Personal Environmental Control Systems (PECS): Fundamentals, Opportunities and Challenges

Ongun Berk Kazanci, PhD, Associate Professor

International Centre for Indoor Environment and Energy - ICIEE

Technical University of Denmark

Introduction

- Personalized Environmental Control Systems - PECS (e.g., micro-climatization systems, localized heating and cooling systems, personalized ventilation)
- PECS condition the immediate surroundings of the occupants, creating a ”personalized” space
- Provide individual control over indoor environmental quality (IEQ) factors
  - Heating / Cooling
  - Ventilation
  - Lighting
  - Acoustics
- Personalized control (user-controlled, automatic control)

Introduction

- IEA EBC Annex 87 Definition of PECS:

"A Personalised Environmental Control System (PECS) is a system that can provide individually controlled thermal, air quality, acoustic or luminous environments in the immediate surroundings of an occupant, without affecting directly the entire space and other occupants' environment"

History

- As early as 1979, Madsen and Saxhof: An unconventional method for reduction of the energy consumption for heating of buildings

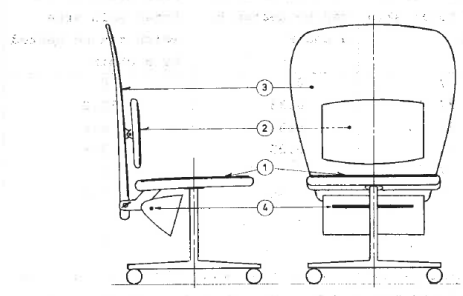


Fig. 6. Principle shetch for a heated chair. Each of the four elements can be controlled separately to a wanted effect.

1. heating element in seat.
2. heating element in back
3. radiation heating element behind the back
4. radiation heating element for legs and feet

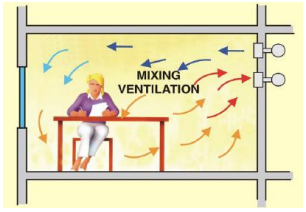
More recently

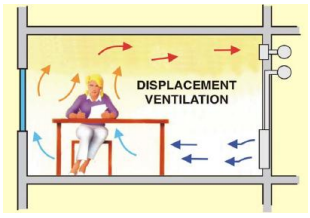
- Continuing from end of 90s and early 2000s
  - Personalized heating, cooling, and ventilation
  - Personalized control
  - More focus on personalized ventilation, and individual needs and preferences
  - Different air terminal devices
  - Different systems and combinations
- Physical measurements
- Measurements with breathing thermal manikins
- Human subject experiments
- Field measurements (limited)

PECS – Generic example

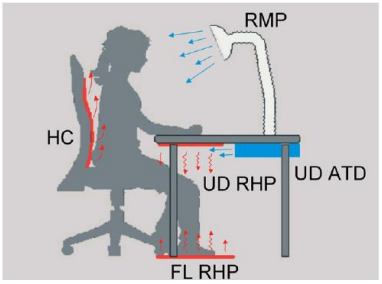
Source: Jun Shinoda and Ongun Berk Kazanci, 2023

PECS Examples





Source: Melikov 2010



Source: Watanabe et al. 2010

Source: Zhang et al. 2010

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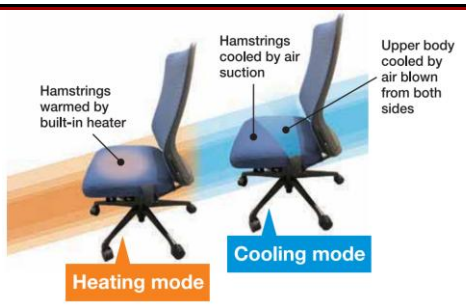
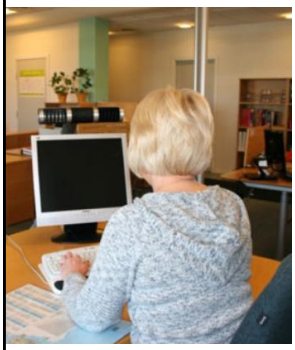
PECS Examples

