Comparison of Conventional Ventilation and Demand Control Ventilation on Energy Usage and Quality of Air

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BACKGROUND

School districts continue to look for ways to improve student achievement. Using traditional methods they have: (1) increased the number of professional development classes teachers must attend; (2) realigned the scope and sequence of the curriculum to better match assessment content; and (3) standardized teaching techniques for specific contents to insure a equitable knowledge base for all students.

We have spent a lot of time and money deciding what we teach, when we teach it, and how we teach it; we tend to ignore the “where” we teach. We may be overlooking a way to significantly increase student achievement.

Early research had shown a positive relationship between the learning environment and student performance [2]. Specifically, poor indoor air quality (IAQ) was associated with greater absenteeism and slower learning rates[3].

More recent research has confirmed this relationship. Research of elementary students has shown students' math and reading scores increased as the IAQ increased[4]. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) guidelines suggest that an acceptable level of IAQ can be maintained by introducing outside air at a rate of 15cfm/person (average adult male)[1].

Many schools insure air quality by the conventional method of turning on an air ventilation system and leaving it on. However, engineers usually design the system assuming the worst-case scenario, that of the classroom being fully occupied throughout the day. In a typical classroom this is seldom the case. In elementary schools students often leave the classroom en mass for lunch, recess, gym, music, art, library, or computer lab; groups of students may leave for various special education classes throughout the day. This conventional ventilation paradigm usually provides adequate air flow. However, constant cooling and heating of air is costly and often the IAQ may not need improvement.

IAQ is affected by several factors and it is unreasonable to monitor for all possible contaminants and various levels of occupancy, however the CO_2 level in a classroom can be used as a surrogate indication of occupancy and IAQ[1].

HYPOTHESIS

By using a demand control ventilation (DCV) system based on the CO_2 level, we should be able to maintain an acceptable level of IAQ, running the ventilation system on an “as needed” basis. This method may show significant energy savings when compared to a conventional “constantly on” method.

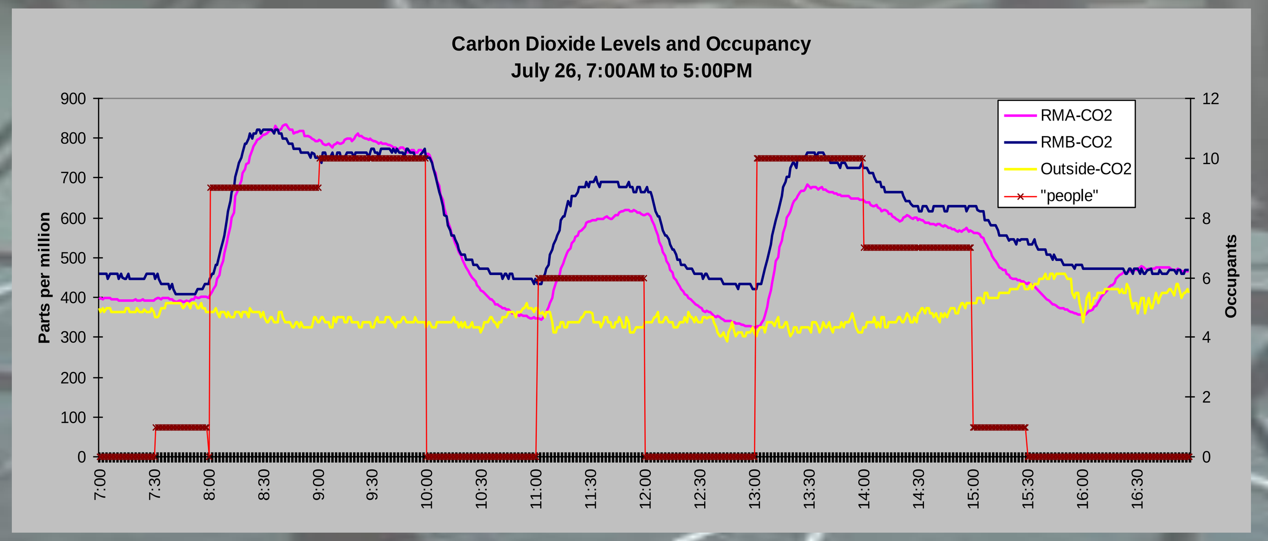
ABSTRACT

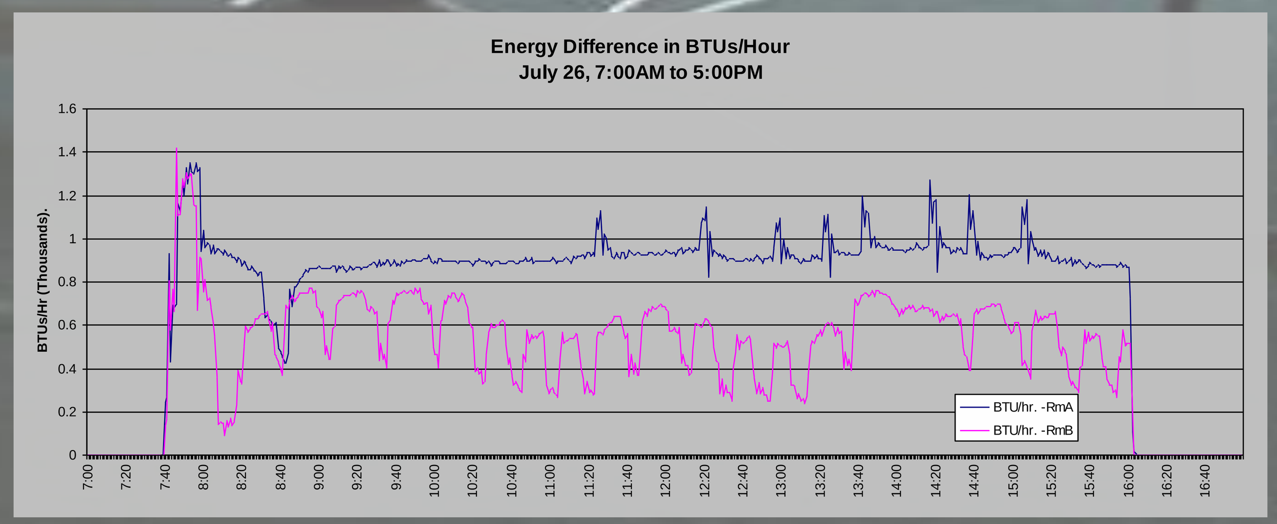
Indoor air quality (IAQ)[1] is a significant factor in student performance. The general guideline of regulating the IAQ is to draw outside air at the rate of 15 cubic feet per minute for each occupant. For many schools the conventional method is to engineer for the worst case scenario and operate the ventilation system at that rate. This method does not consider the variability in occupancy in the average classroom. A test was performed to compare the effects of employing a CO_2 Demand Control Ventilation system (DCV) and a conventional system where outside air is supplied at a constant rate of 15cfm/person, with respect to energy consumption, energy cost, and quality of air under various occupancy loads.

