Evaluation of a Kitchen Ventilation Demand Control System Installed in a Boston Pizza, Whitby, Ontario

Prepared by:

Fisher-Nickel, inc.
Food Service Technology Center
12949 Alcosta Boulevard, Suite 101
San Ramon, CA 94583

Contributors:

Finn Projects
Toronto, Ontario

Melink Corporation
Cincinnati, OH 45243

Air Con Systems
Whitby, Ontario

Prepared for:

Enbridge Gas Distribution Inc.
500 Consumers Road
North York, ON Canada
North York, Ontario M2J 1P8

December 22, 2004

TABLE OF CONTENTS

Background 1

Objective 1

Melink Intelli-Hood Controls 1

Description of Exhaust Ventilation System 2

Field Measurements and Calculations 3

Reduction in Makeup Air Heating Load 6

Return on Investment 7

Conclusion and Recommendation 7

BACKGROUND

The energy intensity and utility costs associated with operating a commercial kitchen ventilation (CKV) system are recognized within the HVAC design community and food service industry. However, the commercial kitchen exhaust system and its associated makeup air system continue to be designed and operated as single speed ventilation systems, without the ability to respond to variations in cooking equipment usage in a working kitchen.

A more recent innovative and attractive energy saving strategy is the application of demand ventilation control (variable speed fan control) to kitchen exhaust systems. Demand control capitalizes on the fact that cooking appliances spend many hours in an idle or ready-to-cook mode that does not need the same ventilation rate as a cooking condition. The application of two-speed or variable speed fans can achieve reductions in exhaust (and makeup) airflow when appliances are not being used to capacity (or have been turned off). NFPA 96 (Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations) was amended in 2001 to permit a minimum exhaust duct velocity of 500 fpm (changed from 1500 fpm). This code change will facilitate retrofitting demand ventilation controls in existing kitchens.

OBJECTIVE

The objective of this Enbridge customer case study was to evaluate the technical and economic benefits of installing the Melink *Intelli-Hood® Controls,* a commercially available, demand-ventilation (variable speed) control package, on the kitchen ventilation system at a Boston Pizza restaurant in Whitby, Ontario. The overall goal is to promote energy-efficient design strategies for commercial kitchen ventilation (CKV) systems while the underlying benefit for Enbridge is effective demand side management (DSM) of the gas load associated with heating makeup air (MUA) in commercial kitchens.

MELINK *INTELLI-HOOD® CONTROLS*

The Melink *Intelli-Hood Controls* package is a demand-ventilation-based energy management system for commercial kitchen exhaust hoods (Figure 1). The *Intelli-Hood* controls the speed of the exhaust fans and MUA fan through variable frequency drives (VFDs). The VFDs receive a signal from a controller, which receives input for controlling the exhaust and MUA from two sources. First is an infrared (IR) beam that crosses the bottom of the exhaust hood. When this beam is obstructed (reducing its intensity to less than 95% of full input), the exhaust hood and MUA unit will go to 100 percent speed (or a preset maximum speed). The IR beam can be broken by either smoke or steam produced by the cooking process. The second control input comes from temperature probes placed in the exhaust duct collars. As a temperature probe senses a rise in temperature, the controller signals the fans to ramp up proportionally from a predetermined minimum speed to a predetermined maximum speed. Different temperature ranges can be programmed into the system.

