Assessing and Communicating Indoor Environmental Quality

MANUEL GAMEIRO DA SILVA
ADAI, LAETA, Department of Mechanical Engineering
University of Coimbra, Portugal
e-mail: manuel.gameiro@dem.uc.pt

LEO VAN CAPPELLEN
Van Cappellen Advies bv,
The Netherlands
e-mail: vca@teleconsult.nl ;
leo@vancappellen.com

EDUARDO SANJUANELLO
Colswe Consulting AB,
Sweden
e-mail: eduardo@colswe.com

This paper describes how a developed multiprobe measuring system is used for the assessment of Indoor Environmental Quality (IEQ) in buildings. The objective of the work has been to develop an intuitive, coherent and user-friendly system for either short term or long term IEQ audits. Apart from the presentation of the measured values in tables and graphics, the main novelty of the system is the classification of the indoor environmental conditions in each sampling, according to the categories defined for thermal comfort, relative humidity and indoor air quality according EN-16798-1 [1]. The system introduces innovative graphical representations for reporting different phases of audits.

The concept of Indoor Environmental Quality (IEQ) is defined as the set of conditions associated with the thermal environment, the indoor air quality, the acoustic environment and the visual environment.

Assessing IEQ involves usually the measurement of various environmental variables and the subsequent calculation of composed indices that somehow take into account the human perception of the various types of stressors. The multiple evaluation of IEQ, considering simultaneously two or more aspects of IEQ (e.g. thermal comfort, indoor air quality and noise), is usually done with different measuring systems from different suppliers, resulting in a considerable investment both in monetary terms and in the time needed to get used to the different operation procedures.

The existence of miniaturized probes to measure various input environmental quantities, integrated to electronic digital circuits, gave the opportunity to develop new measuring systems. Having as a starting point the experience of implementing a detailed IEQ monitoring system in office buildings [2], the authors decided to develop a simpler system oriented to auditing activities. This paper presents the project of a multiprobe device for the assessment of IEQ and the related software tools to allow its interface and operation with a personal computer. A need for more detailed information about the IEQ aspects in buildings will certainly be induced by the launching of the Smart Readiness Indicator [3, 4] that is expected to include, in the evaluation criteria, besides others more energy related, comfort, health, convenience and communication with users.

Measuring System

The multiprobe device (**Figure 1**) is equipped with sensors to measure/display the variables below and it has the shape of a USB memory stick to be connected to the COM port of a personal computer.

- temperature;
- relative humidity;
- illuminance level;
- atmospheric pressure;
- concentration of CO_2;
- an Indoor Air Quality index based on volatile organic compounds concentration.

The initial main technical requirements defined for the system project were to:

- Develop a multiprobe system able to measure relevant IEQ variables;
- Present the instantaneous values of the measured quantities with an on-running adjustable sampling time step;
- Optimize the quality of measured data, providing to the users the possibility of an easy update of the multiprobe calibration file, according to their needs;
- Register the measured data in appending mode in a file created in the beginning of the data acquisition process and adding the data values after each sampling moment, minimizing this way the risk of data loss in case of any unexpected occurrence;
- Give to the user the possibility of having an adequate organization of measuring data files, including information about the multiprobe ID unit, the calibration data, the date, time and location of the sampling procedure, either in the name, either in the header of data files;
- Communicate the information, about IEQ, in its distinct dimensions, in a way easily understood by non-experts.

