

HVAC SYSTEMS

The Low-Hanging Fruit of Energy Conservation



When designing large commercial HVAC systems, energy efficiency is always top-of-mind, while energy conservation is often an after-thought. Yet, both ideas are critical to meeting decarbonization goals and greenhouse gas (GHG) reduction. So, what's the difference between the two?

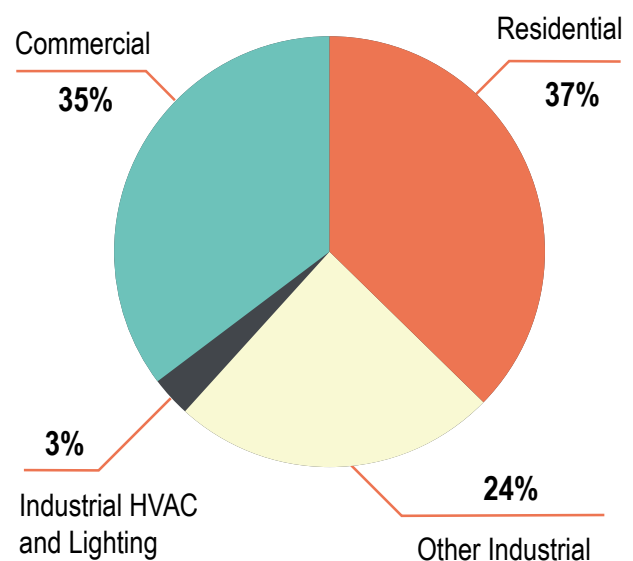
Energy efficiency involves using technology to reduce the amount of energy it takes to produce the same outcome. (e.g., chillers and boilers with a better Coefficient of Performance). Energy conservation concerns changing people's behavior to reduce the amount of energy used (e.g., carpooling).

It's understandable (if not predictable) that conservation takes a back seat. It involves changing human habits, and people dislike change. To that point, it's probably easier to design a more accurate thermostat than it is to get a building full of people to stop adjusting one. The challenges and messiness of changing human habits often push conservation down the priority list as something to be tackled later.

It's unfortunate too, because even small energy conservation efforts can have huge implications for decarbonization and GHG reduction. Human activity, at scale, brings exponential change, but only if we can fundamentally change our habits for the long term.

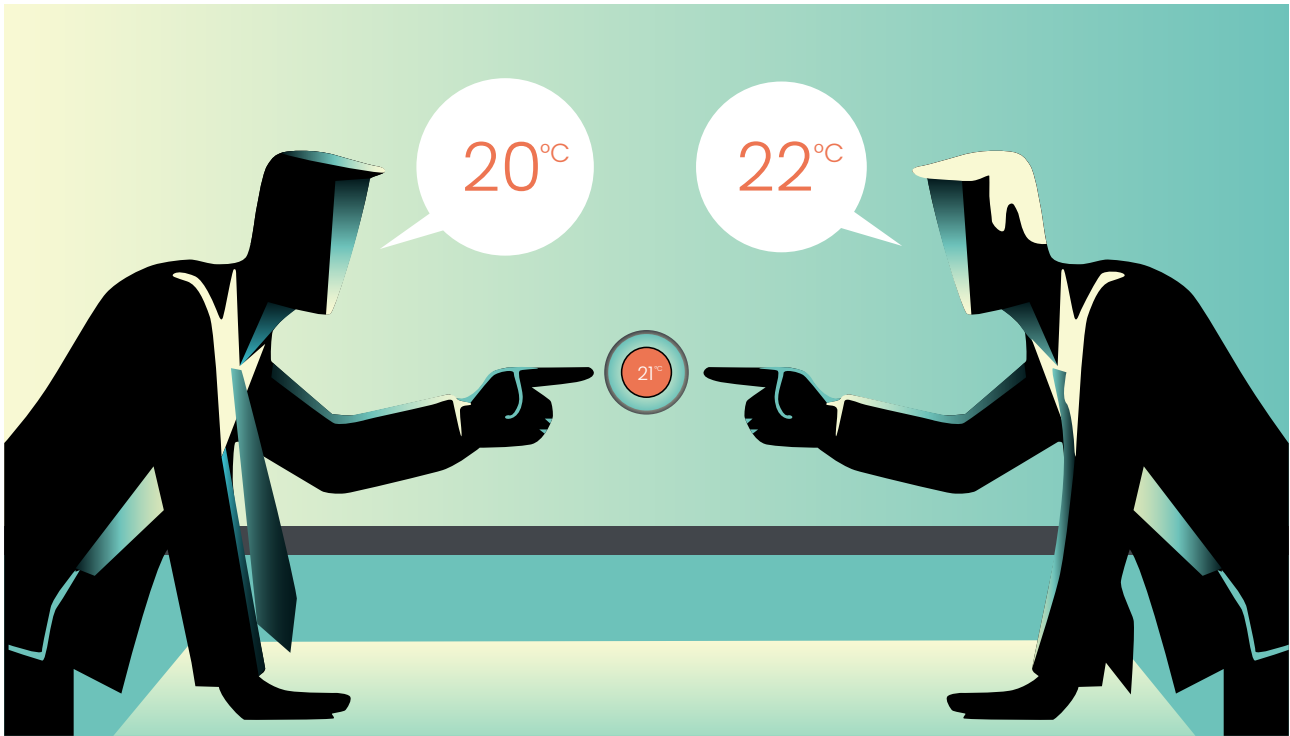
It's easy to see the potential environmental impact when you consider that buildings create around 40% of the world's GHG emissions and that HVAC systems account for the same percentage of a building's total energy use.