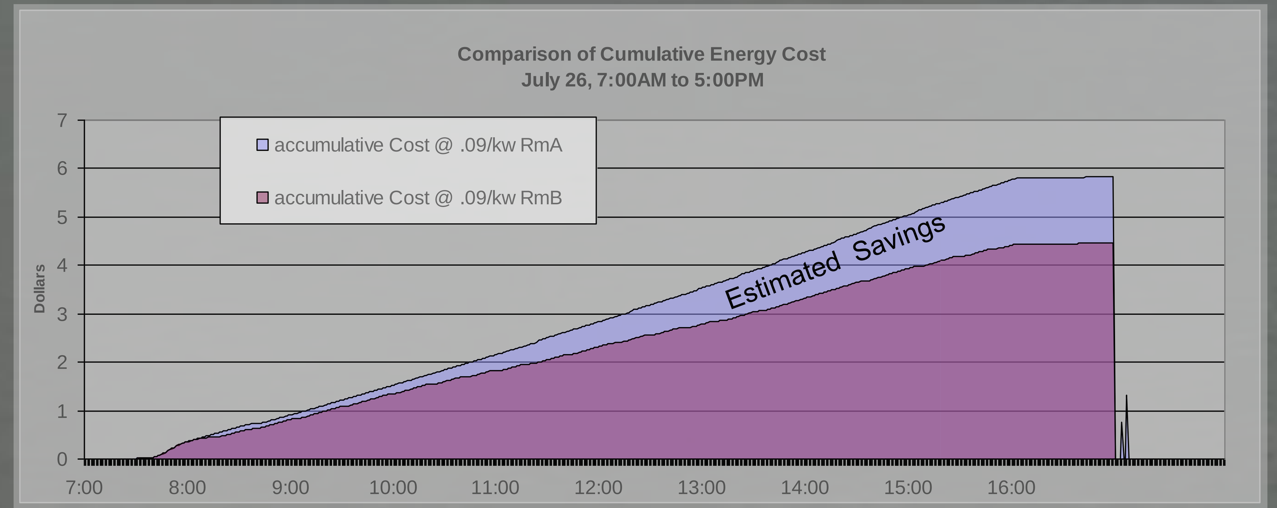
Resultant data tended to support the hypotheses.

RESULTS

Data showed that CO2 levels were well within acceptable range of IAQ in every condition and that the difference between the DCV and conventional system never exceeded 130 ppm. The total watts needed to run the equipment and cooling system showed the DCV system used about 25% less energy than the conventional system.







METHOD

Matched pairs of rooms, West Rooms A and B, were used at the state-of-the-art Energy Resource Station in Ankeny, Iowa. Each room has approximately 280 sq.ft. of floor space; a little more than 1/3 of an average classroom. Four metal androids capable of approximating normal body CO_2 and BTU emissions were placed in each room to simulate students. These were adjusted to represent occupancy rates of 1 to 10 students, a little more than 1/3 of an average class size, varying the number of occupants from 7:30AM to 4:00PM. Room A was set to introduce outside air at a constant rate of 15cfm/person for the worst case scenario of full occupancy, or 150cfm. Room B was set to introduce outside air on an as-needed basis to maintain a CO_2 level between ambient levels and 1020ppm[1]. Lower limit was arbitrarily set at 400 ppm to insure optimum IAQ. Test parameters were monitored during a four day period in late July. Energy consumption in both kilowatts/hr and BTU/hr were computed and compared. Estimated energy costs were computed at an arbitrary rate of $0.09/KW and compared.

DISCUSSION

The data tends to support the hypotheses. Significant savings in both energy and energy costs can be realized by implementing a DCV system, while not exceeding acceptable IAQ limits. Although this data was gathered in the heat of summer, we could expect analogous savings throughout the school year. The cost to install a DCV system in the initial construction phase would show immediate payback. Costs to retrofit older buildings would vary considerably. School districts should determine this cost and calculate payback periods. It would be hard to argue against a system that saves them money.

REFERENCES

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ACKNOWLEDGEMENT

Thanks go to the U.S. Department of Energy, Office of Science; the ACTS Program at Ames Laboratory at Iowa State University; and ACTS coordinator Adah Leshem-Ackerman.

Special thanks to Curtis Klaassen, P.E., Manager, Energy Resource Station, Xiaohui Zhou, M.SC., Research Scientist , and the rest of the staff of the Iowa Energy Resource Station for their guidance and patience.