Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of the Environment, Transport, Energy and Communications DETEC

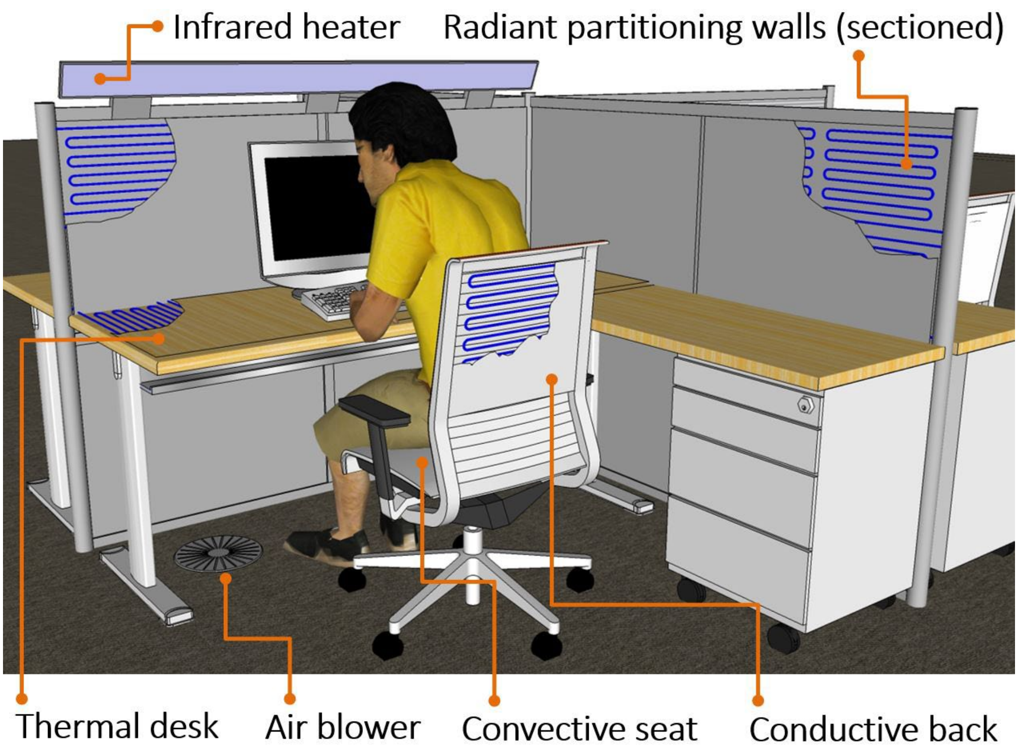
Swiss Federal Office of Energy SFOE
Energy Research and Cleantech Division

Interim report dated 06 11 2023

IEA EBC Annex 87

Scientific contribution of EPFL to IEA EBC Annex 87

Annual Report 2023



Source: ©EPFL2023, Building2050, Sergi Aguacil and Dolaana Khovalyg

Date: 06 11 2023

Location: Bern

Publisher:
Swiss Federal Office of Energy SFOE
Energy Research and Cleantech
CH-3003 Bern
www.bfe.admin.ch

Co-financing:
École Polytechnique Fédérale de Lausanne
CH-1015 Lausanne
www.epfl.ch

Subsidy recipients:
École Polytechnique Fédérale de Lausanne
Laboratory of Integrated Comfort Engineering (ICE)
Passage du Cardinal 13B
CH-1700 Fribourg
https://www.epfl.ch/labs/ice/

Authors:
Dolaana, KHOVALYG, EPFL, dolaana.khovalyg@epfl.ch

SFOE project coordinators:
Andreas, ECKMANNS, andreas.eckmanns@bfe.admin.ch
Nadège, VETTERLI, nadege.vetterli@anex.ch

