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THERMAL COMFORT MANAGEMENT METHOD USING HVAC SYSTEM BASED ON MULTISENSORY COMFORT MAPS

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ABSTRACT

This paper describes the study and research taken under Project oBEMS (Office Building Energy Management System). This is an intelligent hardware and software overlay for office building automation systems based on the advance methods for measuring thermal room conditions. This method allows for managing thermal comfort in certain space by controlling installed Heating, Ventilation and Air Condition system (HVAC) in real time with the use of multisensory map of comfort.

Keywords: energy conservation in buildings, systems for energy saving, Building Energy Management System.

1. INTRODUCTION

Thermal comfort in office buildings is now an essential topic in every environment [1,3,4,5]. These times every modern building is equipped with building management system which is dedicated to control thermal comfort in defined spaces, floors or occupancy zones. The controlled space usually accommodates many occupants working in the areas called open spaces, which can be re-configured according to the needs of occupants [5,7]. Finding the method of proper control of thermal comfort in such space using HVAC control system based on existing infrastructure is very important, as it reflects in keeping thermal comfort at desired levels and it can generate possible energy savings. Project oBEMS is aimed to connect various approaches and various information – temperature, humidity, carbon dioxide, occupancy, weather and many more - to provide consistent method for measuring, concluding and controlling the thermal comfort by using HVAC control system which exists in the building to support occupants and landlords with their actions to provide the best thermal conditions in the building and energy savings.

2. THERMAL COMFORT MEASUREMENT

Common methods define thermal comfort in the selected individual occupant position or for whole measured space. Measurement takes place using sensors installed at the individual occupant location (e.g. desk) or on the wall (usually at the entrance door together with BMS control panel for HVAC system) [3,7]. In our project we showed that thermal comfort cannot be represented by one-point measurement and then extended for whole space. Using our testing room showed in the Fig. 1 and temperature measurement method using FLIR meters we showed that temperature is not evenly distributed over the room. This means that thermal comfort expressed by PMV indicator is also not evenly distributed over the measured space [1,3]. This was also confirmed in the real existing buildings, where we took measurements of comfort providing the measurement grid. The results of these measurements also showed that our PMV distribution can be very different from the value measured by existing sensors from BMS system (Fig.2). What is more, when BMS sensors shows that comfort is at desired level but in our measurement we observed that it could concern only the space close to the BMS sensor. Rest of the occupied space can be out of range.

