

A Comparative Study of Occupancy-Based Dynamic Ventilation Reset Strategies for Variable-Air-Volume Systems



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Introduction

- The operation of building ventilation systems usually assumes peak occupancy, leading to over-ventilation and energy waste.
- Dynamic ventilation reset (DVR) enhances energy efficiency by adjusting outdoor air flowrate based on real-time occupancy.
- Prior studies have investigated DVR strategies at the zone level, system level, and their integration, but performance comparison between different DVR strategies is missing.
- ASHRAE Standard 62.1-2016 introduced the occupied standby mode, the impact of which on energy performance needs to be investigated.

Methods

Building Model

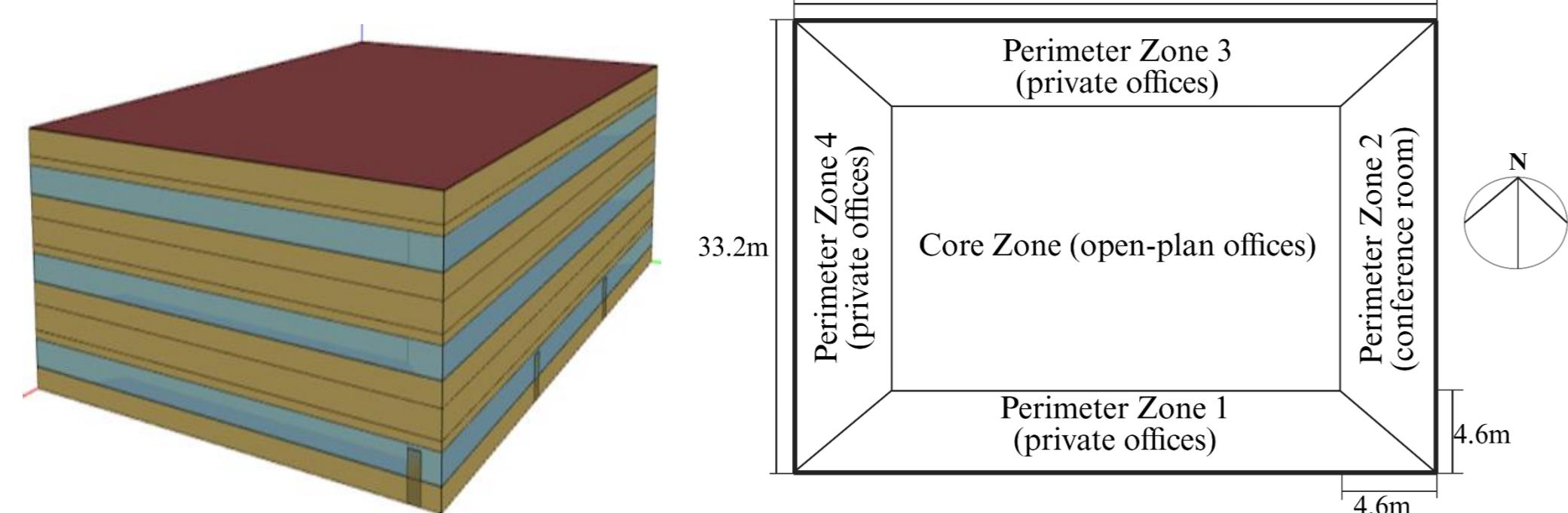


Fig. 1: Isometric view (left) and thermal zones (right) of the DOE medium office prototype building

Occupancy Modeling (LBNL Occupancy Simulator)