SFOE contract number: SI/502560-01

Zusammenfassung

Dieser Jahresbericht gibt einen Überblick über den Beitrag des Laboratory of Integrated Comfort Engineering (ICE) der EPFL zum IEA EBC Annex 87 im Jahr 2023. Er liefert Hintergrundinformationen zu den Zielen von Annex 87 und fasst die Ergebnisse der wissenschaftlichen Projekte des ICE-Labors zusammen. Insbesondere werden die Ergebnisse von drei Forschungsprojekten (iThCoM, DynamoMET und pTEACH-RS) vorgestellt. Darüber hinaus werden aktuelle Informationen über die laufende umfangreiche Literaturrecherche zu PECS für Wärme- und Lüftungssysteme gegeben. Schließlich wird eine kurze Zusammenfassung des 2. Expertentreffens in der Schweiz, das in Lausanne stattfand, gegeben.

Résumé

Ce rapport annuel donne un aperçu de la contribution du Laboratoire d'Ingénierie du Confort Intégré (ICE) de l'EPFL à l'Annexe 87 de l'IEA EBC en 2023. Il fournit des informations de base concernant les objectifs de l'Annexe 87, et résume les résultats des projets scientifiques du laboratoire ICE. En particulier, les résultats de trois projets de recherche (iThCoM, DynamoMET, et pTEACH-RS) sont fournis. En outre, des mises à jour concernant l'examen approfondi de la littérature en cours sur les PECS thermiques et de ventilation sont fournies. Enfin, un bref résumé de la deuxième réunion d'experts en Suisse, qui s'est tenue à Lausanne, est présenté.

Summary

This annual report provides an overview of the Laboratory of Integrated Comfort Engineering (ICE) at EPFL contribution to IEA EBC Annex 87 in 2023. It provides the background information regarding the goals of Annex 87, and summarizes the results of scientific projects of the ICE lab. Particulally, the results of three research projects (iThCoM, DynamoMET, and pTEACH-RS) are provided. In addition, updates regarding the ongoing extensive literature review on thermal and ventilation PECS are provided. Finally, a brief summary of the 2nd expert meeting in Switzerland held in Lausanne is given.

Contents

Abbreviations

IEA	International Energy Agency
EBC	Buildings and Communities Programme
ICE	Laboratory of Integrated Comfort Engineering
EPFL	École Polytechnique Fédérale de Lausanne
SFOE	Swiss Federal Office of Energy
PECS	Personalised Environmental Control Systems
HVAC	Heating, Ventilation, and Air-Conditioning
MET	Metabolic rate
TSV	Thermal sensation vote
TCV	Thermal comfort vote
IAQ	Indoor air quality

1 Introduction

1.1 Background information and current situation

A Personalised Environmental Control System (PECS) is defined as "*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*". There has been a growing interest in thermal PECS since as early as 1977 [1] since they can offer several benefits over the traditional space climatization in buildings using centralized HVAC (Heating, Ventilation, and Air-Conditioning) systems [2]. The primary benefit of PECS is the provision of higher satisfaction with the indoor environment due to the improvements in the immediate indoor environment experienced by the occupants due to the possibility of personalized local control of climate conditions [3–5]. Secondly, PECS offer the potential to reduce operational energy of buildings due to (i) widening the range of temperature setpoints of the background environment, and consequently reducing thermal energy provided by the centralized conditioning system or even avoiding any (e.g., in well-insulated buildings) [6], (ii) reducing supply air flow rates into the space as primary thermal conditioning is enabled by PECS and only the minimum required fresh air for ventilation purposes is needed [7], (iii) conditioning occupants only when they are present [7-8]. Finally, the well-being and productivity of occupants can be targeted when PECS are applied properly [9-10]. Given the fact that the personnel cost of offices is significant [11], an indoor environment boosting work productivity can help to decrease the total operational cost of businesses. Thus, PCSs are the paradigm shift in the way we climatize our buildings allowing targeted heating/cooling of people rather than spaces that are often unoccupied.

