EBC

Energy in Building and Communities Programme

Energy and Indoor Environmental Quality Performance of Personalised Environmental Control Systems

Energy in Building and Communities ANNEX 87

The International Energy Agency (IEA) is a global organization that works to create a safe and sustainable energy future. Established in 1974, it arose from the need for coordinated response during oil supply shortages.(IEA – International Energy Agency, n.d.) Recognizing the growing importance of energy security and sustainable energy technology, the IEA has broadened its scope in recent years.

The IEA established the Energy in Buildings and Communities Programme (EBC) in 1977. (International Energy Agency's Energy in Buildings and Communities Programme || IEA EBC, n.d.)This program brings together 26 countries to address this issue through coordinated research projects. These projects, known as "Annexes," use the expertise of participating countries to minimize duplicating research efforts and speed up information transfer. The EBC's ultimate purpose is to move the building industry toward sustainability. By 2030, they hope to have near-zero energy use in new buildings and communities and solutions for the vast majority of existing structures.

EBC Annex 87 seeks to quantify the benefits of PECS. The project will investigate the impact of PECS on occupant health, comfort, energy use, and potentially even costs. By understanding these benefits, stakeholders can make informed decisions about incorporating PECS into building designs

Project Objectives

1. EBC Annex 87 focuses on establishing clear guidelines for PECS design, operation, and integration with existing building systems.
2. It aims to define design criteria for PECS, ensuring these systems are effective and meet user needs
3. Annex 87 will develop operation guidelines for PECS
4. It seeks to quantify the benefits of PECS
5. The Project will investigate the impact of PECS on occupant health, comfort, energy use, and potentially even costs

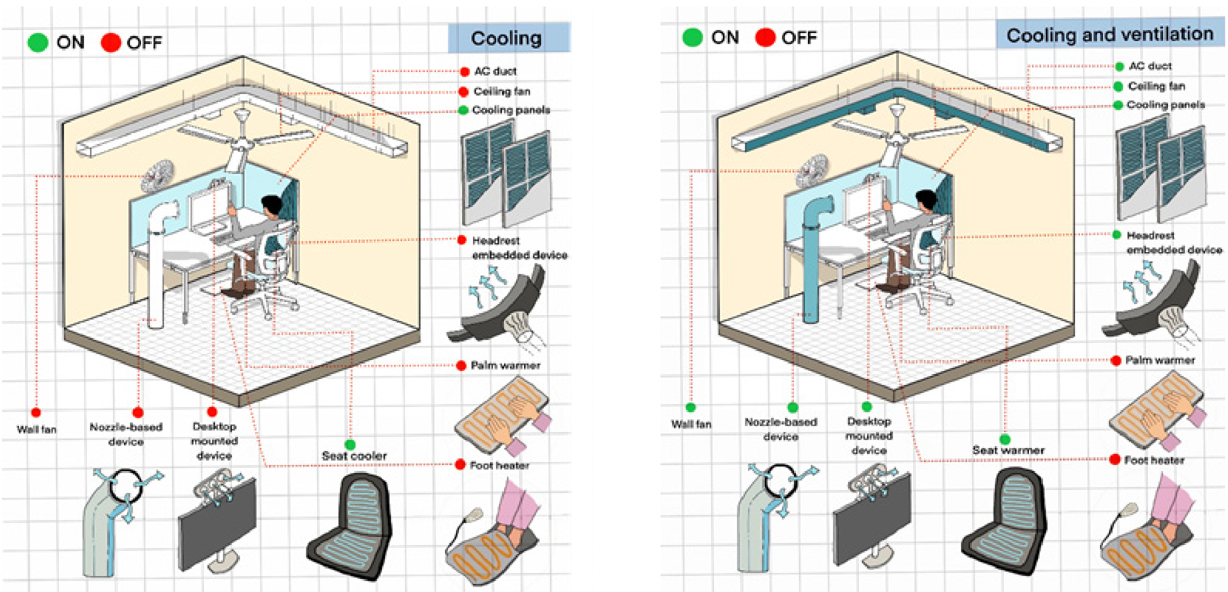

Figure 1: Cooling, Cooling and Ventilation PECS system in a Desk environment

Introduction to Personal Environmental Comfort System

Conventional heating, ventilation, and air-conditioning (HVAC) systems are designed to condition the entire building volume. In contrast, Personal Comfort Environmental Systems (PECS) target conditioning only the occupied zones of the space, while maintaining the remaining volume at a relatively under-conditioned state.(Rawal et al., 2020) Personal Environmental Comfort Systems (PECS) enable increased thermal comfort and acceptability conditions in a wider temperature range, resulting in energy savings. (André et al., 2020)In comparison to traditional HVAC systems used to condition spaces in buildings, PECS is said to offer several advantages, including enhanced productivity and health, potential energy savings, and higher satisfaction with the indoor environment due to improvements in the occupants' immediate indoor environment the possibility of personalized control and most importantly energy savings.