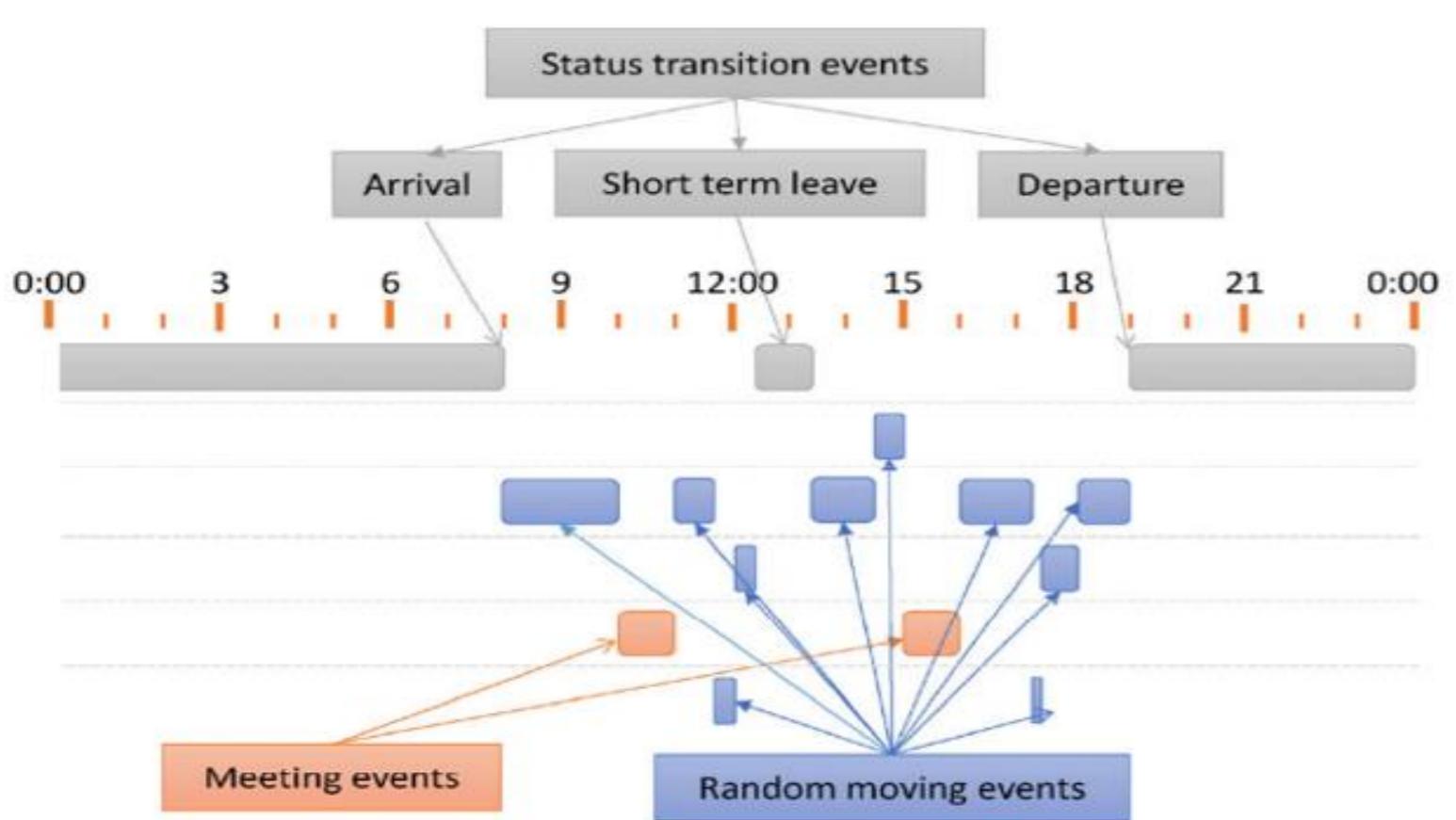


Fig. 2: Schematic of Occupancy Simulator engine

Simulation Framework

- Use EnergyPlus as the simulation software.
- Develop separate models for the three ventilation control strategies (Table 1).
- Rely on the Energy Management System (EMS) in EnergyPlus to implement occupancy-based controls (Fig. 3).