The positive impacts of PECS are broad (i.e., higher satisfaction of occupants, enhanced well-being and productivity, less building energy use) and they are worthy of investigation, especially, in the view of the built environment transition toward occupant-centric solutions and energy crisis urging to reduce energy use in buildings. An increasing pool of research has advanced different aspects of thermal PECS over the past decades [2,12-13], however, there are still so few PECS commercially available and deployed in real buildings. The main issue is in difficult to compare the performance of different PECS since prior studies primarily explore a single type of device, rarely a few. Studies also used different instance as their reference cases, therefore, a direct comparison between different study results regarding their performance is not realistic. To increase the market presence of PECS and their deployment in actual buildings, standardized methods to design PECS and their integration with the centralized HVAC system should be developed along with a selection guide. In addition, the interaction between different PECS (e.g., combinations of thermal and ventilation) should be better understood. For these reasons, a global scientific initiative Annex 87 "*Energy and Indoor Environmental Quality Performance of Personalised Environmental Control Systems (PECS)*" was launched in 2022 supported by the Buildings and Communities Programme (EBC) of the International Energy Agency (IEA). The main objectives of Annex 87 are (i) to optimize PECS for energy use, human comfort, and productivity, (ii) to develop guidelines on integrating PECS in already existing buildings, (iii) to define standardized performance evaluation of PECS, (iv) to address current barriers for a wide implementation of PECS in buildings, and, finally, (v) to provide input to standards about proper application of PECS. Among numerous international participants of Annex 87, Laboratory of Integrated Comfort Engineering (ICE) at EPFL, headed by Assist. Prof. Dolaana Khovalyg, contribute to the international efforts to advance the global knowledge on the energy effectiveness of thermal PECS through its fundamental and applied research. In addition, Assist. Prof. Khovalyg, as one of the leading experts in the field, co-leads the Subtask A "*Fundamentals*" and she is actively involved in cross-subtask activities.

1.2 Purpose of the project

The purpose of the ICE participation in Annex 87 is to advance the knowledge in design and operation of thermal PECS and their application via research involving experimentation with humans (controlled studies and field tests), modeling of human thermo-physiological responses, and building energy simulations.

1.3 Objectives

The objectives of the ICE activities contributing to Annex 87 are:

- Establish scientific evidence for the need of the personalized climatization approach
- Develop methods for personalized sensing to enable the use of PECS
- Development and testing of novel PECS in terms of effect on human comfort and energy reduction in buildings

2 Procedures and methodology

There are 3 research projects that ICE currently contributes to Annex 87 (description is in Appendix):

1. iTHCoM: Non-Invasive AI-powered Thermal Comfort Monitoring
2. DynamoMet: Daily dynamics of metabolic rate in healthy adults in an office case study
3. pTEACH-RS: Thermal Environments and Architecture for Cooling and Heating with Personalized Radiant Systems

All projects involve experimentation. Projects iThCoM and DynamoMet involved testing of human subjects in a controlled environment in the ICE climatic chamber (https://www.epfl.ch/labs/ice/research-facilities/), while the project pTEACH-RS involves detailed characterization of the radiant environment created by radiant mobile walls in an experimental building prototype CELLS (https://www.epfl.ch/labs/ice/cells-building-prototype/).

In addition, the ICE lab is involved in the extensive literature review on thermal and ventilation PECS that spans across Subtasks A-D. Assist. Prof. Khovalyg is the coordinator of the review activities and authorship rules.

3 Activities and results

3.1 Scientific activities and results

- **iTHCoM project:** The project was successfully completed and resulted in an open access publication Rida et al. "*Toward contactless human thermal monitoring: A framework for Machine Learning-based human thermo-physiology modeling augmented with computer vision*" (listed in section 7).

