Indoor Microclimate Modification: Cooling the Person, Not the Building

HVAC cools buildings. Biothermal Microconditioning cools the person at their desk. [8]

At a Glance

Conventional HVAC treats the entire room volume. Personal comfort systems target the individual. Kim et al. (2019) showed PCS extends the acceptable temperature range by 4 to 5 degrees. [8] A meta-analysis of 64 studies found PCS shift comfort thresholds by 2.2 degrees. [20] Biothermal Microconditioning brings this to living systems.

Deep Dive

The central inefficiency of conventional HVAC is volumetric: it conditions an entire room to serve the people in it. A typical office has 200 cubic metres of air volume for 20 occupants. Each person occupies roughly 2 cubic metres of that space at desk height. The system chills 200 cubic metres to cool 40 cubic metres of occupied zone. The other 160 cubic metres, above head height and in unoccupied corners, receive the same conditioning and waste the same energy.

Personal comfort systems (PCS) address this by targeting the individual. Kim, Bauman, Raftery, Arens, Zhang, Fierro, Andersen, and Culler (2019) published a 6-month field study in Building and Environment with 37 real office workers using internet-connected PCS chairs with embedded sensors. The chairs generated continuous streams of heating and cooling usage data at high temporal resolution. Key finding: personal comfort systems extended the acceptable temperature range by 4 to 5 degrees Kelvin. A cooling cushion combined with a desktop fan raised the upper comfort limit to 29.5 degrees Celsius, while a heated cushion extended the lower limit to 15 degrees Celsius. [8]

A 2025 meta-analysis published in Applied Energy evaluated 64 peer-reviewed studies on personal comfort systems across multiple climate zones and device types. PCS improved thermal sensation and overall comfort by an average of one scale unit on standard comfort scales. Comfort temperature thresholds shifted by 2.2 degrees Celsius lower in heating and higher in cooling modes. The developed Coefficient of Comfort Temperature Shift (CCTS) metric quantified this: an average corrective energy power of 42.6 watts per degree Celsius. Among heat transfer methods, conduction and hybrid approaches outperformed others in both heating and cooling. [20]

ASHRAE Standard 55 (2023) defines thermal comfort as the condition of mind expressing satisfaction with the thermal environment, assessed by subjective evaluation. Six factors determine this: metabolic rate, clothing insulation, air temperature, radiant temperature, air speed, and humidity. [7] The adaptive model, based on worldwide field data and incorporated since the 2004 standard revision, recognises that occupants actively interact with their environment. Behavioural, physiological, and psychological adaptation means that comfort preferences vary with contextual factors and available adaptation opportunities. [21]

Biothermal Microconditioning applies the personal comfort principle using living systems rather than mechanical devices. A managed plant cluster creates a microclimate at the occupied breathing zone, 0.5

to 2 metres above floor level. The canopy shades the person from radiant heat. Evapotranspiration cools the air within the cluster radius. Transpiration adds moisture to counteract the dry air that mechanical cooling creates. The building HVAC handles the bulk room volume. The plant cluster handles the 2 cubic metres around the person.

The energy implication: when personal comfort is handled at the zone level, the central HVAC setpoint can relax. Research shows setpoint increases of 2 to 5 degrees save 10 to 60 percent on cooling energy. Easy Retrofit. 1 day.

Summary

Conventional HVAC cools the entire room to a single setpoint. In a 200 cubic metre office with 20 people, the system chills space including ceilings and unoccupied zones. The person sits in 2 cubic metres.

Personal comfort systems target the individual. Kim et al. (2019) ran a 6-month study with 37 workers in Building and Environment. PCS extended the acceptable temperature range by 4 to 5 degrees. A cooling cushion and fan raised the upper limit to 29.5 degrees. [8]

A 2025 Applied Energy meta-analysis of 64 studies found PCS improved thermal sensation by one scale unit and shifted thresholds by 2.2 degrees Celsius. Average corrective power: 42.6 watts per degree. [20]

ASHRAE Standard 55 (2023) defines comfort through six factors. Its adaptive model recognises that occupants interact with their environment. [7] The CBE at UC Berkeley documents that preferences vary with context and adaptation opportunity. [21]

Biothermal Microconditioning applies the personal comfort principle using living systems. The plant cluster creates a microclimate at the breathing zone. HVAC handles the bulk volume. The plant handles the person.