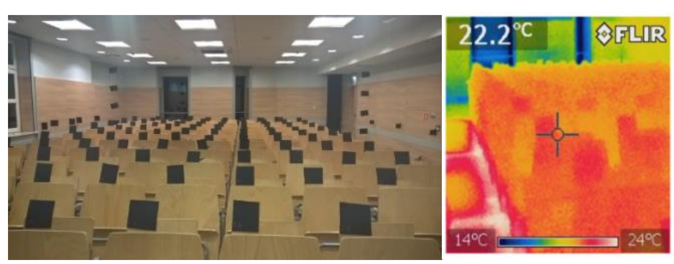

Fig.1. Test room photo and measurement method

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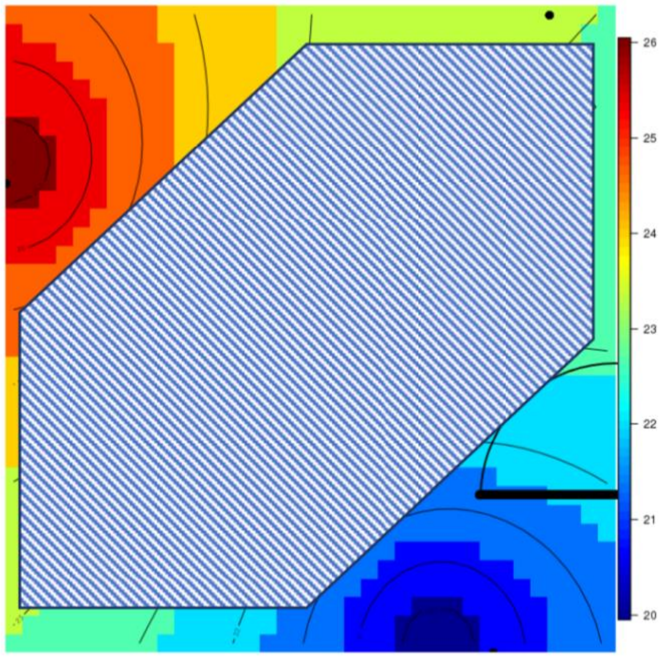
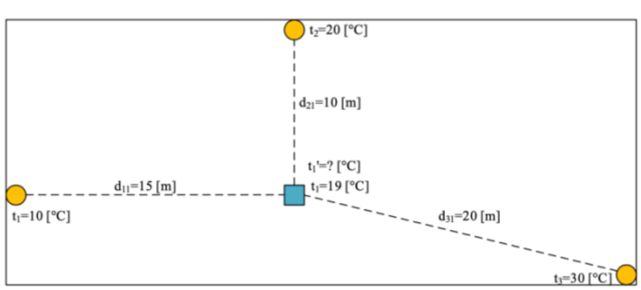


Fig.2. Temperature distribution over the measured space. Distribution of the comfort field in a room with a designated zone of required comfort (hatched field).

3. METHOD OF APPROXIMATION

Real environment does not allow for thermal comfort measurements using the measurement grid. Project oBEMS required the method for creating the thermal comfort distribution which can be derived from minimum number of measurement points which does not affect the occupied space [2]. We developed approximation method which allows for calculation of comfort map using minimum number of sensors located at room boundaries or space boundaries in the way we can use them to measure and calculate with the least error thermal comfort distribution over the space (Fig.3).



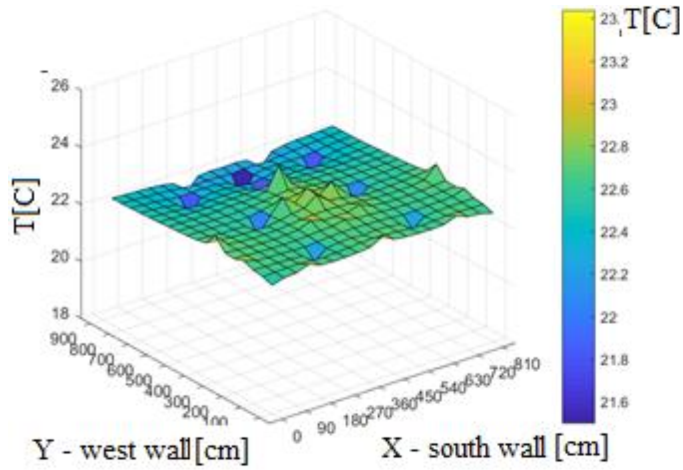


Fig. 3. Thermal comfort distribution in the testing room

At the beginning we used third party sensors, but during the further works we developed a new sensor which accommodates several sensors and is able to make complex measurement in selected point. New sensor (Fig.4) measures temperature, humidity, light, occupancy and pass this information to the base station and through the gateway to the management system where the information is processed according to the other acquired data or data taken from database.

Fig. 4. Multisensor unit

4. THERMAL COMFORT MAPS

Using the approximation method described above our management system is able to create comfort maps over the space in real time by analyzing and synthesizing the measured data from multisensory set of sensors in the room. Example of the comfort map is showed on the Fig. 5.

