Assessing demand-controlled ventilation strategies based on one CO_2 sensor

Gabriel Rojas*[1]

1 University of Innsbruck
Unit for Energy Efficient Buildings
Technikerstrasse 13, Innsbruck, Austria
** gabriel.rojas@uibk.ac.at*

SUMMARY

The common demand control approach for MVHR systems using one CO_2 sensor within the ventilation unit is assessed based on a typical residential apartment situation using CONTAM models. The simulation results confirm that air flow and therefore fan electricity and ventilation losses can be reduced compared to constant flow control, in particular for higher nominal air exchange rates. However, under certain boundary conditions, e.g. unevenly occupied dwellings indoor air quality in certain rooms may suffer with this DCV strategy.

KEYWORDS

Mechanical ventilation, demand control, CO2 control, residential ventilation, cascade ventilation

1 INTRODUCTION & METHOD

Demand control ventilation (DCV) is a viable approach to reduce air flow when residential dwellings are not occupied. A common approach is to position one single CO_2 sensor in the common exhaust usually within the MVHR unit. This avoids sensor installation and cables within the dwelling. However, questions arose if this approach may impair air quality under certain boundary conditions. Therefore, a residential apartment was modelled with the software CONTAM as described in previous papers (Rojas, Pfluger, and Feist 2016). It represents a typical Austrian three-person household in a 76 m² dwelling (unless varied). The average exceedance (threshold deviation) of CO_2-concentration during room occupation in the winter season (December through February) is evaluated as follows:

$$TD = \frac{\sum_{i=all\ hours\ where\ c>1000ppm}(c_i - 1000)}{t_{total\ time\ of\ room\ occupation}} \quad (1)$$

It quantifies the extent and duration of all exposure events where the target value for CO_2 of 1000 ppm is surpassed. In a similar manner the shortfall of relative humidity (below 30%) is quantified. In previous work this evaluation method has been extended to include building material related pollutants and mould risk (Rojas et al. 2016).

2 RESULTS & CONCLUSION

Figure 1 shows the evaluation results as a function of the nominal air flow rate. Each point represents the result from one simulation run. The following four DCV strategies were compared against a reference case with constant air flow:

- 2-point controller: 0.3 <700 ppm and 1 >900 ppm
- 2-point controller: 0.3 <600 ppm and 1 >800 ppm
- proportional controller: 0 <700 ppm ramping to 1 at 900 ppm
- proportional controller: 0 <600 ppm ramping to 1 at 800 ppm

Additionally, the results for the “extended” cascade ventilation principle with constant air flow is also shown. The extended cascade is a simplified air distribution concept with no dedicated supply air into the living room, see e.g. (Rojas, Pfluger, and Feist 2014). One can see that all DCV strategies can reduce total air flow rate (Figure 1, right) compared to the constant flow cases. Therefore, time periods with low air humidity (<30%) are also reduced (Figure 1, middle). However, the performance in terms of CO2 concentration in the bedroom is equal or worse than the constant flow case. The extended cascade ventilation achieves low CO_2 exceedance levels at a total air flow rate of >60 m³/h, at this flow rate the relative humidity shortfall is still small.

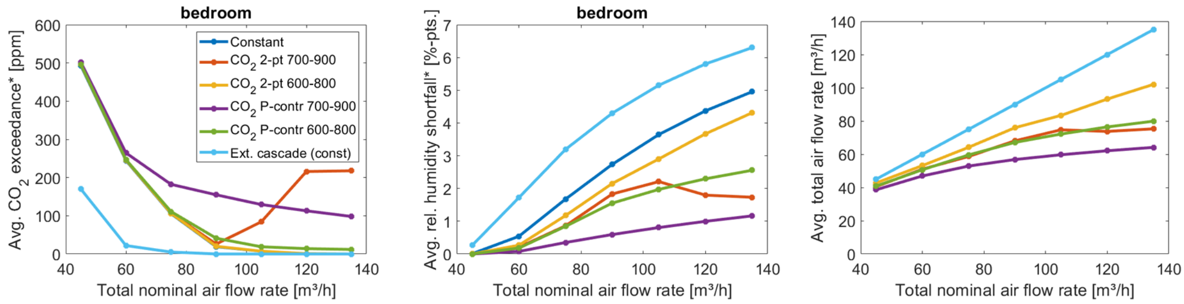

Figure 1: Comparison of CO_2 exceedance (left), relative humidity shortfall (middle) and reduction in total air flow (right) for different control strategies (see text). Note, that the dark blue line is below the yellow line (left) and below the light blue (right). (* during occupation in winter period)