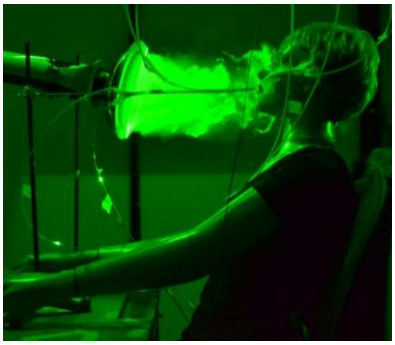


https://www.daidan.co.jp/sustainability/pdf/2020/daidan_report2020_all_eng.pdf

http://abee.or.jp/designaward/past/16/docs/06.pdf



Melikov 2016



Bivolarova et al., 2017

https://www.dyson.com/wearables/dyson-zone-air-purifying-headphones/announcement

https://www.coolingpost.com/news-headlines/fujitsu-develops-personal-cooler/

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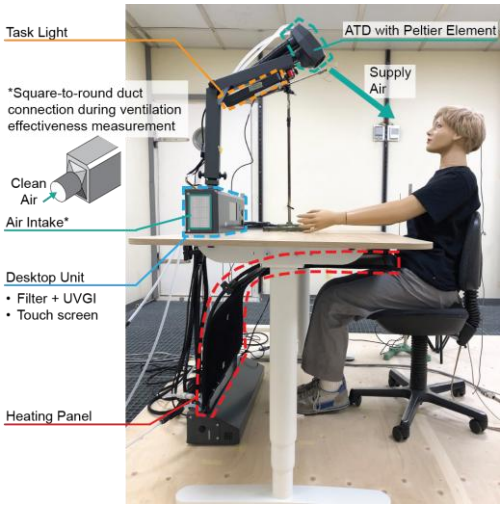
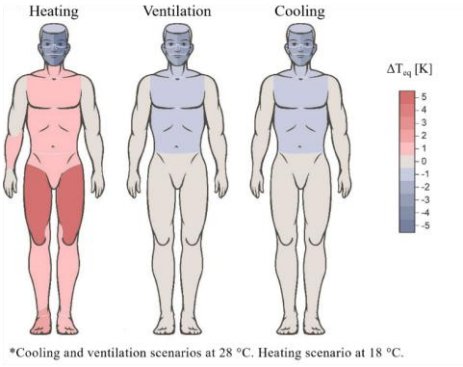
PECS Prototype



- **Multifunctional:**
  Heating, Cooling, Air-cleaning, Lighting
- **Stand-alone:** Independent from background system
- Evaluation with participants and thermal manikin



*Cooling and ventilation scenarios at 28 °C. Heating scenario at 18 °C.

Shinoda, J., Bogatu, D.I., Watanabe, F., Kaneko, Y., Olesen, B., Kazanci, O.B., 2024. Performance Evaluation of a Multi-Functional Personalized Environmental Control System (PECS) Prototype. Building and Environment

Bogatu et al., Resilient cooling and ventilation for buildings and people, PhD Thesis, Technical University of Denmark, 2024

Why is PECS important now?

- COVID-19 pandemic
  - Even higher interest in infection control
  - Personalized ventilation can provide fresh air more efficiently than mixing ventilation
  - Personalized (localized) exhaust
- Climate change
  - Resilience to climate-related disruptions, e.g., heatwaves, wildfires and outdoor air pollution
  - Energy efficiency, carbon neutrality
- Comfort, health, and wellbeing of indoor occupants
- Interaction of multiple IEQ factors

Why PECS?

- Improved comfort, health and productivity
- Higher occupant satisfaction with the indoor environment
- Potential energy and cost savings
- Address individual differences
- Resilience (both thermal and air quality)
- Pandemic-proofing
- Flexibility

Why not PECS?