Personal Environmental Comfort Systems (PECS) provide a realistic option for balancing thermal comfort and energy consumption in buildings. Personalized conditioning aims to create a microclimate zone around a single workplace. In this way, the energy is deployed only where it is needed, and the individual needs for thermal comfort are fulfilled. (Veselý & Zeiler, 2014)A case study of the LM College of Pharmacy Building will look into the potential of PECS to improve occupant happiness while cutting energy usage.

Need for Personalized Environmental Comfort System

The increasing climate problem necessitates a rapid response. Global temperatures have reached 1.1°C beyond pre-industrial levels, and unchecked emissions point to a future of several degrees of more warming. (IPCC, 2021) This leads to more intense heatwaves, increasing sea levels, and unpredictable weather patterns. As average temperatures rise and heatwaves intensify, staying cool becomes a challenge. People in regions that were once accustomed to mild summers are now grappling with extended periods of scorching heat. This disrupts the natural ability of our bodies to regulate temperature, leading to discomfort, fatigue, and even health risks for vulnerable populations. The evident escalation in air-conditioned spaces in buildings to control indoor thermal environments exerts a significant increase in energy use in a scenario where buildings account for 55% of the world's energy demand. (IEA, 2022). Energy efficiency is a critical tool in this fight. In this case, energy efficiency is even more crucial since it may help us adapt to a changing climate and reduce the environmental impact of our energy use.

Research suggests Personal Comfort Environmental Systems (PECS) could be a game-changer for energy efficiency in buildings. The PECS approach brings along several benefits and challenges in terms of controlling the indoor environment, and energy performance, in addition to moderating the occupant's interaction with the ambient environmental control systems. (Rawal et al., 2020) By reducing the room temperature and the application of a personal comfort system, studies showed over 30% energy savings while achieving much greater user satisfaction. (Zhang et al., 2015)