2014 Electricity Sale for Buildings (U.S.)



Source: U.S. Dept of Energy

Given the enormous potential for energy savings, it's imperative that the HVAC and automation industry look for new ways to leverage research into human psychology and current workplace trends to make buildings more efficient. So, while it's critical we continue to innovate technical solutions for energy efficiency, we can maximize their impact by applying what we know about human behavior into our designs and processes.



Resetting Temperature Expectations

Office temps are the proverbial bone of contention among workers. Perhaps no topic fomenters the most division among workers as the “correct” office temp. Some constantly crusade for a cooler climate, while others turn to space heaters or thicker clothing to weather the winter months. It's difficult or impossible to suit the thermal comfort levels of everyone in the office. Still, most managers strive to please the majority while keeping energy costs low.

Typical commercial lease agreements in Australia, stipulate a 22.5 ± 1.5 °C setpoint in summer as the acceptable thermal condition for commercial buildings. However, much like in-door air comfort itself, these stipulations are highly subjective and inflexible. Temps are often set based on the assumption that workers become less productive in hotter environments. However, this assumption doesn't reflect current evidence.

One 2017 study found that subjects given cognitive skills tests showed no negative effect on “cognitive load” when temps were raised above standard setpoints. The results suggest temperatures proscribed by leases are likely based more on social convention or wrong assumptions about worker productivity. Meanwhile, the widespread over-cooling of commercial buildings is consuming more energy, emitting more GHGs, and costing more to operate. The study’s authors also note that maintaining an interior summer temp of 25°C could cut office cooling energy consumption by 18%.