A summary of the results is as follows:

Individual differences in human thermal comfort raise the challenge of providing environmental satisfaction to diverse occupants of buildings. A common practice of estimating the thermal comfort of people is monitoring the environment surrounding them using sensors that are usually attached to building and furniture surfaces away from people. Thus, more than this approach is needed for personalized sensing. The most direct way of knowing the thermal comfort of individuals is their surveying, which is limited by the participation rate and limited continuous feedback. Therefore, there is a need for a non-intrusive and scalable sensing solution to monitor individuals' thermal comfort in buildings continuously to survey if a building meets comfort criteria and for better climate control of buildings, avoiding energy waste to condition the spaces that are not occupied. Within the iThCoM project, a non-invasive sensing framework for monitoring the indoor environment using humans themselves as sensors was developed. It is a regular RGB and infrared (IR) camera-based solution that uses computer vision to detect individual parameters such as sex, age group, activity, and clothing of people in the field of view of the cameras. Personal parameters, in addition to the limited skin temperature measurements using an infrared camera, provide input to the Machine Learning-based human thermo-physiology model, learning from the physical model, to determine in real-time an individual's thermal state (i.e., skin temperatures of all body parts, and the core body temperature). As outcomes of the iThCoM project, the achieved accuracy of personal parameters detection was 70-90%, and the accuracy of thermal state prediction was 60-95%. The sensing framework can be further advanced by expanding the input dataset and larger human population set.

- **DynamoMet project:** Experimental part of the project is completed, and data analysis is ongoing. Preliminary data processing resulted in a CISBAT2023 conference publication Liao & Khovalyg "*Human sitting behavior at office work and its effect on metabolic rate under varying thermal exposure*" (listed in section 7).

A summary of preliminary results is as follows:

Analysis of metabolic rate (MET), the heat emission from the human body, in females, showed both inter- and intra-individual differences. In some participants, the metabolic rate at a relatively comfortable temperature of 24°C was higher than at a cooler environment of 18°C, while in other participants, it was the opposite. Also, the difference in metabolic heat production of the same person was different between morning and afternoon sessions. Some factors explaining the subjects having higher MET at 24°C are the following:

1) A temperature of 24°C was set on the first day, while 18°C was on the second day. Being in an unfamiliar environment could cause increased stress or anxiety, which could elevate the metabolic rate [14]. In addition, subjects were asked to wear a silicon face mask to measure energy expenditure, which may cause some discomfort and need some time to accustom. The body's stress response involves releasing stress hormones like cortisol and adrenaline, which could increase heart rate, blood pressure, and overall energy expenditure, leading to a higher metabolic rate. The mental effect could last for hours to a day or even longer, depending on the individual.
2) The result of thermal comfort surveys showed that most of the subjects felt relatively warm at 24°C. When the body feels warm, it may increase blood flow to the skin by dilating blood vessels near the skin's surface. Vasodilation could increase metabolic rate since the heart has to pump more blood to accommodate the increased blood flow [15]. Additionally, the respiration rate may increase to help dissipate excess heat through the respiratory system, involving losing heat through the evaporation of moisture from the respiratory tract. Thus, increasing respiration could result in a higher metabolic rate [16].
3) The efficiency of mitochondria in producing adenosine triphosphate (ATP) can be higher at cooler temperatures, which leads to a lower metabolic rate as less energy is wasted as heat [17]. Therefore, it could result in a lower metabolic rate in response to cooler thermal exposure.

Overall, there are many factors that could affect the human metabolic rate. Due to individual differences, different factors may have different intensities of effects on individuals. The factor of dynamic sitting shows a greater influence on metabolic rate for some of the subjects, while the other factors mentioned above have a greater effect on metabolic rate than dynamic sitting.

- **pTEACH-RS project**: Part of the testing conditions were completed in the summer of 2023, and the continuation of the work is planned for 2024.

