Practical use of the Annex68 IAQ Dashboard

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SUMMARY

The present paper aims at illustrating the practical use of the Annex68 IAQ Dashboard. To this end, numerical simulations have been performed to provide useable data about the Indoor Air Quality (IAQ) of a low-energy detached house. The dashboard has been used to compare three possible solutions of ventilation systems commonly found in French residential buildings i.e. natural ventilation using vertical ducts for extraction, self-regulated exhaust and balanced mechanical ventilation. The analysis shows that a 50% IAQ improvement can be achieved with a balanced system compared to other ventilation systems.

KEYWORDS

Indoor Air Quality, IAQ metrics, low-energy building, ventilation system.

1 ANNEX68 IAQ DASHBOARD

IEA Annex 68 Subtask 1 aimed at setting up the metrics to assess the performance of low-energy buildings as regards indoor air quality (IAQ) combining the aspirations to achieve very high-energy performance without compromising indoor environmental quality (Abadie and Wargocki, 2017). We proposed IAQ sub-indices based on acute (short-term) and chronic (long-term) effects as the ratio of the concentrations to the guideline levels; for chronic effects, we also proposed the DALY approach (Disability-Adjusted Life Years) as an IAQ index. As for the multipollutant index, we proposed the maximum of the calculated indices acknowledging limitations and inaccuracies introduced by aggregation methods. Finally, the value of the index, or set of sub-indices, for IAQ ultimately needs to be weighed against the additional use of energy needed to improve IAQ in comparison with current standard practice. Figure 1 presents the graphical representation of IAQ indices along with energy consumption. All indices for single pollutants are seen for long-term (LT) and short-term (ST) effects using two approaches (based on Exposure Limits and DALY). Energy consumption is displayed in the lower right corner.

2 METHODOLOGY

As an example, we use the time-varying pollutant concentrations obtained by Cony-Renaud-Salis et al (2018) by numerical simulations by coupling a building energy simulation software with a multi-zone indoor air quality and ventilation program. The case study is two-storey low-energy house with one living room and three bedrooms located in La Rochelle, France (small city, low pollution). See the references for more details regarding wall compositions, furniture quantity and everyday objects such as books, shoes, computers, TV monitor, etc. Ventilation rates have been calculated according to the French standards (180 m^3/h during 30 min. at noon and 19:30, 105 m^3/h otherwise). The goal of this study is to evaluate the IAQ of three possible solutions of ventilation systems commonly found in French residential buildings using the IAQ dashboard: natural ventilation using vertical ducts for extraction (NAT), self-regulated exhaust (EXH) and balanced mechanical ventilation (BAL). We considered here 9 out of the 16 target pollutants identified in Subtask 1: acetaldehyde, acrolein, benzene, formaldehyde, nitrogen dioxide, particulate matter (PM2.5, PM10), styrene and toluene. The time-varying pollutant concentrations have been integrated according to the occupancy schedule in order to calculate the exposure to each pollutant during one week in winter.