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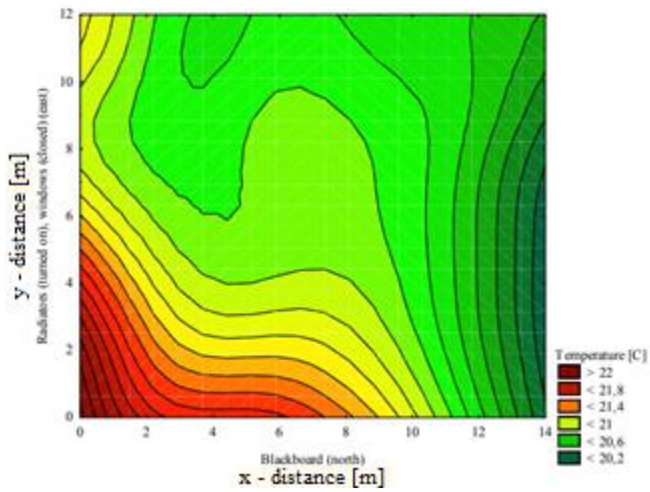

Fig. 5. Thermal comfort map based on the temperature measurements in the testing room.

5. DECISION MAKING PROCESS

These maps allow for division of space into cells and calculations of thermal comfort within the space. Based on these calculations, the decision making module concludes which cell is out of range and how many of such cells exists. Then preliminary decision is made based on the average number of cells if the system should make any actions in regards of cooling or heating action in BMS system which controls HVAC infrastructure. This decision is also taken by using additional data present in the management system. These decision-making process is showed on the Fig. 6.

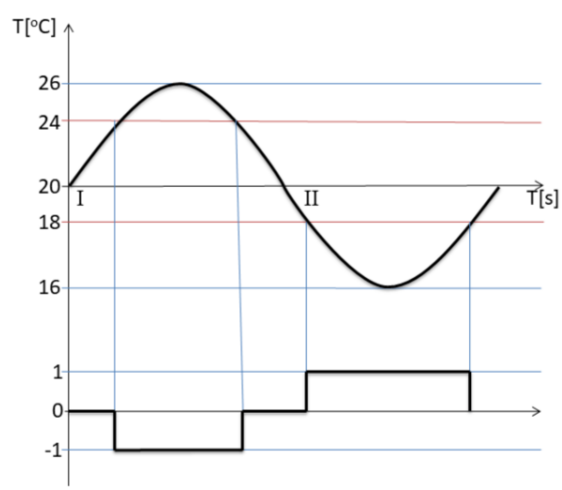

Fig. 6. Decision making process based on the temperature measurement in the room.

6. ADDITIONAL INFORMATION

Proper and final decision is made by consideration of additional information present and gathered previously in the oBEMS system. This additional information covers: occupancy data based on the carbon dioxide measurement, weather forecast, digital thermal room model. All these additional information are participating in the final decision algorithm which tells the BMS system if cooling or heating should take place and what efficiency should be applied to achieve the desired thermal comfort level over the space according to the thermal capacity of the space or building.

7. MANAGEMENT SYSTEM

Project oBEMS also covers the developing information system for data acquisition from many locations. These data are stored in the database and calculation module allows for creating comfort maps. Furthermore the data is displayed on the user interface screen called dashboard (Fig. 7). On the user dashboard we can see thermal comfort map, changes over selected timeline, we can apply temperature ranges and desired parameters, as well as occupancy functions, weather forecast, desired actions and energy consumptions measurements (Fig.8). Management system integrates all parts of the process by providing visual interface from the measurement to the decision-making process creating the real time feedback and real time thermal comfort with the preview of energy consumption.