A summary of preliminary results is as follows:

Testing the effect on local comfort and radiant heat exchange of different locations of mobile radiant partitioning walls was tested in the facility CELLS at an indoor air temperature of 28C. A single-panel case was tested at 3 locations around a work desk (front, side, back), and two-panel cases were tested at 2 locations around a desk (front+back, side+back). The surface temperature of the panels was around 14°C for single panel cases and 19°C for two-panel cases. The operative temperature and cooling power observed were the following: (i) front position: 27.7 °C, 146 W/m^2; (ii) side position: 27.0 °C, 147 W/m^2; (iii) back position: 26.7 °C, 140 W/m^2; (iv) front+side position: 26.8°C, 54 W/m^2, (v) side+back position: 26.5°C, 54 W/m^2. The results show that the side+back position of radiant partitioning walls has the greatest effect on the reduction of the operative temperature near the occupant's location, while the background environment is at 28°C. In addition, such a reduction is achieved at higher surface temperature (19°C) and less cooling power (54 W/m^2) compared to a single panel case. To better compare single-panel and two-panel cases, the surface temperature of the panels should be the same. In the tests, a temperature below 19°C was not possible to achieve due to the limitations of the current cooling systems.

- **Literature review:** A common literature review to understand state-of-the-art and define the research gaps related to PECS for domains Thermo and IAQ was initiated across Annex 87 Subtasks A-D. For Subtask A co-led by Prof. Khovalyg, the literature review should provide information related to «*definition and identification of the requirements of PECS in terms of localized and background Indoor Environmental Quality (IEQ)*» and «*the benefits of PECS regarding comfort, health and productivity*». To start the review process, a literature search query was identified in a working group in July'2023, a systematic search of the literature was performed across databases Scopus, Taylor & Francis, Web of Science, Google Scholar, and PubMed. In total, 14'807 papers were identified from all databases, and 1'317 papers were kept for the review after the screening of abstracts. To gather the required information for subtasks A-D from the publications, an extensive review table was developed, and, currently, a preliminary in-depth review of papers and testing of the table if it is usable is ongoing. In parallel, the authorship rules have been established under the lead of Prof. Khovalyg.

3.2 Hosting Annex 87 meeting in Switzerland (Lausanne, EPFL campus)

The 2nd expert meeting of the working phase of IEA EBC Annex 87 was hosted at EPFL campus in Lausanne on September 11-12, 2024. The organization of the meeting was possible thanks to the financial support of the Swiss Federal Office of Energy (SFOE). The meeting was organized by the ICE lab, and it included 1.5 day of the work overview and discussions, including a welcome dinner (Figure 1). A detailed agenda of the meeting is provided in Appendix.

Figure 1. Annex 87 meeting in Lausanne (September 11-12), during the working time and welcome dinner at Hotel Rivage Lutry.

4 Evaluation of results to date

The results obtained to date are satisfactory and have a direct input to the activities held in Annex 87.

5 Next steps

- **DynamoMet project:** Data analysis will be completed in 2024. The data processing and analysis will include metabolic rate data, TSV (thermal sensation votes) and TCV (thermal comfort votes) data of standing and walking sessions, heat flux data of seat sensing, all of the physiological parameter's data (skin temperature, core temperature, heat flux, heart rate, heart rate variability, accelerometry), and all of the environmental parameters data. The research questions to be answered are: (i) the magnitude of correlation between metabolic rate, sitting behaviour, comfort, and physiological parameters at different thermal exposures; (ii) the magnitude of inter- and intra-individual variation in human body heat production (metabolic rate). overall and local, depending on the activity types and time of the day.

- **pTEACH-RS project:** Repeat testing performed in 2023 after upgrading the cooling machine to reach 14°C of surface temperature in two-panel cases at 28°C of environmental temperature. Test the cooling conditions with the panels (i.e., test how much radiant panels can increase local operative temperature if ambient temperature is at 18°C). After tests are completed, estimate the energy saving potential of local radiant heating/cooling.

- **Literature review:** Detailed review of papers to be completed in January'24 with a following analysis of the information gathered. Once the analysis is completed by May'24, a review paper draft will be prepared and the submission of the completed paper is expected in October'24. The review paper should outline the requirements of PECS in terms of localized and background IEQ, and outline the benefits of PECS regarding comfort, health, and productivity of individuals.

