Air Cleaner as an Alternative to Increased Ventilation Rates in Buildings: A Simulation Study for an Office

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SUMMARY

1 INTRODUCTION

Indoor air pollution is a significant concern due to its adverse effects on human health and productivity. With people spending most of their time indoors, exposure to indoor air contaminants can lead to various health issues, including respiratory problems, cardiovascular diseases, and even an increased risk of lung cancer and premature mortality. Additionally, poor indoor air quality can result in short-term symptoms like headaches, eye and throat irritation, fatigue, and asthma, impacting workplace productivity and absenteeism. To address these challenges, this study explores the potential of advanced air cleaner technology as an alternative to increased ventilation rates in buildings, focusing on an office environment.

2 BACKGROUND

The study begins by highlighting the sources of indoor air pollution, including outdoor pollutants from fossil fuel burning and waste incineration, as well as indoor sources such as cleaning products and biological activities. To enhance indoor air quality, traditional approaches involve using supply air filters in ventilation systems and reducing indoor pollutant sources while increasing outdoor air ventilation. However, this study investigates different air filtration methods, including central HVAC filters, room air cleaners, and combined active chilled beams with filters, to effectively remove both particulate and gaseous pollutants (Pope and Dockery , 2006), (Manisalidis et al., 2020).

3 DESIGN AND BUILDING MODEL

The research adopts a representative building model of a typical office room located on a middle floor of a high-rise building. The room has specific dimensions, and its surfaces are considered adiabatic, except for the south-oriented facade with a window. Shading devices are incorporated to block incoming solar radiation when it exceeds a certain threshold. The study includes hourly profiles for occupancy, appliances, and lighting to represent user behavior and internal heat gains. The building's heating and cooling system is designed to maintain a comfortable indoor air temperature within a specific range.

4 SYSTEM MODELS

Four different HVAC system configurations are implemented and evaluated in the study:
Reference case: A typical office ventilation system with a heat recovery unit, a heating coil, and supply and return fans. The system delivers outdoor air to the office room and maintains a specific air temperature.

4.1 System-based filter

A filter is integrated at the system level, allowing for lower outdoor air flow rates by filtering and recirculating return air from the room. This configuration reduces the need for larger ducts and offers potential energy savings. Room-based filter: A filter is placed at the room level, and air is filtered within the room using a small fan. Although this approach is less efficient in terms of fans, it offers localized air cleaning benefits.

Beam-based filter: A filter is incorporated into an active chilled beam unit, where room air is filtered by the device integrated into the beam. This system provides efficient recirculation of air through induction, resulting in energy savings.

5   RESULTS

The study presents the results of the four HVAC system configurations, focusing on their total primary energy use. Comparing the cases, the integration of a filter in the beam unit resulted in primary energy savings of approximately 26% compared to the reference case. The room-based and beam-based filter systems have similar energy demands for space heating, while the reference case requires slightly more energy due to the lack of air recirculation. For space cooling, the room-based and beam-based filter systems have higher energy demands, while the reference case has the lowest energy demand due to higher outdoor air supply. The system using filters has the lowest energy demand for the heating coil, while the reference case has the highest.

6   CONCLUSION

The study concludes that air cleaning technologies, such as portable air cleaners or combined chilled beams with air cleaners, can be effective solutions for mitigating indoor air pollution and improving air quality in specific rooms. However, it emphasizes the importance of considering energy performance when selecting air cleaners and ventilation systems for indoor environments. The appropriate choice of air cleaner and ventilation system can significantly impact energy efficiency and indoor air quality. The integration of filters in the HVAC system, particularly in active chilled beam units, demonstrates notable energy savings. Overall, the research provides valuable insights into optimizing indoor air quality while maintaining energy efficiency in office buildings.Please use the spell-check and grammar check before submitting your summary. Your summary should be 1- to 2-page long. The topic, the approach, and the results must be clear. The conclusions to be drawn from your contribution must be clear. Keep it brief, yet informative to capture readers' attention. Avoid abbreviations and jargon. Think about how people interested in the topic would search and find your study.

KEYWORDS

Air cleaning, Ventilation rate, Building, Simulation, Office

8   REFERENCES

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