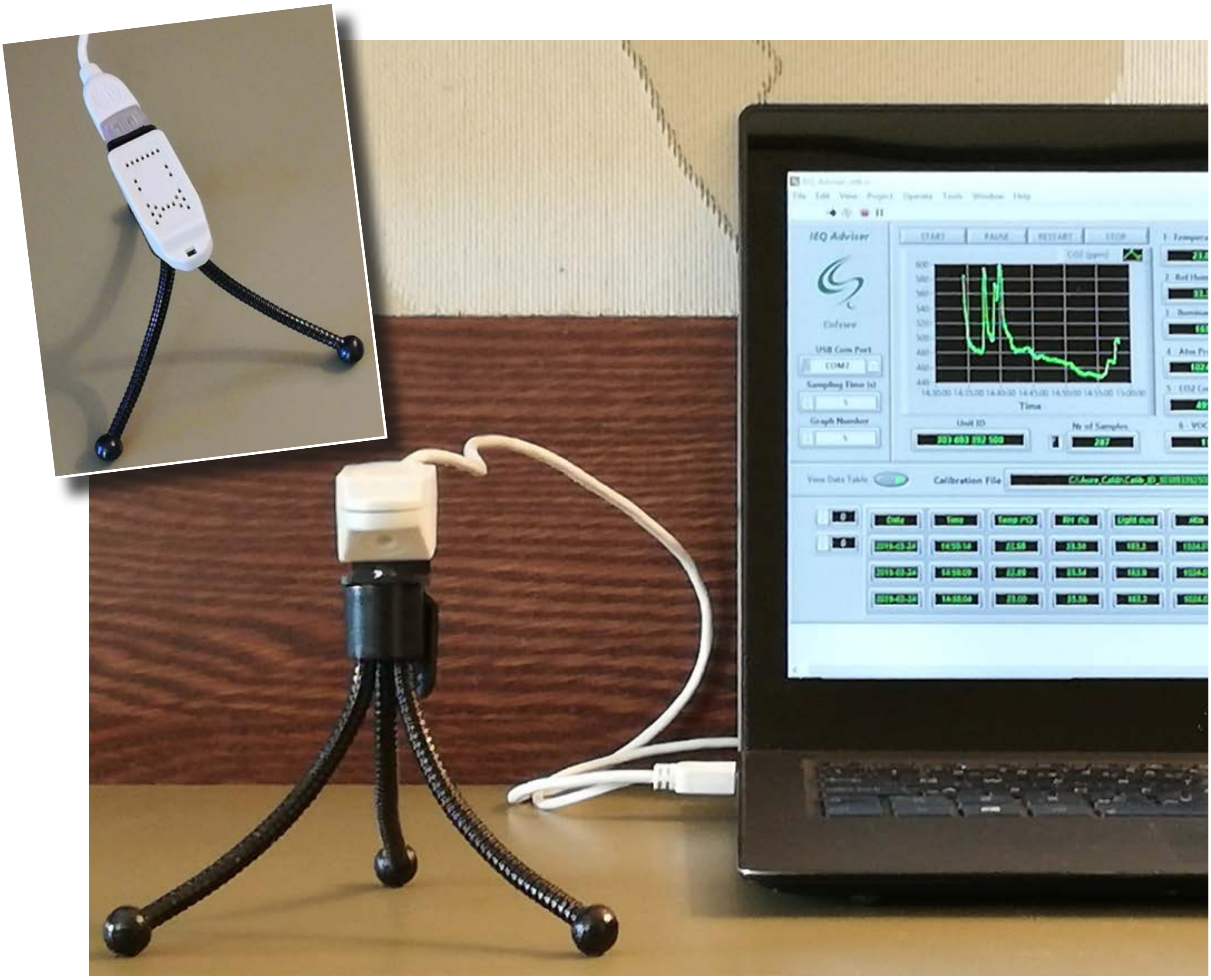

Figure 1. The developed IEQ multiprobe.

Software Tools

A set of software tools has been developed to support the use of the measurement system. The first one is called AURA IEQ DISCOVERER® to manage the operations below. The **Figure 2** shows the interface with the user during a sampling procedure where the multiprobe device was connected together with an operative temperature probe.

- Communication of the multiprobe device with the computer.
- Management of the sampling process.
- Presentation of the numerical values in displays, in a table and in graphical format.
- Categorization of the indoor conditions according to the standard EN 16798-1 [1] and the scale of an IAQ Index based on VOCs concentration.

The **Figure 2** shows the interface with the user during a sampling procedure where the multiprobe device was connected together with an operative temperature probe. Other software tools are developed to manage for example the calibration process of the multiprobe devices, to operate simultaneously with multiple devices or to operate the multiprobe device together with a low speed omnidirectional anemometer and a globe or an operative temperature probe. The latest allows the calculation and the display of complementary thermal comfort indices (e.g. PMV-PPD and WBGT).

As it has been previously mentioned, one of the main novelties of the developed system is the communication strategy based on the classification of the indoor environment aspects, using the categories, from I to IV, proposed by EN 16798-1 . The color scheme suggested in standard ISO 7730:2005 [5] to identify the thermal comfort categories has been adopted to fill the boxes used for the categorization of indoor environment. Three examples of the categorization section of the AURA IEQ DISCOVERER® interface are depicted in **Figure 3**. The first one refers to the same situation presented in the **Figure 2** where all the analyzed aspects are in the best possible category, i.e. on target, which is graphically indicated by the symbol (⦿) displayed in the small square box on the right side.

In case the HVAC Season is switched from Heating to Cooling, the situation changes to the second example in the middle of **Figure 3**. For the same operative values, the thermal comfort in summer changes to category 4. The box indicating the category changes the color from white to red and the graphical symbol (▼) in the small box on the right side indicates lower temperatures than the optimal target. It corresponds to a situation where people would feel cold.

