Hawai‘i Natural Energy Institute Research Highlights

Grid Integration & Energy Efficiency

Modeling and Validating Indoor Air Quality in Hawai‘i Classrooms

OBJECTIVE AND SIGNIFICANCE: In recent years, especially since COVID, there has been increased attention focused on indoor air quality. Under this project, HNEI contracted Miller Kelley Architects (MKThink) to evaluate room air quality under different use cases and different ventilation typologies. Simulated and measured carbon dioxide (CO_2) concentrations were used as a metric for air quality. The project's objective was to gain additional understanding of the optimal ventilation configurations to minimize exposure to CO_2 or other contaminants.

KEY RESULTS: This study found that:

- At the same air exchange rate, the worst configuration (vents on same wall) had average CO_2 concentrations that were 52-77% higher than the best configuration (vents on opposite walls);
- The worst performing configurations also had more uneven distributions of CO_2, resulting in pockets of very high concentrations; and
- Using the better performing vent configuration could allow for a lower ventilation rate while maintaining good air quality and thus save energy.

BACKGROUND: In 2022, MKThink conducted a study to assess the concentration of CO_2 in classrooms under a variety of physical configurations and occupancies. This work, involving both field measurement and computational fluid dynamics (CFD) modeling was intended to identify whether methods could be developed to inform instructors about how to maintain high quality indoor air quality in real time. Results showed some interesting trends based on air exchange rate (AEC) and location of the exhaust vent compared to the location of the fresh air inlet vent, but the project stopped short of reaching defined conclusions that could be used to manage air quality while minimizing energy use. The major objective of this follow-on effort was to further analyze the results of the previous work to provide additional guidance in the placement of ventilation system and to identify possible methods to manage energy from HVAC while maintaining air quality.

PROJECT STATUS/RESULTS: MKThink conducted additional analysis for a subset of the original study including four inlet-exhaust location configurations and three different air exchange rates deemed to be within normal operating ranges of commercial HVAC systems. As expected, for the same vent configuration, the average CO_2 concentration tracked monotonically with the air-exchange rate, decreasing as the AEC (inlet clean air flow) was increased. CFD modeling of the various configurations also indicated that the average CO_2 concentration and the variability (difference from average) differed significantly with different inlet-exhaust configurations. Location of exhaust vents on the opposite wall from the primary air inlet showed significantly lower average values and less variability than configurations where the exhaust was on the same wall or a wall perpendicular to the inlet vent. Unfortunately, the CFD models assumed a higher human volumetric breathing rate than a more recent literature search indicates, making direct comparison of the CFD and previous measurement in the classroom difficult. This project is now completed.

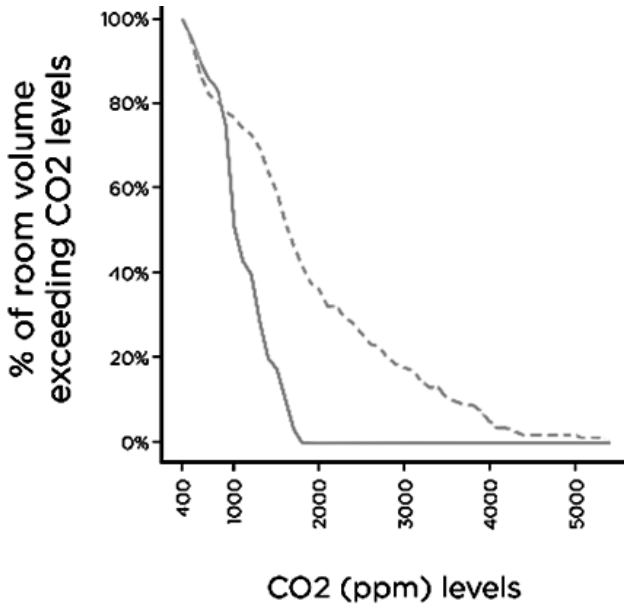

Figure 1. Percentage of the room volume exceeding CO_2 concentrations (ppm) for vents on the same wall (dotted line) vs vents on opposite walls (solid line).

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Contact: Richard Rocheleau, rochelea@hawaii.edu

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