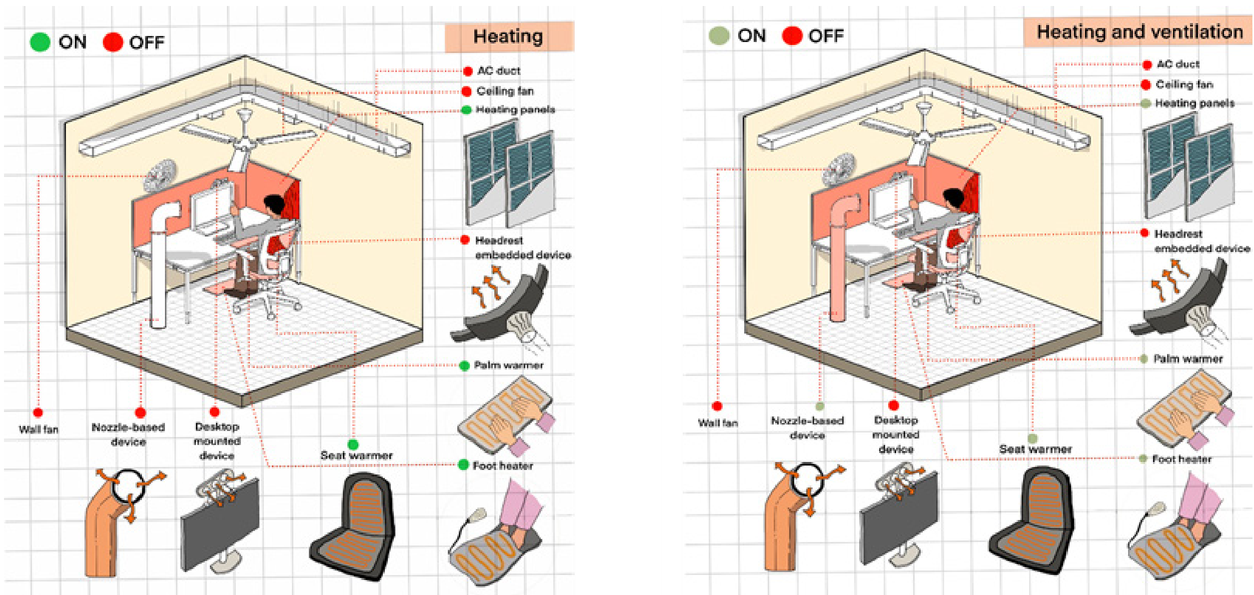

Figure 2: Heating, Heating and Ventilation PECS system in a Desk environment

Types of Personal Environmental Comfort System

PECS come in a variety of categories, each designed to address specific needs. Heating PECS, for example, include air sleeves, heated seats, and foot warmers, providing localized warmth for the occupant. Heating and ventilation PECS, such as desktop-mounted devices or radiant panel seats, offer combined heating and airflow control. Similarly, cooling PECS encompass air sleeves, cooling garments, and radiant panels for individual cooling needs. Combination cooling and ventilation PECS come in various forms like desktop units, movable panels, or radiant panels with fans, providing both cooling and airflow control in a targeted area. Finally, ventilation-focused PECS include desktop and movable panel devices, fixed panels with nozzles, personal fans, and even ventilation integrated into seats or garments. This wide range of PECS options allows for customization based on individual needs and building environments.

Why PECS?

A suitable thermal climate is critical for tenant satisfaction and productivity in office buildings. Numerous investigations have proven this link, however there is still a gap in understanding the exact mathematical relationship between temperature and work productivity. To remedy this, Stephen's 2017 study recommends that those constructing future workspaces, particularly in academic contexts, consider measures that improve thermal comfort. This involves providing more private offices for individual users, strategically tilting buildings to maximize sunshine exposure, and isolating office areas from heat-generating equipment such as public areas. Finally, the study suggests that office building design principles explicitly address occupant productivity. This entails adding recommended ranges for various indoor environmental quality (IEQ) elements, such as temperature, into design specifications.

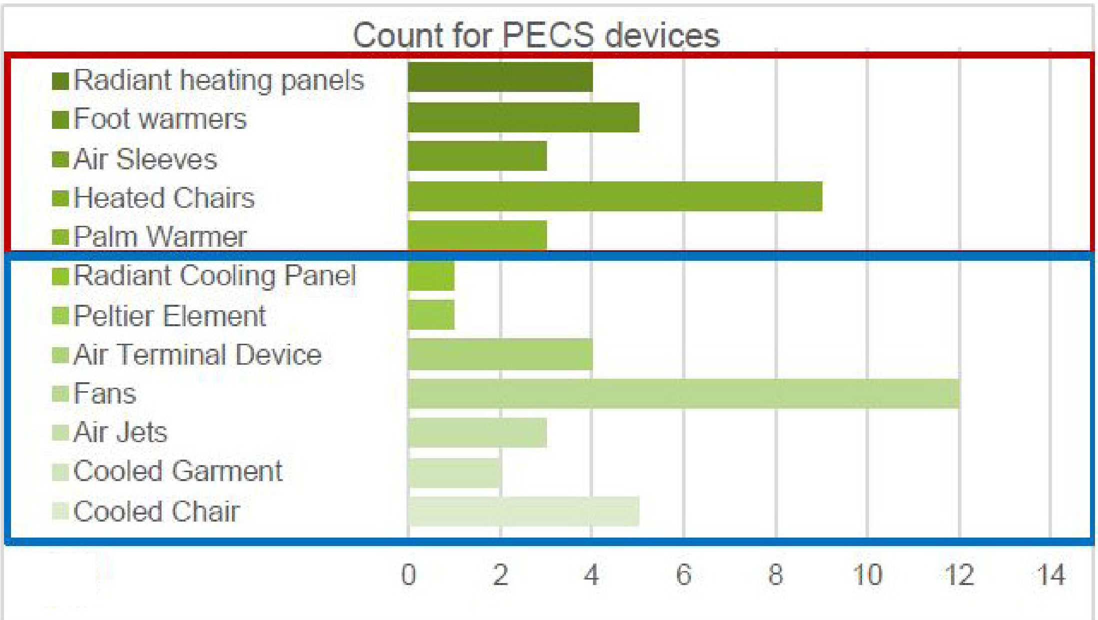

Figure 3: Count analysis for types of PECS devices reported in the literature.

Figure 4: Conventional HVAC system in a classroom at setpoint 25°C

Figure 5: Conductive Cooling_27°C PECS with HVAC System in the classroom

How PECS helps

Among the various heat transfer mechanisms employed by Personalized Environmental Control Systems (PECS), convection offers the most energy-efficient method for cooling, heating, or ventilation. This is because convection relies on the natural movement of air to achieve thermal comfort. PECS devices that utilize convection, typically fans, promote air circulation without requiring significant power to generate or manipulate heat directly.

While both convection and conduction are observed in both cooling and heating applications of PECS, convection offers a distinct advantage. Conduction, often used in thermoelectric cooling/heating systems for chairs or body-worn devices (a phenomenon known as Spatial Alliesthesia), requires direct contact for heat transfer. This can be less efficient than convection, which can cool or heat a wider area without direct contact.