6 National and international cooperation

- The ICE lab engaged into the *Round Robin Test in Living Labs for Personalized Comfort modeling* led by University of Perugia (Italy)
- The ICE lab submitted a research proposal with Empa (Switzerland) to SNSF. The project focuses on developing a holistic methodology for energy effectiveness of thermal PECS.

7 Publications

- Rida M., Abdelfattah M., Alahi A., Khovalyg D. (2023) *Toward contactless human thermal monitoring: A framework for Machine Learning-based human thermo-physiology modeling augmented with computer vision*, Building and Environment, 110850, DOI:10.1016/j.buildenv.2023.110850
- Liao R., Khovalyg D., *Human sitting behavior at office work and its effect on metabolic rate under varying thermal exposure*, CISBAT 2023, 13-15 September 2023, Lausanne, Switzerland

8 References

[1] T. L. Madsen and B. Saxhof. An unconventional method for reduction of the energy consumption for heating of buildings. In Second International CIB Symposium on Energy Conservation in the Built Environment, pages 31–43, 1977.

[2] R. Rawal, M. Schweiker, O. B. Kazanci, V. Vardhan, Q. Jin, and L. Duanmu. Personal comfort systems: A review on comfort, energy, and economics. Energy and Buildings, 214:109858, 2020.

[3] D. B. Greenberger, S. Strasser, L. L. Cummings, and R. B. Dunham. The impact of personal control on performance and satisfaction. Organizational Behavior and Human Decision Processes, 43(1):29–51, 1989.

[4] J. Kim, F. Bauman, P. Raftery, E. Arens, H. Zhang, G. Fierro, M. Andersen, and D. Culler. Occupant comfort and behavior: High-resolution data from a 6-month field study of personal comfort systems with 37 real office workers. Building and Environment, 148:348–360, 2019.

[5] M. Kwon, H. Remoy, A. van den Dobbelsteen, and U. Knaack. Personal control and environmental user satisfaction in office buildings: Results of case studies in the netherlands. Building and Environment, 149:428–435, 2019.

[6] H. Zhang, E. Arens, D. E. Kim, E. Buchberger, F. Bauman, and C. Huizenga. Comfort, perceived air quality, and work performance in a low-power task-ambient conditioning system. Building and Environment, 45(1):29–39, 2010. International Symposium on the Interaction between Human and Building Environment Special Issue Section.

[7] S. Schiavon, A. K. Melikov, and C. Sekhar. Energy analysis of the personalized ventilation system in hot and humid climates. Energy and Buildings, 42(5):699–707, 2010.

[8] S. Schiavon and A. K. Melikov. Energy-saving strategies with personalized ventilation in cold climates. Energy and Buildings, 41(5):543–550, 2009.

[9] A. Q. Ahmed and S. Gao. Numerical investigation of height impact of local exhaust combined with an office work station on energy saving and indoor environment. Building and Environment, 122:194–205, 2017.

[10] A. Lipczynska, S. Schiavon, and L. T. Graham. Thermal comfort and self-reported productivity in an office with ceiling fans in the tropics. Building and Environment, 135:202–212, 2018.

[11] Dolaana Khovalyg, Cecile A. Berquand, Giulia Vergerio, Verena M. Barthelmes, Arnab Chatterjee, Cristina Becchio, and Dusan Licina. Energy, SBS symptoms, and productivity in swiss open-space offices: Economic evaluation of standard, actual, and optimum scenarios. Building and Environment, 242, 2023.

[12] W. Song, Z. Zhang, Z. Chen, F. Wang, and B. Yang. Thermal comfort and energy performance of personal comfort systems (pcs): A systematic review and meta-analysis. Energy and Buildings, 256:111747, 2022.

[13] M. Vesely and W. Zeiler. Personalized conditioning and its impact on thermal comfort and energy performance - a review. Renewable and Sustainable Energy Reviews, 34:401–408, 2014.

[14] George P. Chrousos, "Stress and disorders of the stress system", Nature Reviews Endocrinology, 2009, 5: 374–381 https://doi.org/10.1038/nrendo.2009.106

[15] Rowell L B, "Human cardiovascular adjustments to exercise and thermal stress", Physiol Rev. 1974, 54(1):75-159, doi: 10.1152/physrev.1974.54.1.75.