Table 1: Overview of ventilation control strategies

| Control Strategy | Terminal Minimum Airflow | System Outdoor Airflow | Calculation Approach (ASHRAE Standard 62.1) |
|------------------|-------------------------------|---|--|
| Baseline | Design values | Design values (unless economizer overrides) | Simplified procedure $V_{pz-min} = V_{oz} * 1.5$ $V_{ot} = V_{ou}/E_v$ |
| Zone DVR | Reset based on zone occupancy | Design values (unless economizer overrides) | $V_{pz-min} = V_{oz}/OAFraction$ |
| System DVR | Design values | Reset based on total building occupancy (unless economizer overrides) | Normative Appendix A $V_{ot} = V_{ou}/E_v$ |

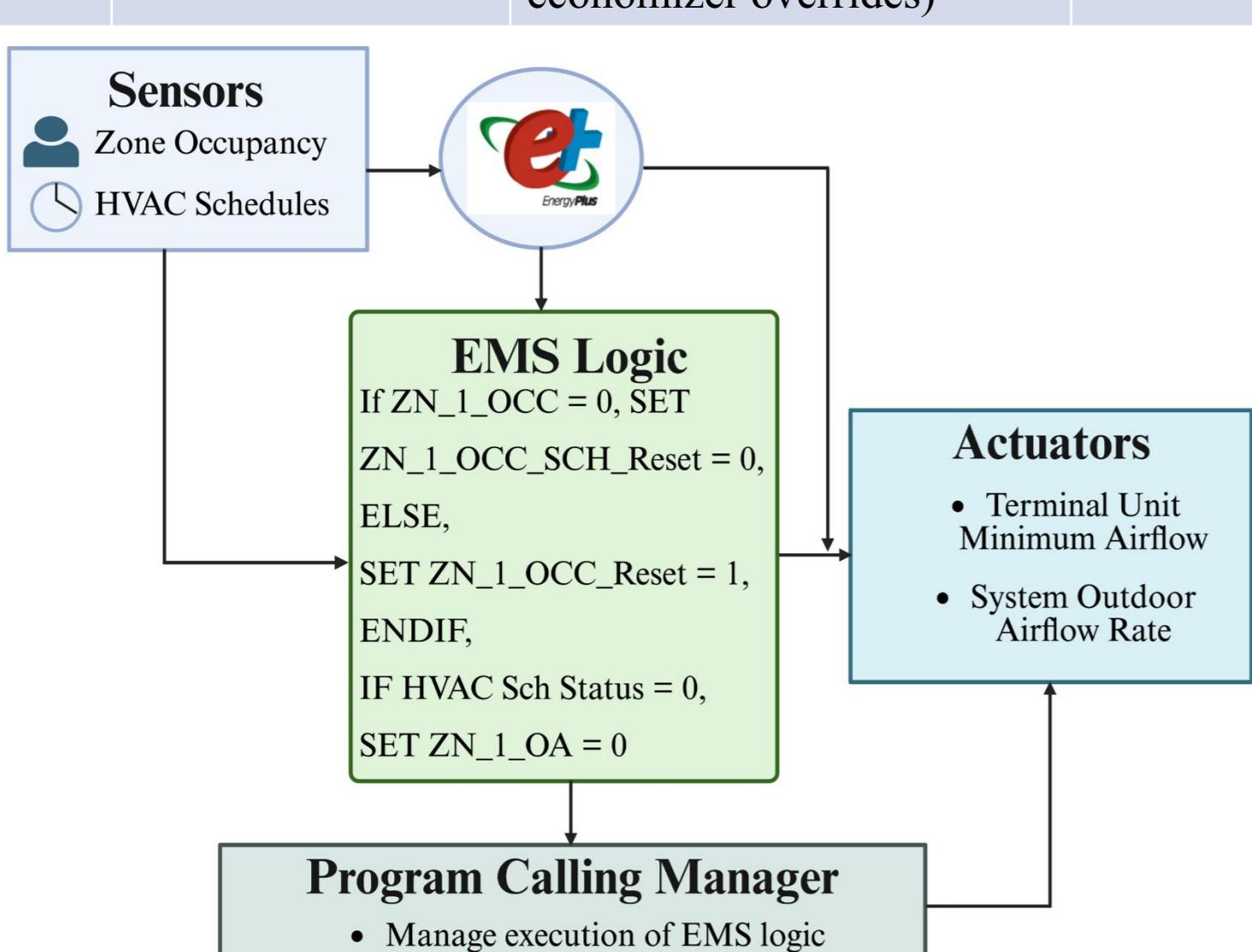


Fig. 3: Overview of EMS control framework

Methods cont'd

Selected Climate Locations

Table 2: List of climate locations

| Location | Climate Zone | Climate Type |
|-------------------------|--------------|----------------|
| Miami, FL | 1A | Very hot humid |
| Tucson, AZ | 2B | Hot dry |
| San Diego, CA | 3C | Warm marine |
| New York City, NY | 4A | Mixed humid |
| International Falls, MN | 7 | Very cold |