In contrast, PECS devices that rely on radiation heat transfer, such as compressive cooling technology or large-scale electromagnetic radiation systems, tend to consume the most power. These systems often require significant energy to generate the specific wavelengths needed for heat transfer, especially when catering to a low view factor (meaning a small area of the body is being targeted). Therefore, for energy-conscious operation, convection-based PECS solutions reign supreme.

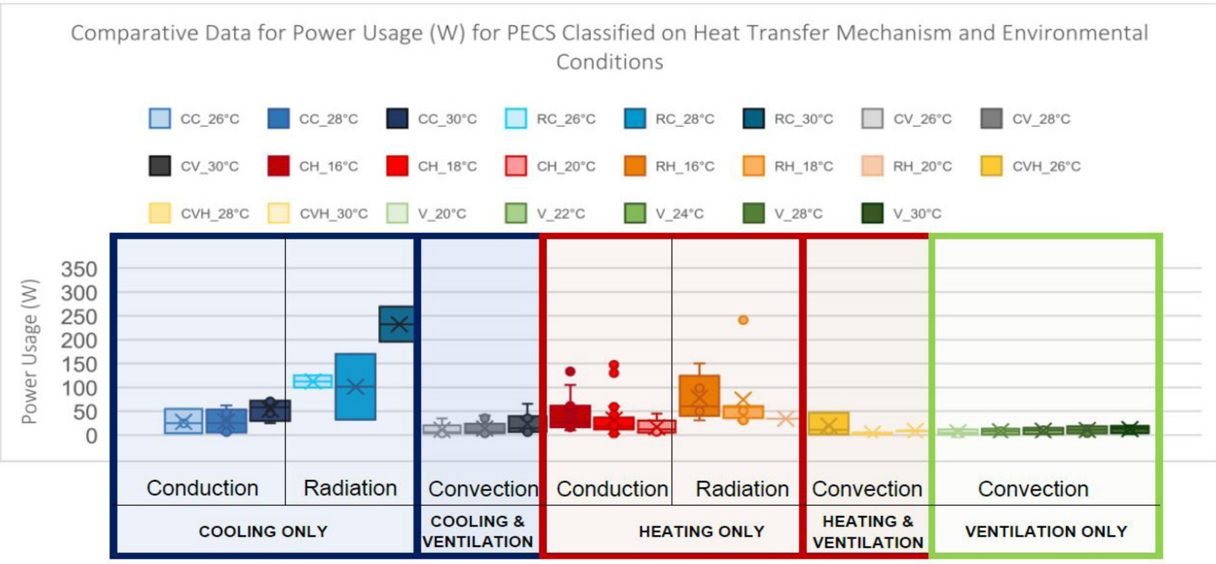

Figure 6: Power Usage Data Comparative Summary for all PECS types at given ambient temperatures (CC-Conductive Cooling; RC- Radiative Cooling; CV- Convective Cooling; CH- Conductive Heating; RH- Radiative Heating; CVH- Convective Heating; V- Ventilation)

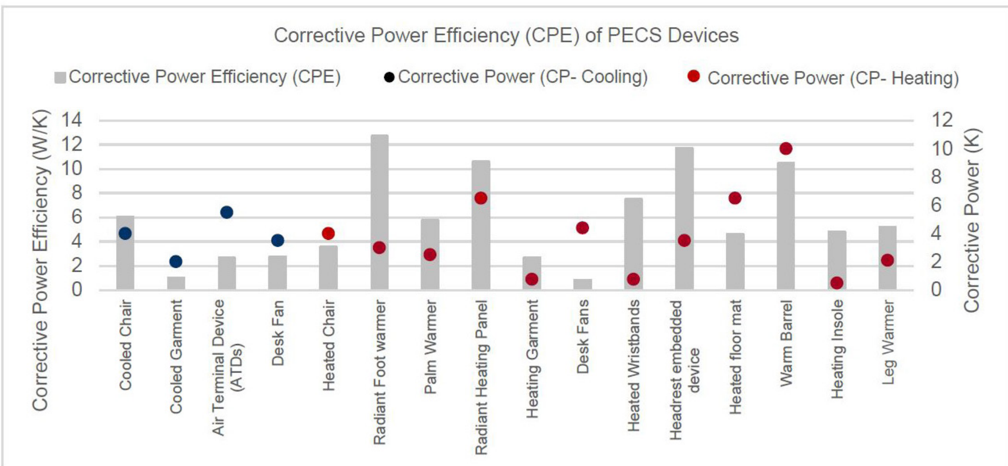

Figure 7: Corrective Power Efficiency data for PECS device applicability

Energy in Building and Communities Programme

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Building and Environment - Advancements in Personalized Environmental Control Systems (PECS) (Call For Papers)

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