[16] C. F. O'Cain et al., "Airway effects of respiratory heat loss in normal subjects", Journal of Applied Physiology, 1980, 49:875-880, https://doi.org/10.1152/jappl.1980.49.5.875

[17] Rolfe, D. F., & Brown, G. C, "Cellular energy utilization and molecular origin of standard metabolic rate in mammals", Physiological Reviews, 1997, 77: 731-758, doi: 10.1152/physrev.1997.77.3.731.

9 Appendix

- Summary of the ICE research projects
- Agenda of the 2nd expert meeting of the working phase of IEA EBC Annex 87 hosted in Switzerland (Lausanne, EPFL)

Description of the ICE lab projects:

iTHCoM: Non-Invasive AI-powered Thermal Comfort Monitoring

The transition toward human-centered indoor climate control is beneficial for occupants' well-being and from an energy-saving perspective. Yet, it requires knowledge of individuals' thermal state at the level of body parts. Current state-of-the-art solutions are based on invasive wearable technologies. They suppose physical access to people, hence cannot scale with the number of occupants (e.g., in public spaces with a continuous flow of people). This project aims to investigate non-invasive multi-modal sensing solutions such as IR and RGB cameras and to develop a Machine Learning-based human thermo-physiology model to effectively monitor occupants' thermal states in indoor spaces. We will show that it is possible to remotely measure individuals' thermal states given a new set of input attributes that are detectable with cameras. This could be used for personalized HVAC controls with human-in-the-loop. Advanced computer vision techniques such as human body part detection and attribute recognition will be used to extract these key attributes. Upon success, our work will pave the way to the first scalable and cost-effective human-centered indoor climate control improving the well-being of occupants and limiting energy use in buildings.

pTEACH-RS: Personalized Thermal Environments and Architecture for Cooling and Heating with Radiant systems

Radiant heating and cooling systems are an energy-efficient technology to target the conditioning of occupants of buildings and not the indoor air volume. To personalize the radiant heating and cooling, a set of movable partitioning walls with novel radiant heat exchangers and a radiant under-desk heater/cooler are built at the ICE lab. Thus, the project aims at the advanced characterization of the indoor thermal environment created by personalized radiant systems using the novel scanning and thermography methods by CHAOSense, the development of tools to predict the effect of radiant systems on the thermal experience of people. The project outcomes will deepen the knowledge of the localized radiant thermal environment resultant of the localized device, large glazed windows, and building-attached standard radiant ceiling panels via experimentation in the facility CELLS (Controlled Environments for Living Lab Studies) at the EPFL-Fribourg site. Special attention to the spatial and temporal exposure of humans to shortwave and longwave radiation will be paid. The main research questions are: (i) what is the dynamic spatial variation of radiant heat transfer between the surface of a person’s skin and clothing and the environment when exposed to several settings of radiant heating while the overall environment is beyond comfortable limits? (ii) how much radiative heat needs to be provided to bring the mean sensation of the person back to neutrality? (iii) what should be the arrangement of local heating using radiant panels, their surface temperature, and the distance from the person to shift the mean and local sensation of the person to neutrality when the starting sensation is cold/warm.

DynamoMet: Daily dynamics of metabolic rate in healthy adults in an office case study

Indoor temperatures in buildings are set to provide thermal comfort for occupants. The widely used thermal comfort model called PMV/PPD based on the energy balance between the human body and the environment uses metabolic rate as an input representing a human’s internal heat generation. Since our understanding of the metabolic rate variation during daily indoor activities is still limited, in this study, we want to determine met values variation that can be observed in healthy adults during a full-day experiment imitating typical office routines that would include sedentary and standing work. The type of meal given during the day will be standardized to observe comparable postprandial effects across participants. The measured metabolic rates of individuals will be compared with standard approaches to determining met values. Apart from the knowledge on how metabolic rate can change minute-by-minute, as a practical output, we want to develop a dynamic metabolic rate model based on secondary physiological indicators (skin temperature, core temperature, heart rate, etc.) that can indirectly inform regarding the change in met with acceptable accuracy. Thus, we plan to perform simultaneous measurements of physiological parameters using a mix of sensors (laboratory-grade and low-cost sensors) while the dynamic metabolic rate is measured using an indirect calorimeter.