The third example on the right of **Figure 3** represents a situation in which the user breathed on the multiprobe device, warming it a little and increasing the local CO_2

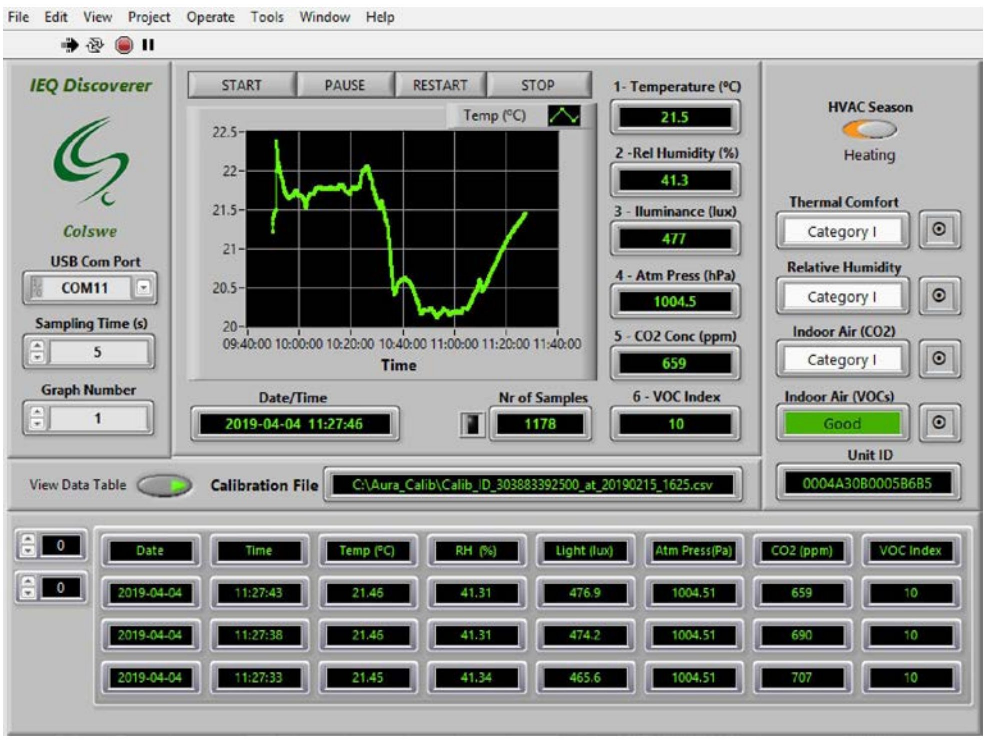

Figure 2. The interface window of IEQ Discoverer software tool during data acquisition.

concentration compared to example 2. The thermal comfort category improves from category IV to III and the color in the category box changes from red to yellow with values still lower than the optimal target. On the contrary, indoor air quality based on CO_2 concentration changes to category III and the graphical symbol (▲) in the small box on the right side indicates higher values than the optimal target.

The data files saved by AURA IEQ DISCOVERER® during the data acquisition process have a header with the following information: location of the sampling points (building, room and point reference), ID unit number of the multiprobe, name and date of the calibration file. Thirteen columns below the header display the date and time of the measurement, numerical values of all the measured variables, the status of the four categories, as well as the information on the HVAC season

Results

To facilitate the reporting of audits results, a data processing excel spreadsheet template has been created to display in graphs the evolution in time of the variables of the indoor environment. Similar graphs to those shown in **Figure 4** and **Figure 5** display the category intervals in colors according to EN 16798-1. Thus, a fast perception of the performance of the analyzed site, is facilitated.