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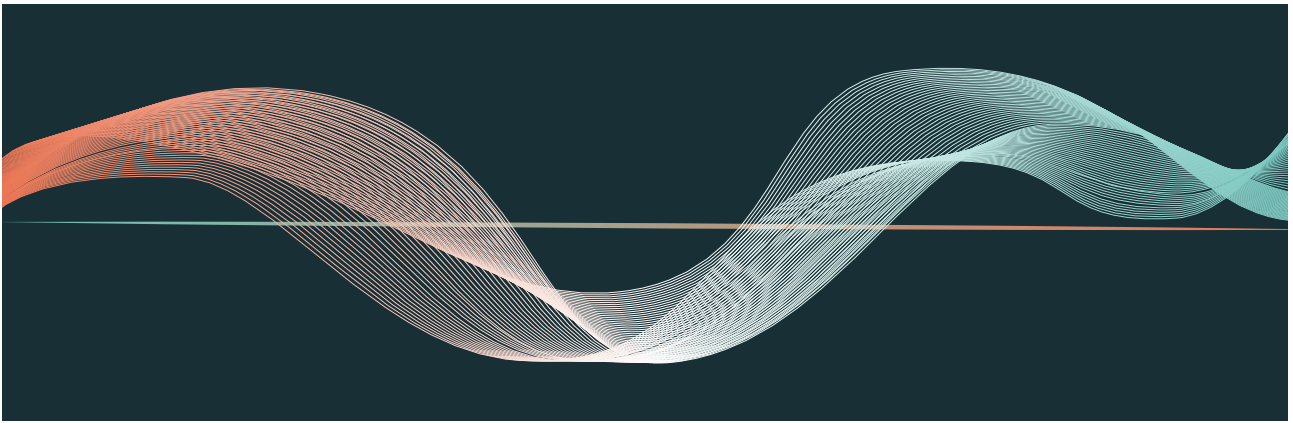
(Source: 2017 Study. Zhanga, Fan et al)

There’s clearly a need to reset indoor temperature expectations to achieve real energy conservation. But resetting expectations must start at the lease level. Most health and safety departments, like in the US and Australia, don’t mandate specific temperatures for commercial workspaces.

Instead, they offer guidelines and target ranges. So, there are opportunities for property owners to work with tenants to shift expectations of “acceptable” building temperatures.



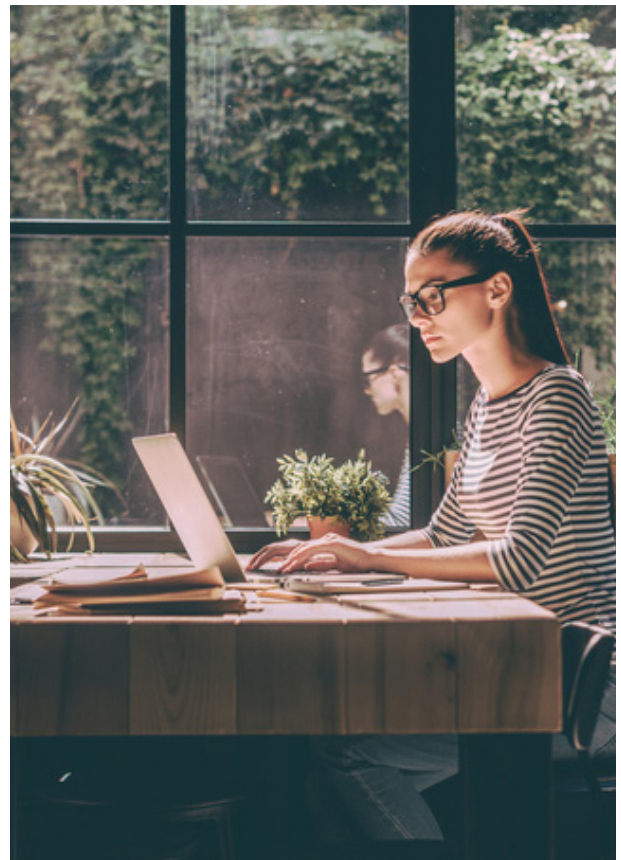
Shifting setpoint tolerances from $\pm 1.5^{\circ}\text{C}$ to $\pm 3^{\circ}\text{C}$ could provide enough flexibility and legal cover to shift indoor temps when local weather and environmental changes allow. The change would, however, require increased trust between owners and lessors along with an understanding that the end goal is a greener building for everyone. Tenants would likely expect regular energy savings reports as assurances their efforts are contributing to decarbonization. Overall, resetting temperature expectations for owners and occupants would place the industry in a position to make a massive contribution to energy conservation.