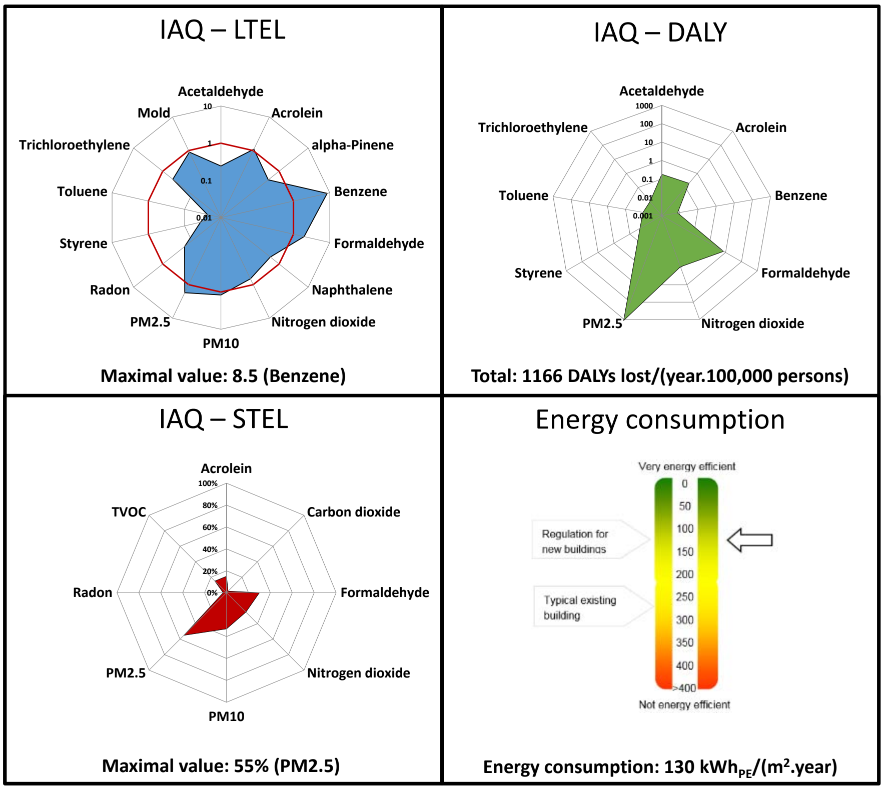

Figure 1: *IAQ/Energy dashboard for low-energy residential buildings – IAQ-LTEL is for Indoor Air Quality – Long-Term Exposure Limit, IAQ-STEL is for Indoor Air Quality – Short-Term Exposure Limit and IAQ-DALY is for Indoor Air Quality – Disability-Adjusted Life Years (data represented here are just for display and do not represent actual situation).*

3 MAIN RESULTS AND FINDINGS

Among the four quadrants of the IAQ dashboard, only the one relative to Long-Term Exposure Level is represented here because no energy consumption calculation has been carried out here (fourth quadrant), there is no exceedance of short-term exposure levels (third quadrant) and DALY representation (second quadrant) does not allow clear comparison between the cases. Figure 2 presents the IAQ-LTEL for the three ventilation systems compiled in one graph to ease the comparison. Overall, the results obtained by these numerical simulations confirmed the trend observed with real experimental data such as those used in Subtask 1: LTEL is higher than 1 (i.e. pollutant concentration higher than the Exposure Limit Value) for acrolein, benzene, formaldehyde, nitrogen dioxide and particulate matter (PM2.5, PM10) and lower than 1 for the other pollutants. In this example, benzene is identified as the pollutant of higher index; actions to improve the IAQ should then focus in reducing indoor benzene sources that are here the building materials. Regarding the performance of the three ventilation systems, it should be noted that, even if the systems were sizing (ducts and fans) with the same objective in terms of exhausted airflow rates, the simulation results show 20% higher airflow rates for the balanced system compared to the self-regulated exhaust; those for the ventilation natural system tend to be the lowest. This fact explains why LTEL is lower for the BAL and higher for the NAT systems for pollutants of only indoor emissions (acetaldehyde, acrolein, benzene, formaldehyde, styrene and toluene). The role of the filtration regarding the BAL system is clearly observed for PM2.5 and PM10 (PM2.5 LTEL values are 0.6, 1.1 and 1.2 for BAL, EXH and NAT systems, respectively). Outdoor gaseous pollutant concentration (nitrogen dioxide) is almost not affected by the ventilation systems.

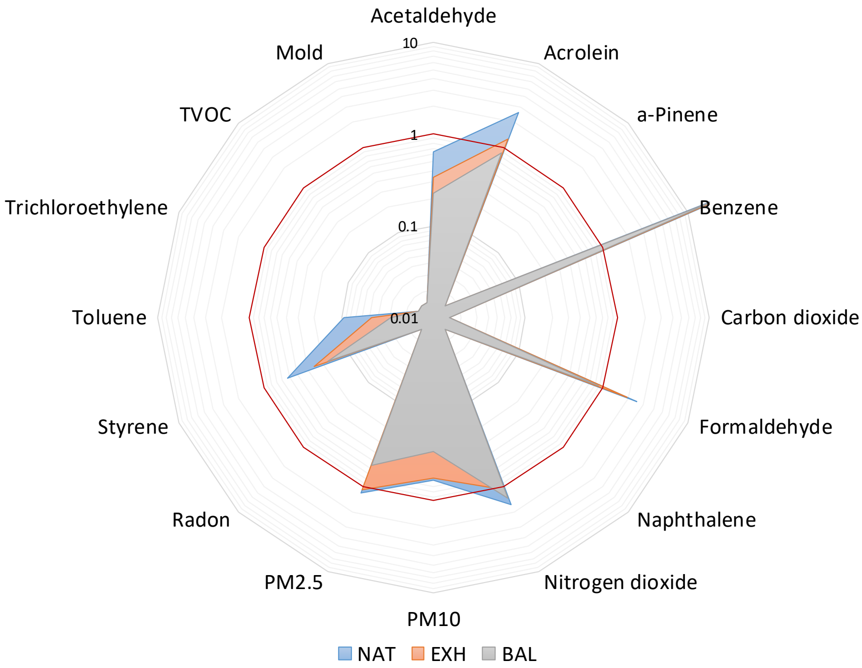

Figure 2: *IAQ-LTEL quadrant for the studied case.*

4 CONCLUSION

This exercise shows that, for the ventilation cases studied here that comply with ventilation regulations in terms of permanent airflow rates, the assessment of system performance can be limited to the long-term LTEL index. Its value for PM2.5 demonstrates that a 50% IAQ improvement can be achieved with a balanced system compared to other ventilation systems.