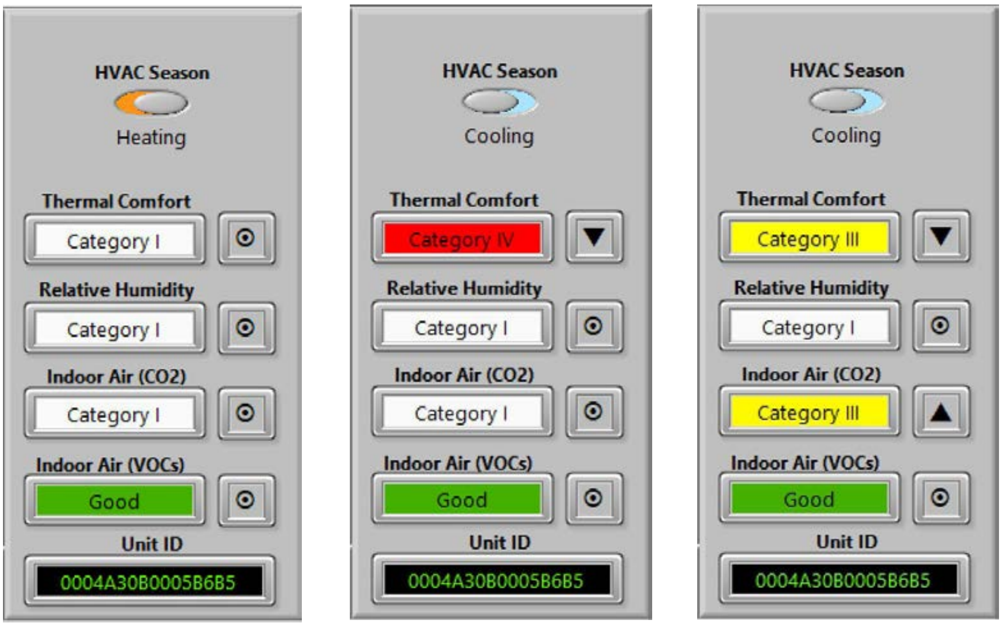

Figure 3. Different aspects of the categorization section of the IEQ Discoverer interface.

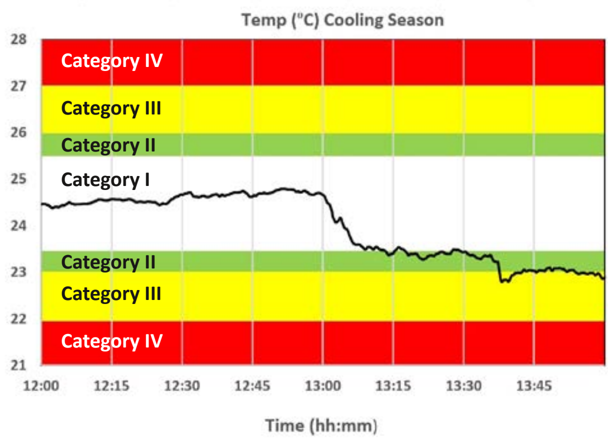

Figure 4. Evolution in time of Operative Temperature displayed with colored backgrounds for the categories defined in standard EN 16798-1.

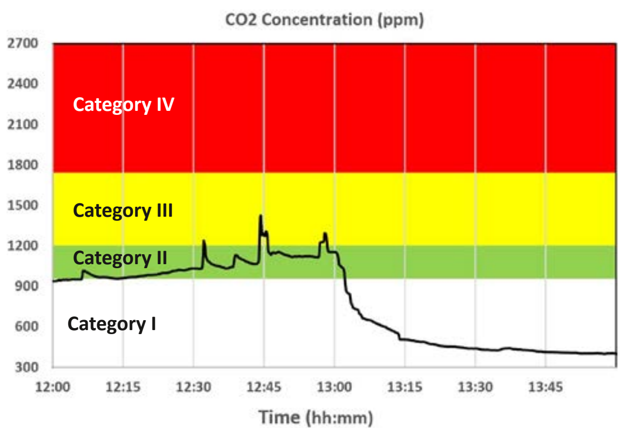

Figure 5. Evolution in time of CO_2 concentration displayed with colored backgrounds for the categories defined in standard EN 16798-1.

Conclusions

The concept initially defined for the IEQ monitoring system has been successfully implemented. The system is an attempt to allow a better spread of the use of IEQ assessments, due to the integration of different probes in only one measuring device and to the innovative communication strategy. It is expected that a larger number of users will have access and easily understand the different dimensions of the evaluation of IEQ, with positive impacts in terms of well-being, health, safety and productivity of people in buildings and other indoor environments. ■

References

[1] EN 16798-1:2018 Energy performance of buildings — Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics — Module M1-6.

[2] Manuel Gameiro da Silva, João Dias Carrilho, Leo van Cappellen, John van Putten, Bart Smid, "Gemeentehuis Horst aan de Maas: a case of excellence in indoor environmental quality", Rehva Journal, Volume 55, Issue 4, August 2018, pp 40-50.

[3] Directive 2018/844/EC on Energy Performance of Buildings, Official Journal of the European Communities, 19.6.2018, Brussels.

[4] Stijn Verbeke, Yixiao Ma, Paul Van Tichelen, Sarah Bogaert, Paul Waide, Mathias Uslar, Judith Schulte, Kjell Bettgenhäuser, Ashok John, Andreas Hermelink, Markus Offermann, Jan Groezinger "Support for setting up a Smart Readiness Indicator for buildings and related impact assessment" second progress report of Study accomplished under the authority of the European Commission DG Energy, 2017/SEB/R/1610684, 12 June 2018.

[5] ISO 7730:2005 Ergonomics of the Thermal Environment – Geneva: International Standardization Organization.