- Not entirely new – significant amount of research exists
- Despite the proven benefits
  - Lack of design or operation guidelines
  - Lack of guidance about their integration in buildings
  - Standards and building codes are not ready
  - Far from ”solved”, still several issues to be addressed
  - Not at the level of a common solution in buildings
  - Very limited ”real world” examples
  - Very few commercial products

IEA EBC Annex 87

- IEA EBC Annex 87 - Energy and Indoor Environmental Quality Performance of Personalised Environmental Control Systems
  - Subtask A: Fundamentals
  - Subtask B: Applications and technologies
  - Subtask C: Control, operation and system integration
  - Subtask D: IEQ and energy performance evaluation
  - Subtask E: Policy and advocacy actions

IEA EBC Annex 87

- Gaps to be addressed
  - Integration with the ambient (background) system
  - Building codes/regulations, standards
  - Commissioning and maintenance
  - User interfaces and interaction with occupants
  - Sizing
  - Cost-benefit and productivity

Concluding remarks

- Focusing on the PECS itself, personalized control aspects and the PECS' interaction with the ambient control system
  - Provide design, operation and control guidelines and specifications for PECS
  - Provide guidelines and specifications regarding the interaction of PECS with the ambient system and its effects on the design of the ambient environment and conditioning systems
  - Provide enough data so that it can be seen as a "standard" HVAC component
  - Promote the use and market uptake of PECS
- Future: building-attached -> building-detached -> occupant-attached

Thank you for your attention

Ongun Berk Kazanci, PhD
onka@dtu.dk

References

- T. Lund Madsen and B. Saxhof, "An unconventional method for reduction of the energy consumption for heating of buildings_combined" in Proceedings of the Second International CIB Symposium on Energy Conservation in the Built Environment, Copenhagen, 1979
- Watanabe, S., Melikov, A. K., & Knudsen, G. L. Design of an individually controlled system for an optimal thermal microenvironment. Building and Environment, 45(3), 549-558, 2010
- Zhang, H., Arens, E., Kim, D., Buchberger, E., Bauman, F., & Huizenga, C. Comfort, perceived air quality, and work performance in a low-power task–ambient conditioning system. Building and Environment, 45(1), 29-39, 2010
- A. K. Melikov, Indeklima og Aktiv Ventilation, Kgs. Lyngby: International Centre for Indoor Environment and Energy, 2010
- Shinoda, J., Bogatu, D.I., Watanabe, F., Kaneko, Y., Olesen, B., Kazanci, O.B., 2024. Performance Evaluation of a Multi-Functional Personalized Environmental Control System (PECS) Prototype. Building and Environment
- Bogatu et al., Resilient cooling and ventilation for buildings and people, PhD Thesis, Technical University of Denmark, 2024

References – further reading

- Rawal, R., Schweiker, M., Kazanci, O. B., Vardhan, V., Jin, Q., & Duanmu, L. Personal Comfort Systems: A review on comfort, energy, and economics. Energy and Buildings, 214, 109858, 2020
- A. Warthmann et al., "Personal climatization systems - A review on existing and upcoming concepts" Applied Sciences, vol. 9, 35, 2019
- A. K. Melikov, "Advanced air distribution: improving health and comfort while reducing energy use" Indoor Air, vol. 26, pp. 112-124, 2016
- A. K. Melikov, "Human body micro-environment: The benefits of controlling airflow interaction" Building and Environment, vol. 91, pp. 70-77, 2015
- H. Zhang, E. Arens and Y. Zhai, "A review of the corrective power of personal comfort systems in non-neutral ambient environments" Building and Environment, vol. 91, pp. 15-41, 2015
- M. Vesely and W. Zeiler, "Personalized conditioning and its impact on thermal comfort and energy performance – A review" Renewable and Sustainable Energy Reviews, vol. 34, pp. 401-408, 2014
- A. K. Melikov, "Personalized ventilation" Indoor Air, no. 14 (Suppl 7), pp. 157-167, 2004