Experimentation of Hybrid Ventilation in Carnegie Mellon University's Intelligent Workplace, Pittsburgh, PA

Flore A. Marion[1], David H. Archer[2]

Carnegie Mellon University, Center for Building Performances and Diagnostics
5000 Forbes Avenue, Pittsburgh PA 15213, USA
(1) fmarion@andrew.cmu.edu, +1412-268-3939
(2) archerdh@andrew.cmu.edu, +1412-268-2004

ABSTRACT

The Center for Building Performances and Diagnostics of Carnegie Mellon University is experimenting with Hybrid Ventilation in Pittsburgh, Pennsylvania, USA, to evaluate the potential energy savings of this technique in a region where there are many variations in climate throughout any given year.
Sharing the results of this experiment aims to increase awareness of this technique in the US and develop its implementation in the future.
The current project consists of opening different 8 windows, located in 2 offices and a conference room of the Intelligent Workplace, when specific conditions are met and using the mechanical system otherwise. The mechanical system includes a desiccant wheel unit that conditions outside air to a set humidity and temperature, and mullions where chilled water is circulated to cool the space. The experiment, started in spring 2009, will establish the number of hours of natural ventilation at night and during occupation time and evaluate the energy saved.
The success of such a system lies in the algorithms followed to fully operate hybrid ventilation based on measurements of outdoor and indoor conditions: temperatures, humidity, wind velocity, rain, occupancy, etc.
The one developed at CMU has been programmed in TRNSYS to evaluate the energy saving and the hours of window opening: About 10% of energy is estimated to be saved which will be compared to the experimental results of spring, summer and fall 2009.

INTRODUCTION

With the stimulus funding opportunity, the United States is finally looking at ways to reduce its energy consumption. To achieve this goal, in addition to making technologies more efficient, the most efficient way is actually to make use of natural resources available for free and harmless for people and environment.
Making use of climate to maintain comfortable indoor environment instead of tightening building meets this principle. The center for building performance is evaluating the performance of hybrid ventilation in a common US climate in Pittsburgh, PA and shares its results to help develop this technology.
Hybrid ventilation consists of the combination of natural ventilation and mechanical ventilation used complementarily to maintain a comfortable environment.

CONCLUSIONS

As the experiment shows, Hybrid ventilation can be integrated even in area with a wide annual temperature range as it still provides savings and should not be reserved for project in very mild climate.
In addition to energy saving, hybrid ventilation has lots of positive impact on the occupants: it improves the occupants connection to the outdoors, widens their comfort zone, increase productivity [5] and their awareness of energy saving as, in the case of the Intelligent Workplace, when seeing the operable windows operating, people walking through are indirectly encouraged to open their window.
Even if easily implementable in building retrofit, Hybrid ventilation benefits depend on the building architecture[6] and it is more efficient if integrated in the design phase of the project.
This experiment will continue in the fall as long as weather permits, and overall cooling conclusion will be made. Guidelines will be written for building owners and designers.
As future work, optimization of the algorithms will be envisioned to increase, if possible, the operation of the natural ventilation, as well as the integration of automated blinds to reduce solar gain and glare.

EXPERIMENTATION

After modeling the project [2] in TRNSYS [3] and COMIS [4], it has been implemented in the intelligent workplace: 8 Windows have been mounted in the north area; Sensors have been appropriately located in the conference room to collect room temperature, humidity and mullions surface temperature; a weather station including temperature, humidity, wind speed and rain sensors has been mounted on site; and the control logic has been programmed with LABVIEW.
The algorithm decision is relayed by a National Instrument Fieldpoint to 3 Somfy controllers that operate the Somfy actuators on the transom operable windows.
Outputs are an on/off signal to windows, ventilation system, and cooling system.

This experiment is run in a lived-in facility with real laboratory-life conditions.
For instance, the cooling set point was maintain below 21°C at multiple occasions for several days for another experiment needs in May which explain the high cooling loads for the month of may.
Therefore the natural ventilation did not at this time reduce the energy load for cooling in comparison to the previous year but is below the prediction of the modeling results. The low cooling loads in July can also be justified by an abnormally clement weather for Pittsburgh in addition to the hybrid ventilation operation.
Performance results are expected to be achieved by the end of the entire cooling season.

Then ventilation load are overall half the 2008 consumption.
They are also largely below the modeling estimation which can be attributed to a lower frequentation than estimated and bigger façade air leakage which would reduce the CO2 concentration and therefore reduce the ventilation needs as well as a less humid climate than average in Pittsburgh.

Table 1: Cooling loads of theIW conference room

	COOLING		
	2009	**2008**	**Modeling**
may	2632.49	459.45	861.36
june	1206.51	635.78	1827.91
july	254.52	2449.46	2124.80
total	4093.52	3862.73	4814.06
% reduction		-5.97%	14.97%

Table 2: Dehumidification load of the IW conference room

	VENTILATION		
	2009	**2008**	**modeling**
may	147.02	497.53	2864.30
june	203.45	1247.73	3246.29
july	783.83	752.96	3884.91
total	1134.30	2498.21	9995.50
% reduction		54.60%	88.65%

The system has been operating on natural ventilation 11.45% of the time which is close to the estimate.
Even in a climate thought as not ideal for natural ventilation, this experiment proved that it is actually suitable more that 11% of the time.

Table 3 : hour of window opening

	Opening hours	
	2009	**modeling**
may	89.84	133.00
june	84.38	135.00
july	78.50	46.00
total	252.72	314.00

Table 4: percent of hours opening

	% opening	
	2009	**modeling**
may	12.08%	17.88%
june	11.72%	18.75%
july	10.55%	6.18%
total	11.45%	14.27%

CONCLUSIONS

As the experiment shows, Hybrid ventilation can be integrated even in area with a wide annual temperature range as it still provides savings and should not be reserved for project in very mild climate.
In addition to energy saving, hybrid ventilation has lots of positive impact on the occupants: it improves the occupants connection to the outdoors, widens their comfort zone, increase productivity [5] and their awareness of energy saving as, in the case of the Intelligent Workplace, when seeing the operable windows operating, people walking through are indirectly encouraged to open their window.
Even if easily implementable in building retrofit, Hybrid ventilation benefits depend on the building architecture[6] and it is more efficient if integrated in the design phase of the project.
This experiment will continue in the fall as long as weather permits, and overall cooling conclusion will be made. Guidelines will be written for building owners and designers.
As future work, optimization of the algorithms will be envisioned to increase, if possible, the operation of the natural ventilation, as well as the integration of automated blinds to reduce solar gain and glare.

REFERENCES

[1Seo J. M., Choi Y. J., Song D. (2008)Hybrid Air-conditioning System Coupled with Controlled ventilation and Radiant Cooling, center for sustainable housing, China, April 2008, 5 pages

[2]"TRNSYS 16 Volume 6 Multizone Building modeling with type 56 and TRNbuild", Solar Energy Laboratory, September 2004

[3] COMIS user guide, LNBL, November 2005

[4] F. Marion, E. ASlanian, S. Masson, D. Archer. (2009). A Hybrid Ventilation System in Carnegie Mellon's Intelligent Workplace 8 pages

[5] T Ayata,O. Yildiz.(2005) Investigating the potential use of natural ventilation in new building designs in Turkey , Elsevier, 5 pages

[6] Francis Allard, Christian Ghiaus.(2006) Natural ventilation in the urban environment; 252 pages