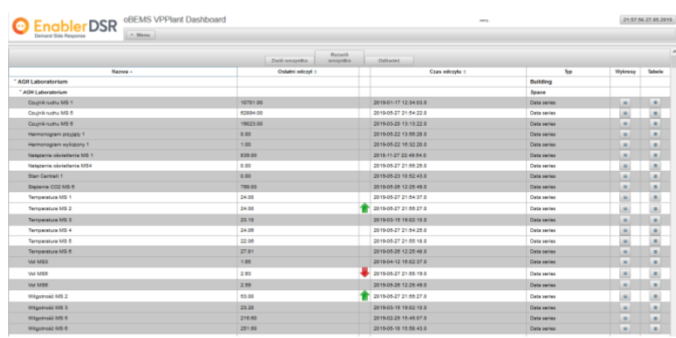

Fig.7. Example of management system dashboard

At the end, when all decisions are made inside the system modules, management system is passing the output data to the BMS system which controls HVAC infrastructure and supervise the actions taken by the BMS system in the building in the way which keeps the thermal comfort at the desired range trying to generate energy savings. In this way oBEMS management system is a type of the virtual bot to control thermal comfort or energy consumption in the building or confined space.

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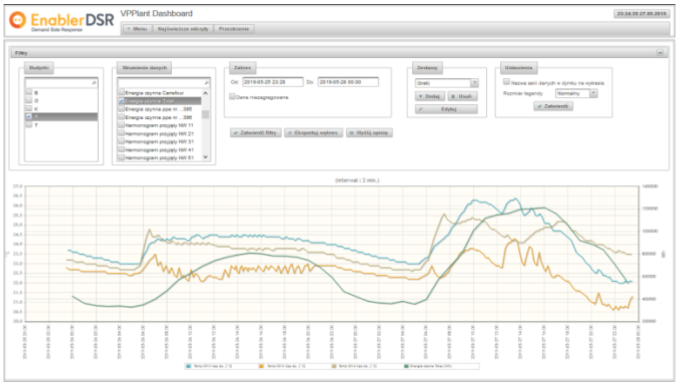

Fig. 8. Example of energy consumptions against the thermal comfort measurement

8. THERMAL COMFORT MANAGEMENT METHOD

The described process creates the method for thermal comfort management in the defined space using multisensory measurement and decision-making process based on measured data, approximation of thermal comfort distribution, additional data like occupancy information, weather forecast and room thermal model and functions. The comprehensive approach described above which integrates various phases of thermal comfort management creates the new method for thermal comfort management and what is more – it includes the feedback in the real time allows for control HVAC system parameters also in real time or according to the desired schedule. The basic diagram of the management method is showed on the Fig. 9.

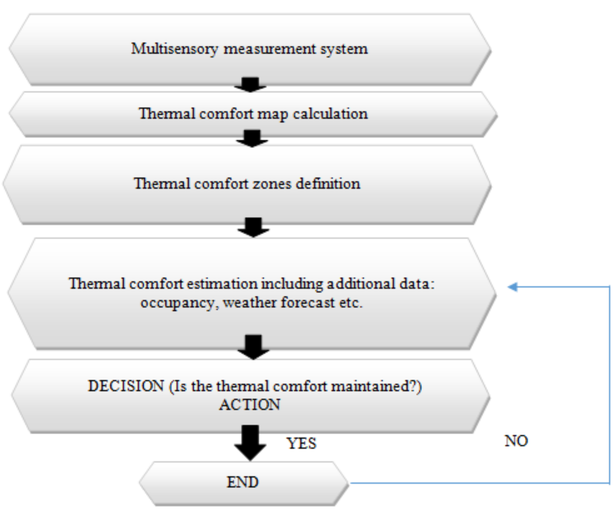

Fig.9. Management method diagram.

9. CONCLUSIONS

oBEMS project was aimed on the finding the new approach and new method together with developing the necessary measurement and management tools. This project now allows for thermal comfort management which can also generate energy savings when thermal comfort parameters and schedules are correctly defined and depends on the objective: energy saving or thermal comfort maintenance.
There is also additional feature coming from the above method. Measuring the thermal comfort distribution and creating thermal comfort maps for the confined space allows for changing the room design so the e.g. workplaces can be re-organized in the way to achieve the best location for every individual office worker in regards of thermal comfort conditions. In this way we can use oBEMS system to provide active thermal comfort management by influencing the HVAC control system and its parameters or passive comfort management using only multisensory thermal comfort maps.

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