Assessment of low-cost CO_2 sensors performance for smart ventilation

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ABSTRACT

To minimize the energy consumption of buildings while maintaining good Indoor Air Quality (IAQ), smart ventilation is an area of growing interest, enhanced in Europe by the directive EPBD (EU) 2024/1275 and the Ecodesign regulation 1253/2014. In this context, the use of low-cost CO_2 sensors to control ventilation systems is increasing, which makes it necessary on one hand to understand better the strengths and weaknesses of these sensors and on the other hand to dispose of an adequate and reproduceable method to assess the performance of these sensors.
Several scientific research studies already evaluate CO_2 sensors. However, they often either compare a small number of CO_2 sensors or use test methods that are not thought to be reproduceable.
This contribution presents a study that performs laboratory tests on six models of low-cost air quality CO_2 sensors, pursuing two objectives:

- Propose a test method suitable for routine assessment, which could support the standardisation processes currently ongoing in Europe on this matter (CEN\TC 247).
- Identify some strengths and weaknesses of these sensors for ventilation control.

First, a test bench for CO_2 sensors was developed allowing to control the reference CO_2 concentration, humidity and air temperature in a test chamber. To control CO_2 concentration and humidity, thermal mass flowmeters are used to regulate the flow in multiple lines that mix before the test chamber. The control of temperature is achieved through thermal conditioning of the test chamber. Before going further, a validation of the test bench was conducted.
Then, six different models of CO_2 low-cost sensors were selected, with a sample of three sensors for each model, resulting of a total of 18 sensors tested. Among the sensors, a wide range of prices were chosen from 8 euros to 60 euros and three different technologies are represented: Non-Dispersive Infrared Radiation (NDIR) single channel, NDIR dual channel and Photoacoustic Spectroscopy (PAS).
The testing protocol is conceived in two phases: first conducting broad testing and secondly proposing a routine test method. In the first phase of the testing, the influence of air humidity and air temperature is evaluated. Moreover, the drift in time should also be evaluated with long-term tests. In the second phase, the analysis of the results will be exploited to choose the appropriate tests for a routine assessment.
As a perspective, this study could be extended in the future to VOCs sensors, which are also used occasionally for ventilation control.

KEYWORDS

CO2, low-cost sensors, laboratory test, NDIR, photoacoustic spectroscopy, smart ventilation