Thermal Comfort and Light Temperature

There is a strong psychological component to our thermal comfort levels. Feeling “hot” or “cold” isn’t only a matter of our skin receptors communicating to our brains. In fact, research has shown that our visual perception is also a factor in how comfortable we feel in a heated or cooled space. Owners, technicians, and engineers should leverage this psychological component when designing integrated and automated systems.

Daylight, for example, can affect our thermal tolerance of cooler and warmer temperatures. One 2019 study published in *Nature* found that low levels of daylight lead to a less comfortable thermal environment during cold conditions and to more comfortable ones in warm conditions. Therefore, covering windows during summer months not only blocks solar radiation, it can also make occupants feel cooler even though internal temps are higher. Conversely, allowing more natural sunlight into spaces during winter months can make people feel warmer despite a lower thermostat setting.

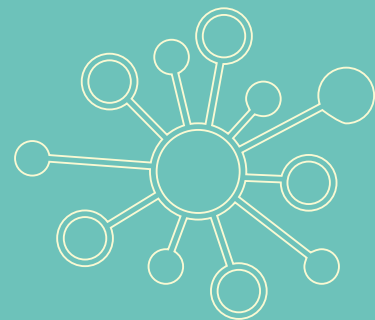


Studies suggest that simply sitting near a window can make us more tolerant of heat and cold.

More importantly, the study hypothesized that occupants could tolerate warmer temps within a room where illumination came from natural sunlight versus electric lighting. The fact that sunlight makes us more resilient to temperature extremes makes sense, given that sunlight is so essential to human physiology and to processes like our circadian rhythm. Further, sunlight is essential to combatting illnesses like Seasonal Affective Disorder during winter months.

Another study examining similar effects of sunlight on thermal comfort found that people who sat next to windows exhibited higher thermal tolerance to ambient air temps. The study's researchers were able to re-adjust thermostat setpoints by 1.21 °C with a potential energy savings of 82%. If similar setpoints became the norm for the industry, even conservative estimates would result in significant energy savings and GHG emissions.

SYSTEM INTEGRATION & THERMAL COMFORT



To maximize energy conservation, architects and engineers would need to design systems to be fully automated and integrated. Window coverings would need to be connected to systems like HVAC, lighting, occupancy, and weather monitoring. AI and machine learning would orchestrate the process, adjusting thermostat setpoints based upon weather forecasts, sunlight luminance, and occupancy rate.

Throughout the day, lighting systems could slowly replace electric lights with sunlight, either by dimming bulbs or shifting LEDs to warmer light temps. Window coverings could shift from blackout screens to semi-opaque, helping occupants increase their thermal tolerance.

Hybrid Work and HVAC On-Demand

With the pandemic slowing, workers are starting to trickle back into the office. However, the return to the office has been a rough road for some companies like Apple, which has seen employee resistance and walkouts by key staff members. The backlash has prompted a reversal of policy for the mega-corp. In addition, there's a growing trend to unionize

among workers, and business feel the pinch to give into employee demands. So, it's safe to say some form of hybrid work is here to stay.

The change in work schedules has also left property owners, managers, and their tenants in a conundrum with respect to leases and utility charges.