2nd meeting of the working phase of

IEA EBC Annex 87, 11th and 12th of September 2023

Schedule

Day 1
Monday, September 11th 2023: 09:15 – 17:00 (CET)

Day 2
Tuesday, September 12th 2023: 09:15 – 12:00 (CET)

Meeting location

EPFL campus (BC building, room **BC 01**), you can find the exact location using the campus map https://plan.epfl.ch/

Participation and registration

- It will be possible to join the meeting online here: Click here to join the meeting
- For any further information regarding the registration or any other issue, please contact: Dolaana Khovalyg dolaana.khovalyg@epfl.ch +410798889206 or Ongun Berk Kazanci, onka@dtu.dk, +4550281327.

Other Information

Participation fee

Attendance is free of charge.

Coffee breaks, lunches, a dinner, and bus transfers will be kindly sponsored by the Swiss Federal Office of Energy.

Contact details

If you experience any difficulties or have any questions, please contact Dolaana Khovalyg dolaana.khovalyg@epfl.ch +410798889206 or Ongun Berk Kazanci, onka@dtu.dk, +4550281327.

Monday, September 11th 2023 (time zone CET)

Time	Activity	Location
08:45 – 9:15	Arrival (coffee, tea, etc.)	Room BC 01
09:15 – 9:45	Welcoming, introductions, agenda, and updates by the OAs	
9:45 – 10:15	Subtask A updates	
10:15 – 10:45	Subtask B updates	
10:45 – 11:00	Break	
11:00 – 11:30	Subtask C updates	
11:30 – 12:00	Subtask D updates	
12:00 – 12:15	Subtask E updates	
12:15 – 13:45	Lunch break	Rooftop BC
13:45 – 14:00	Overview of pending PECS definitions	Room BC 01
14:00 – 15:30	Literature review discussion	
15:30 – 15:45	Break	
15:45 – 17:00	Discussion on PECS definitions, survey	
	Evening activities	
17:30 – 18:30	Visit a daylighting testbed for field measurements (LIPID lab)	EPFL South parking
18:30 – 19:00	Bus transfer from EPFL to the restaurant	EPFL South parking
19:00 – 21:30	Dinner at Hotel Restaurant la Rivage *	https ://hotelrivagelutry.ch/
21:30 – 22:00	Bus transfer from the restaurant to Lausanne Gare (metro)	

*4dl of wine is included in dinner, any extra drink orders should be paid separately

EBC
Energy in Buildings and Communities Programme

Tuesday, September 12th 2023 (time zone CET)

Time	Activity	Location
08:45 – 9:15	Arrival (coffee, tea, etc.)	Room BC 01
09:15 – 9:30	Summary of discussions from the first day	
9:30 – 10:00	Summary of the discussion on the PECS definitions	
10:00 – 10:30	Discuss authorship rules	
10:30 – 10:45	Break	
10:45 – 11:30	Available time slot for any unclarified issues	
11:30 – 11:45	Wrapping up and next steps, end of the meeting	
11:45 – 12:45	Lunch break	Rooftop BC

	Afternoon activities	
13:00 – 14:00	Bus transfer to EPFL-Fribourg campus	EPFL South parking
14:00 – 16:00	Visit research facilities: a building prototype CELLS, a solar house Neighborhub that won Solar Decathlon in 2017, climatic chambers for air quality and thermal comfort studies (ICE and HOBEL labs)	EPFL-Fribourg
16:00 – 17:30	Transfer back to Lausanne by train (to be paid privately)	