Results

- Fig. 4 shows annual heating, cooling, and fan energy consumption by control strategy across climate locations. The percentages on the bars indicate the energy savings relative to the baseline.

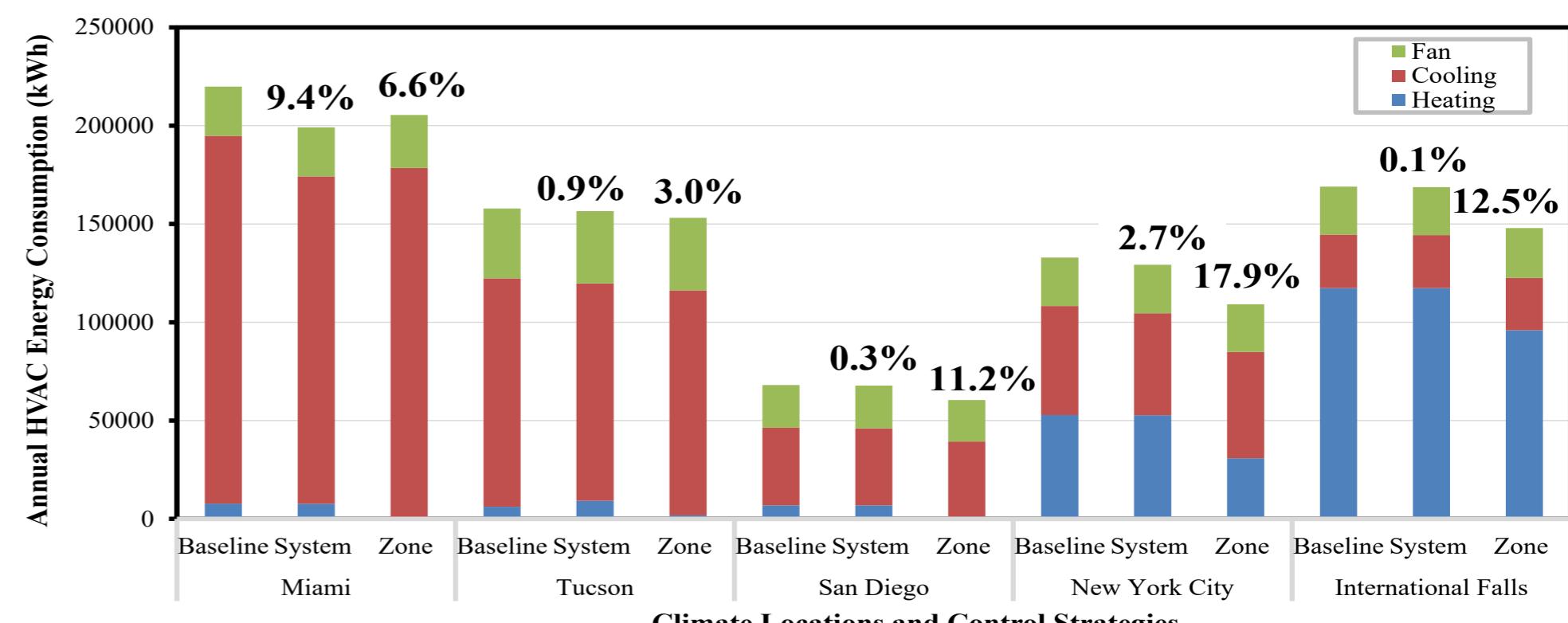


Fig. 4: Annual HVAC energy consumption between the baseline and DVR strategies

- Fig. 5 shows annual heating, cooling, and fan energy consumption of DVR strategies with and without occupied standby mode. The percentages on the bars indicate relative energy savings due to the use of occupied standby mode.

