to controls for hazardous outdoor air conditions.

I know you have been working on indoor air quality in health-care spaces for many years now and are familiar with the CMP process. There are currently two proposals under consideration by SSPC 62.1, one to restore the requirements of active measurement of outdoor airflow rates, and another to publicly display ventilation information. I can easily envision a third proposal that requires the inclusion of indoor air quality metrics in either or both of these requirements. I cannot predict if any of these will be accepted, but you are not alone in your position, and we are always interested in constructive proposals to improve the standard. Even if air quality control does not enter the standard in an analogous manner to thermostatic control, there are a multitude of conceivable uses for measured data that could be used to improve design practices.

Brendon J. Burley, Ph.D., P.E.,
Member ASHRAE, Baltimore

The Role of Cogeneration: Reducing Carbon Emissions

The article "The Role of Cogeneration: Reducing Carbon Emissions" by Richard Sweetser, Life Member ASHRAE and Bruce Hedman, Ph.D., in the November issue of *ASHRAE Journal* presents an unrealistic scale and incomplete picture of the role that combined heat and power (CHP) will have in the use of natural gas as a transition fuel. As we continue to transition to lower carbon energy sources, one thing is clear: natural gas will not disappear overnight.

The article makes a good point that cogeneration is a very efficient way of using natural gas. However, most cogeneration plants last for 40 years or more. While we need to make sure that our use of natural gas is as efficient as possible, cogeneration looks less like a transition and more like a way of locking in the use of fossil fuels.

The author touts renewable natural gas (RNG) as a fundamental way of creating low-carbon CHP operation without noting any of the key concerns surrounding RNG. At best, renewable gas, if all available sources are tapped, will only cover ~15% of the current total U.S. natural gas consumption. This limited supply is reflected in the price of RNG, which is already between two to five times more expensive than conventional natural gas. Why would we use this limited supply for applications such as heat and electricity generation, which already have carbon-free and more efficient alternatives, instead of in industry applications which are notoriously hard to decarbonize?

Finally, RNG is chemically identical to natural gas, meaning that it is largely methane. Methane leakage roughly doubles the impact of natural gas use. As RNG is distributed through the same leaky pipe as natural gas, it will emit methane to the environment and substantially reduce the "low carbon" reality of the fuel source.

Additional key issues the author does not address include:

- The cost-effectiveness of renewable generated electricity compared to cogeneration plants powered with RNG when full maintenance costs of the cogeneration are included.
- In many campus settings, cogeneration plants are sized at or above the campus energy needs, which discourages energy efficiency because energy savings have little monetary value.
- Hydrogen was noted as the key zero carbon fuel source. In addition to the fact that hydrogen is not largely available today, the hydrogen that is available is largely produced from natural gas or other nonrenewable sources.

We feel that the advantages of renewably generated electricity powering efficient, all-electric buildings far outweigh the long-term carbon emissions of CHP systems, however efficient they might be.

Peter Rumsey, P.E., Fellow ASHRAE, San Francisco; Jorlyn Le Garrec, Associate Member ASHRAE, San Francisco

The Authors Respond

This letter provides an opportunity to further describe the important role of cogeneration, or combined heat and power, in decarbonization. The respondents recognize that "natural gas will not disappear overnight" and that "cogeneration is a very efficient way of using natural gas," resulting in enormous amounts of GHG emissions savings today. However, they do not acknowledge ongoing developments in expanding renewable and net-zero carbon fuels including green and blue hydrogen which, we believe, will play an important role in a future net-zero carbon economy.

Renewable and hydrogen-fueled CHP can decarbonize thermal end-uses in industrial and commercial facilities that are difficult or too costly to electrify, as well as critical operations that need dispatchable on-site power for long-duration resilience and reliability. At the same time, CHP's inherent efficiency advantage can serve to further extend the resource base of these emerging renewable and net-zero fuels.

Installing natural gas CHP today by no means locks one into the long-term use of fossil fuels. CHP systems currently operate on a variety of renewable and low- to no-carbon fuels, including renewable natural gas (RNG), hydrogen and biogas.