5 ACKNOWLEDGEMENTS

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Lessons learned from design and operation of ventilation systems in low-energy dwellings in the UK

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SUMMARY

This presentation will cover the key lessons learned from post-occupancy evaluation of the ventilation strategies in several new-build dwellings in the UK. Two ventilation strategies often used for new dwellings in the UK are mechanical extract ventilation (MEV) and whole-house balanced mechanical ventilation with heat recovery (MVHR). Few examples of the design and operation of these systems will be presented identifying the best practice and improvement opportunities for mechanical ventilation systems that are increasingly used in airtight low-energy dwellings.

Issues around system installation and commissioning may compromise energy efficiency of the air distribution system and the airflows supplied to dwellings. Measurement of air flows in new-build dwellings with MEV system showed that actual flow rates may be significantly lower than design intents if the systems are not commissioned effectively. Actual flow rates measured in boos ventilation mode were up to 30% lower than the design target.

The study also found examples of under-ventilation in dwellings with MVHR systems. In addition to system commissioning, maintenance of MVHR system including regular filter replacement is crucial to ensure adequate fresh air is provided to a dwelling. There are improvement opportunities in provision of information and training to building users about MVHR systems. It is suggested that Landlords and housing association can also take more responsibility for system inspection and maintenance in rented accommodation and social housing similar to the requirement for annual inspection of heating systems.

Finally, measurements of concentration levels of several pollutants, identified as high risk in low-energy dwellings in IEA-EBC Annex 68 programme, identified improvement opportunities for source control and enhanced ventilation to reduce concentration level of Formaldehyde to the best-practice exposure limit value. The current regulatory framework in the UK covers major outdoor sources of pollution and TVOC as a proxy for indoor sources related to construction material. However, TVOC is not the best indicator of indoor sources of air pollution and their potential health effects. It is necessary to adopt a more refined approach and address specific volatile organic compounds with potentially high adverse impact on health and well-being to protect building users and strike the right balance between energy efficiency and indoor air quality.

KEYWORDS

Post-occupancy evaluation, low-energy dwellings, Mechanical extract ventilation (MEV), Mechanical ventilation with heat recovery (MVHR), Indoor Air Quality (IAQ)

Figure 1: Examples of dwellings covered in the study: terraced houses with MEV system (left), apartments with MVHR system (right)

Table 1: Measured air flows in sample dwellings with MEV systems against design targets

Dwelling	**Total trickle extract flow rate / design target (l/s)**	**Total boost flow rate / design target (l/s)**
Mid-terrace House 1	11.7 / 30.5	34.9 / 35
Mid-terrace House 2	12.2 / 30.5	30.2 / 35
End of Terrace House	2.2 / 30.5	24.1 / 35

Table 2: Concentration levels of ley contaminants and air change rates in dwellings with MVHR system during heating season

VOC concentration (μg/m³) & Air Change rates per Hour for each zone	**APT. 3 (Block A, 9th Floor)**			**APT. 4 (Block B, Ground Floor)**			**IEA EBC Annex 68 Long Term ELV**
	Living room	Kitchen	Sample bedroom	Living room	Kitchen	Sample bedroom	
Benzene	**1.3**	**1.0**	**1.2**	**1.5**	**2.1**	**1.6**	0.2
Formaldehyde	**29.25**	**26.87**	**29.53**	**21.23**	**31.35**	**27.44**	9
Trichloroethylene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2
Styrene	1.5	2.2	3.0	0.8	0.7	1.7	30
Naphthalene	**5.4**	**5.4**	**5.0**	0.9	0.9	1.3	2
Toluene	2.7	2.9	3.1	2.2	2.6	2.4	250
Tetrachloroethylene	0.6	<0.6	<0.6	1.5	1.2	1.8	100
ACH (PFT measurements)	0.50	0.52	0.76	1.02	1.14	0.6	n/a

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