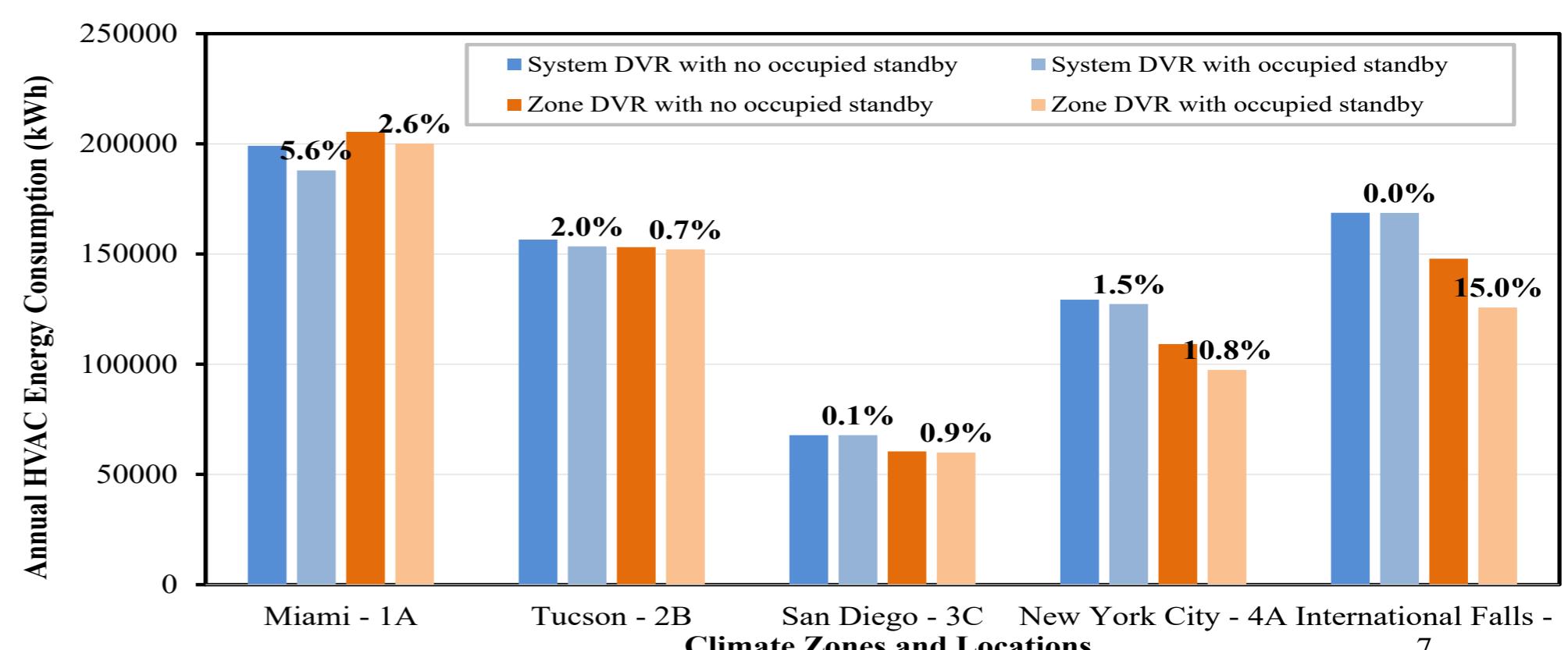


Fig. 5: Annual HVAC energy performance for DVR with and without occupied standby mode

- Fig. 6 compares ventilation performance using ventilation ratio, the ratio of actual outdoor airflow rate to the requirement per ASHRAE Standard 62.1.