RNG is biogas that has been upgraded to commercial natural gas specifications for injection into the existing natural gas pipeline infrastructure and is produced at landfills, through anaerobic digestion at wastewater treatment plants, agricultural operations, food processors and animal feed lots, and from gasification of biomass. RNG can have negative GHG emissions on a life-cycle basis depending on feedstock and can be used as a direct replacement of natural gas in current CHP equipment and systems.

The respondents note "as RNG is distributed through the same leaky pipe as natural gas, it will emit methane to the environment, and substantially reduce the 'low carbon' reality of the fuel source." The latest Environmental Protection Agency (EPA) Inventory of U.S. Greenhouse Gas Emissions and Sinks shows that annual emissions from the natural gas distribution system declined 69% from 1990 to 2019, as natural gas utility companies added more than 788,000 miles of pipeline to serve 21 million more customers.

Distribution systems owned and operated by local natural gas utilities emit only 0.08% of produced natural gas. The pipeline infrastructure adds only a small fraction of GHG emissions to the overall reductions that can be achieved through RNG use in CHP facilities.

While existing hydrogen sources in the U.S. are indeed produced primarily from natural gas, the respondents ignore the massive ongoing global effort to develop pathways to clean hydrogen and the U.S. Department of Energy's efforts to establish net-zero carbon hydrogen as a key pillar in an emerging clean energy economy. Most gas turbines and natural gas engines available today can operate on hydrogen mixtures ranging 10% to 40% depending on the manufacturer and model. All major turbine and engine manufacturers are on track to have 100% hydrogen-compatible systems commercially available by 2030 or earlier, and many existing systems will be able to upgrade to 100% hydrogen with field modifications.

Finally, the respondents state, "We feel that the advantages of renewably generated electricity powering efficient, all-electric buildings far outweigh the long-term carbon emissions of CHP systems, however efficient they might be." Electrifying buildings is a good thing where it makes sense. However, is electrifying buildings the only thing that makes sense? We believe the pathway to a zero-carbon future will require a broad mix of solutions, and CHP, the most efficient way to generate power and thermal energy, will play a critical role in reducing GHG reduce emissions now and in the future.

Richard S. Sweetser, Life Member ASHRAE, Herndon, Va.; Bruce Hedman, Ph.D., Alexandria, Va.

Increasing Ventilation In 1980s High-Rise Commercial Office Buildings

The article "Increasing Ventilation in 1980s High-Rise Commercial Office Buildings" by Jamie Kono, P.E., Associate Member ASHRAE; Jim Gieselman, P.E., BEAP, Member ASHRAE; Meghan Kara McNulty, P.E., Member ASHRAE; Barry Abramson, P.E., BEAP, Life Member ASHRAE, that appeared in the November 2022 issue of *ASHRAE Journal* contains some eye-opening data regarding the indoor air quality that exists in a good portion of today's buildings.

I agree that existing buildings need to evaluate methods of increasing ventilation rates as the most effective means of mitigating airborne particles and improving the overall indoor air safety. However, it is important to keep in mind the other major challenge we face today, reducing energy consumption. Simply increasing ventilation will certainly result in an increase in air safety, but at the cost of additional energy use.

As an alternative, I offer "Option 3A": incremental, floor-by-floor retrofits to provide additional ventilation through a total energy recovery wheel.

Tyler Mancl, P.E., Associate Member ASHRAE, Scofield, Wis.

The Authors Respond

We agree that energy recovery can play an important role in achieving the dual goals of improved indoor air quality and energy efficiency—and not only for the incremental approach, but for all design options. In our article, we aimed to shift the conversation from, "Can we do this [drastically increase ventilation rates]?" to, "How can we do this?" As we move forward with decarbonizing the built environment, the next question must be, "How can we do this efficiently?" Perhaps a discussion of annual energy use for each option would make for a good follow-up article

Jamie Kono, P.E., Associate Member ASHRAE, Atlanta; Jim Gieselman, P.E., BEAP, Member ASHRAE, Atlanta; Meghan Kara McNulty, P.E., Member ASHRAE, Atlanta; Barry Abramson, P.E., BEAP, Life Member ASHRAE, Atlanta

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