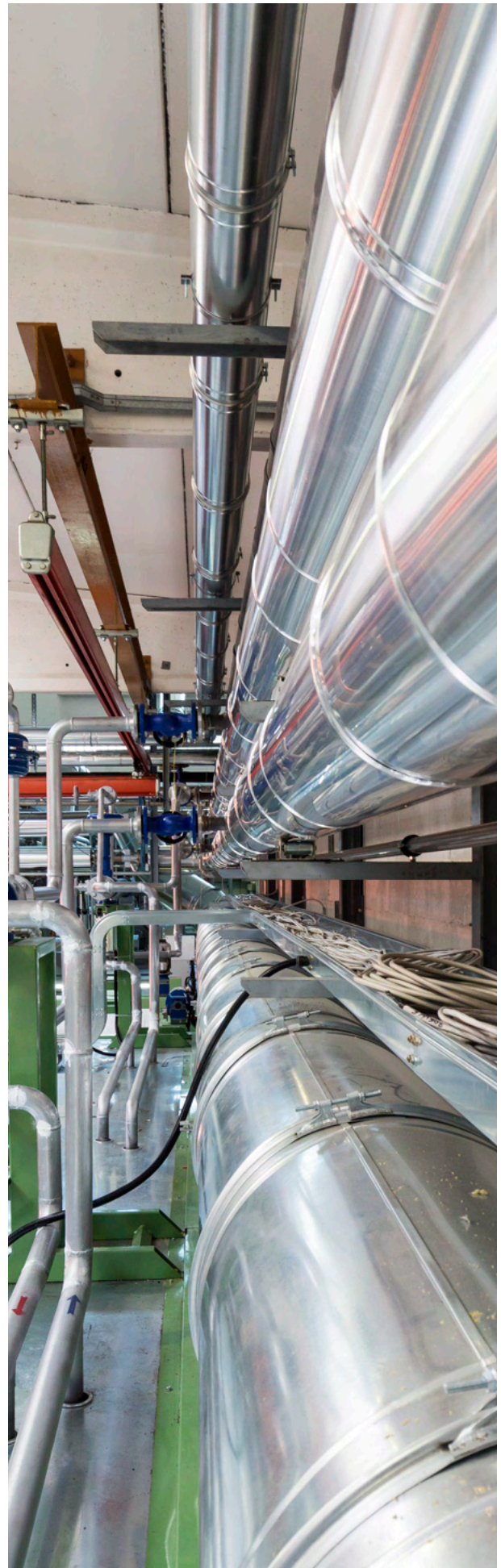
Some tenants moved to a fully remote workforce, leaving behind empty office spaces and years left on leases. To offset costs, these tenants are attempting to renegotiate their utility charges, arguing they're not benefiting from heating and cooling of empty office spaces or common building areas.

Property owners are quick to point out that utility charges must be paid because they're a necessary OPEX item. Managers of large properties with boilers and chillers can't simply shut them down or isolate service to specific areas without affecting other tenants.

The result is building owners trying to entice tenants back to the office, while employees are demanding to stay home. In the middle are tenants paying for utilities they're not using. All the while, million-dollar HVAC systems work to heat and cool vacant spaces to the optimal 21 °C.

Moving to an HVAC on-demand service when it makes sense is one way to solve this utility problem, at least in the short term. Many property owners already use cloud-based apps to automate their after-hours HVAC programs. These platforms give tenants the ability to schedule HVAC service after normal business hours. They're popular with tenants who need to extend their work hours, and, increasingly, those with remote or hybrid staff.

On-demand services give both the property owner and the tenant more flexibility to lower energy costs and consumption. By extending after-hours charges to normal business hours, landlords have a ready-made billing model—one which could easily be adopted as an override for previous HVAC service clauses. By billing tenants flat hourly rates, owners could justify shutting down zones of HVAC services when those zones were unoccupied. Further, the model would ensure tenants were only billed for utilities they scheduled.





Conclusion

Research into human psychological and physiological processes must work in conjunction with HVAC tech innovation. Being highly predictable and crossing cultures, nationalities, and ethnicities, these processes are the “easy” part of the problem. The real difficulty lies in the more unpredictable cultural and political changes like those over the past few years.

Sudden social shifts to work schedules, indoor air quality requirements, and fast-approaching decarbonization mandates leave less time for the industry to adjust. It’s a fact that only heightens the need to engineer flexibility and resilience into our building designs.

For its part, the HVAC tech industry needs to speed up innovation of affordable integrated building systems and smart technology that allows HVAC systems to make real time adjustments based on changes in local climates.

Building owners will also need to ramp up investment in retrofits and new energy saving technologies—a tough sell for those facing shrinking occupancy rates fueled by hybrid work models.

However, adoption of system integration, device connectivity, and cloud-based tools will help ensure owners, managers, and their properties can contribute to energy efficiency and conservation efforts.

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<https://7nox.com>

info@opsysolutions.com

+64 09 972 9163