Evaluation methods for demand controlled ventilation systems: the persistence of the equivalence principle

Jelle Laverge, Arnold Janssens

Ghent University
Jozef Plateaustraat 22
Ghent, Belgium

ABSTRACT

Demand-controlled ventilation is a technology that aspires to adjust the ventilation rate supplied to a space to maintain acceptable indoor air quality, with the goal to minimize the total flow rate. It is, in that sense, a specific implementation of the definition of smart ventilation as it is promulgated by AIVC (Durier, 2018). Several approaches to the evaluation of the performance of such systems have been proposed. In this presentation, we discuss the history of the evaluation of demand-controlled ventilation systems in Belgium as an analysis of how persistent the notion of equivalence is in this process.
At the onset, most ventilation standards and regulations are prescriptive in nature. The controversy around the introduction of demand-controlled ventilation then revolves around continuity of the requirements between demand-controlled and 'default' systems, introducing the 'equivalence' principle, where the acceptability is judged based on comparing the performance to that of an accepted system.
An unintended consequence of a pure 'pass/fail' equivalence approach is that, as it is essentially the solution of a constrained optimization problem, it creates a push in the market towards the minimal acceptable solution. This typically leads to the introduction of additional performance criteria to better constrain the solution space. In Belgium, this lead to the exploration or introduction of criteria on exposure to material emissions, back-draft, peak exposure…
This fundamentally changes the nature of the problem to a multi-objective optimization, where a strict interpretation of the equivalence principle leads to the requirement that any acceptable solution should be dominate (in the pareto-optimal sense) the reference system. A further development in the evaluation of demand-controlled ventilation systems is therefore the introduction of a continuous performance criterium that creates an incentive to work towards pareto optimal solutions. In Belgium this has been achieved with the introduction of the concept of the equivalent performance of a reference system at the same level of indoor air quality.
Although the question under which conditions (weather conditions, occupancy, floor plan layout…) the equivalence needs to hold is not particular to the multi-objective case, the limitations of the approach are starker.
The reference systems might have a number of performance dimensions where the performance level achieved is not considered essential. The obvious solution to this is to then set absolute acceptability criteria for these dimensions. Examples of this include the exclusion of solutions that lead to condensation and mould in the Belgian assessment methods, or the development of the performance criteria in IEA-EBC Annex 68. With different technologies hitting different constraints, however, this introduces the question of equitable weighting of consequences of these absolute acceptability criteria, which in turn leads to the gradual adoption a scalarisation approach to solving the multi-objective optimisation problem. In Belgium, this lead to the introduction of DALY's or even the monetisation of all outputs as a potential solution. In search for an acceptable or understandable limit for these scalarised objectives, we turn to… equivalence with existing solutions.
The equivalence principle is an essential tool that allows us to explore the consequences of introducing new ideas and solutions to our existing toolboxes, but cannot make up for the lack of fundamental underpinning of our design decisions. Adopting it in standards and regulations is a challenge to move forward in the development of better performance criteria and should therefore always be regarded as a temporary stop gap measure.

KEYWORDS

DCV, performance assessment, standards, IAQ