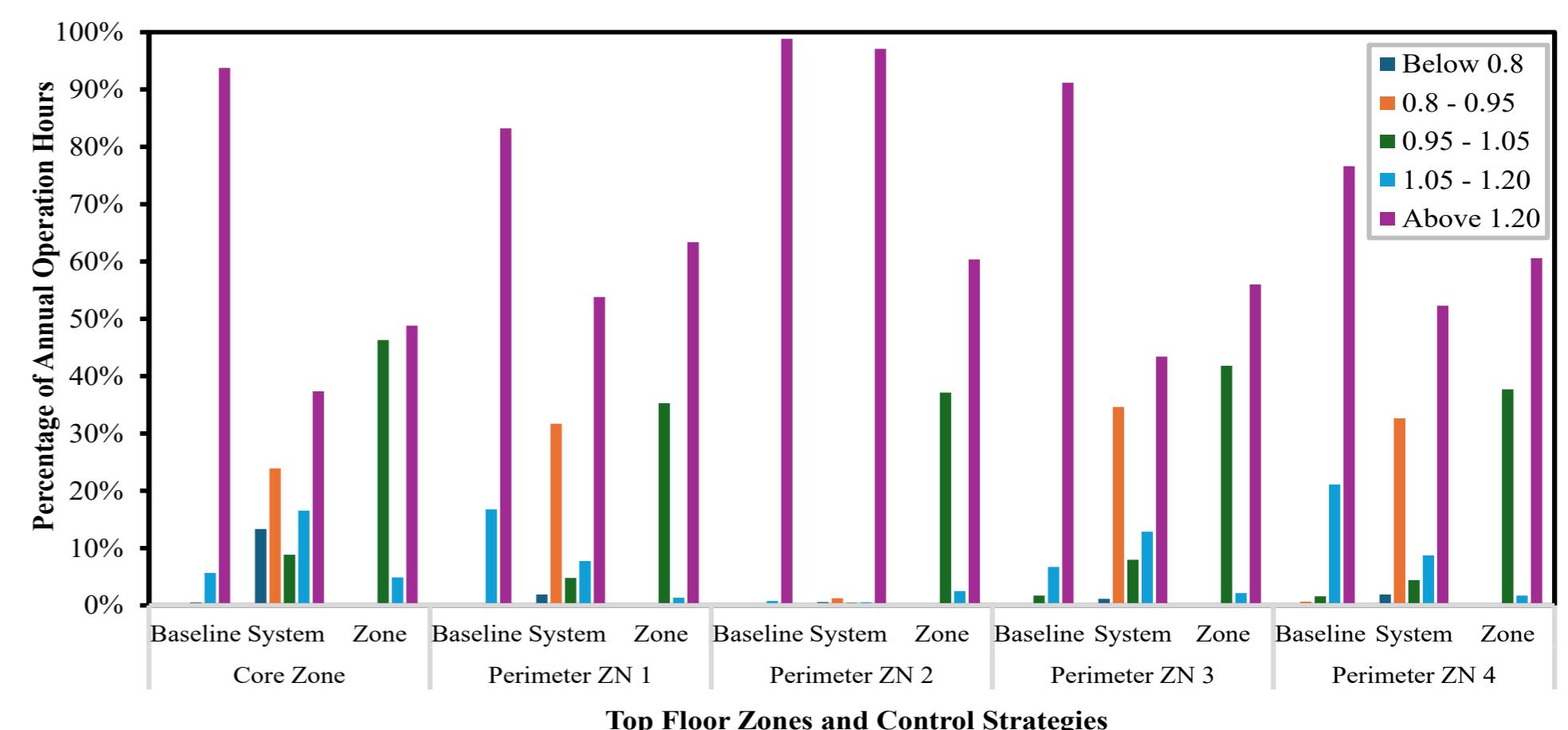


Fig. 6: Histograms of ventilation ratio for top-floor zones in New York City

Conclusions

- Relative to the baseline without DVR, system DVR achieved more energy savings than zone DVR (9.4% vs. 6.6%) only in hot-humid climates, while in mild and cold climates, zone DVR achieved more savings than system DVR (average 13.8% vs. 1.0%).
- Considering occupied standby mode provided additional energy savings by an average of 6% for zone DVR and 1.8% for system DVR across all climate locations.
- Zone DVR maintained satisfactory ventilation, but system DVR caused under ventilation.