To point to potential problematic situations for DCV control strategies with only one CO_2 sensor, Figure 2 shows the simulation results for a two-person household, i.e. with a vacant children's room. One can see that here most of the DCV strategies have substantially higher CO_2 exceedance than with constant air flow. This is due to the fact that the concentration in the exhaust (where CO_2 is measured) is "diluted" by "unused" air from children's and living room, while the two adults are in their bedroom. Only the 2-point controller with low set-point (600-800 ppm) performs equally well as the constant flow case.

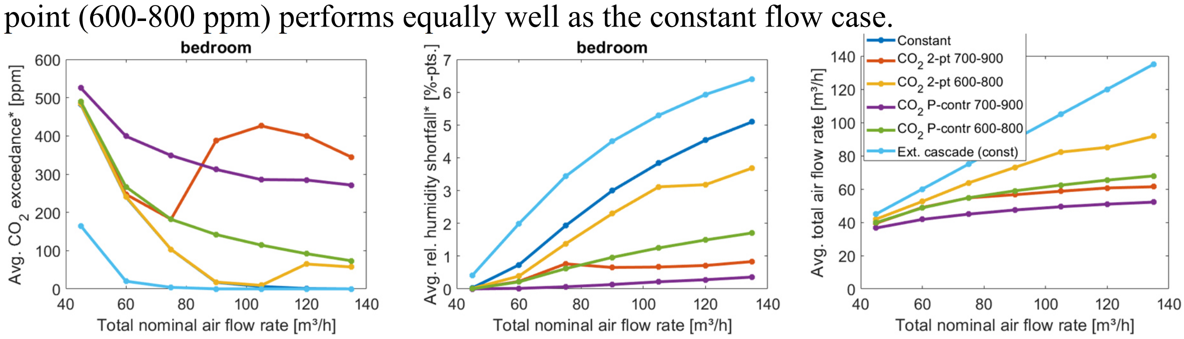

Figure 2: Comparison of CO_2 exceedance (left), relative humidity shortfall (middle) and reduction in total air flow (right) for different control strategies (see text) with vacant children room. Note, that the dark blue line is below the yellow line (left, <115 m³/h)) and below the light blue (right). (* during occupation in winter period)

The presented simulation results confirm that DCV strategies can effectively reduce air flow and therefore fan electricity usage and ventilation losses compared to constant flow strategies. However, care needs to be taken in the design of the actual control strategy, e.g. positioning of the sensor, set-points, etc. to avoid performance shortfalls in terms of IAQ under certain conditions, e.g. unevenly occupied dwellings (as presented here). It is also noted that for the investigated boundary conditions DCV will not substantially outperform the extended cascade ventilation principle, with constant air flow. However, this may change for other boundary conditions (e.g. little occupancy) and DCV may also be beneficially applied to this principle.

3 REFERENCES

Rojas, G., R. Pfluger, and W. Feist. 2014. "Cascade Ventilation-Air Exchange Efficiency in Living Rooms without Separate Supply Air." *Energy and Buildings* 100:27–33. doi: 10.1016/j.enbuild.2015.02.014.

Rojas, Gabriel, Rainer Pfluger, and Wolfgang Feist. 2016. "Ventilation Concepts for Energy Efficient Housing in Central European Climate – A Simulation Study Comparing Indoor Air Quality , Mould Risk and Ventilation Losses." in *Indoor Air 2016*. ISIAQ.