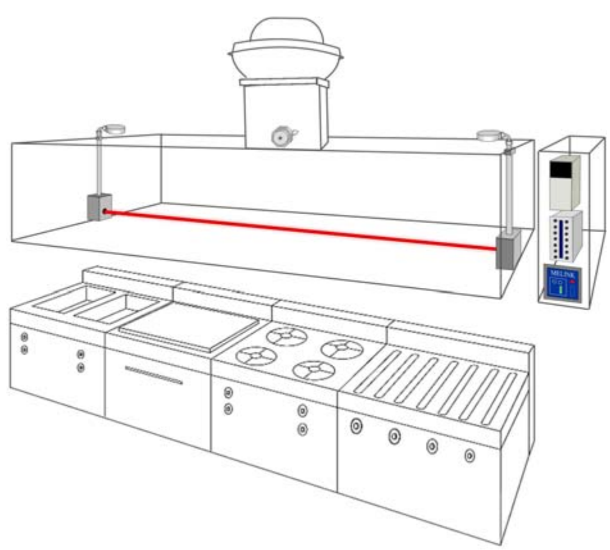

Figure 1. ***Intelli-Hood Controls*** **(Courtesy of Melink®).**

When the system starts up for the first time each day, the controller performs a self-diagnostic test to ensure that the system is correctly calibrated. If everything checks out, the fans go to a preset minimum speed. If not, the system will go into a fail-safe mode and operate at 100% to ensure that all smoke and heat is removed.

DESCRIPTION OF EXHAUST VENTILATION SYSTEM

The exhaust ventilation system in the Boston Pizza kitchen comprised three hoods with a total exhaust airflow of 7500 cfm. A dedicated, direct-fired makeup air (MUA) unit supplied 7100 cfm directly to the kitchen space through several 3-way ceiling diffusers.

Exhaust Hood 1:

A wall-canopy style hood (9 ft wide by 38 inch deep) installed in an island-canopy configuration (i.e., open at back of hood to provide a line-of-site from the front of the appliance line to the back of kitchen) over a short-order appliance line. Exhaust airflow was measured at 4170 cfm (463 cfm/ft).

Exhaust Hood 2:

A wall-canopy style hood (8 ft wide by 72 inch deep) installed over conveyor pizza oven. Exhaust airflow was measured at 1575 cfm (200 cfm/ft).

Figure 2. Exhaust Hood 1 and 2.

Exhaust Hood 3:

A wall-canopy style hood (6 ft wide by 48 inch deep) installed with back of hood against the side of Hood 2. Used to ventilate two stockpot ranges. Exhaust airflow was measured at 1755 cfm (293 cfm/ft).

Figure 3. Exhaust Hood 3.

Figure 4. Exhaust Fans.

Figure 5. Direct-Fired MUA Unit.

FIELD MEASUREMENTS AND CALCULATIONS

The full-speed current draw of the three exhaust fans and MUA unit fan was measured in the field and the power calculated using measured voltage and an assumed power factor of 0.8. Part load measurements were also made and used to calculate the power at the average operating speed for each fan based on average speeds recorded during the monitoring phase of the project (Figures 6 – 9). The reduction in fan power (Table 1) totaled 3.3 kW or 61%. This power reduction translates to an annual energy saving of 21700 kWh. Applying an effective electricity rate of $0.08 per kWh, the cost saving would be approximately $1500 per year.

Table 1. Fan Power Reduction.

			Reduction:
EF-1 (Hood 1)	1.68 kW @ 100%	0.88 kW @ 79%	0.80 kW
EF-2 (Hood 2)	0.40 kW @ 100%	0.14 kW @ 65%	0.27 kW
EF-3 (Hood 3)	0.51 kW @ 100%	0.11 kW @ 54%	0.40 kW
MUA fan	2.83 kW @ 100%	1.00 kW @ 66%	1.83 kW
Total fan power	5.43 kW	2.13 kW	3.30 kW

The average reduction in airflow was calculated for each fan based on the linear relationship between the fan speed and the airflow. The reduction in airflow is shown in Table 2. On average, the exhaust airflow was reduced by 30%.

Table 2. Airflow Reduction.

			Reduction:
EF-1 (Hood 1)	4170 cfm @ 100%	3298 cfm @ 79%	872 cfm
EF-2 (Hood 2)	1575 cfm @ 100%	1022 cfm @ 65%	553 cfm
EF-3 (Hood 3)	1755 cfm @ 100%	951 cfm @ 54%	806 cfm
Total Exhaust	7500 cfm @ 100%	5271 cfm	2231 cfm
MUA fan	7100 cfm @ 100%	4700 cfm @ 66%	2400 cfm

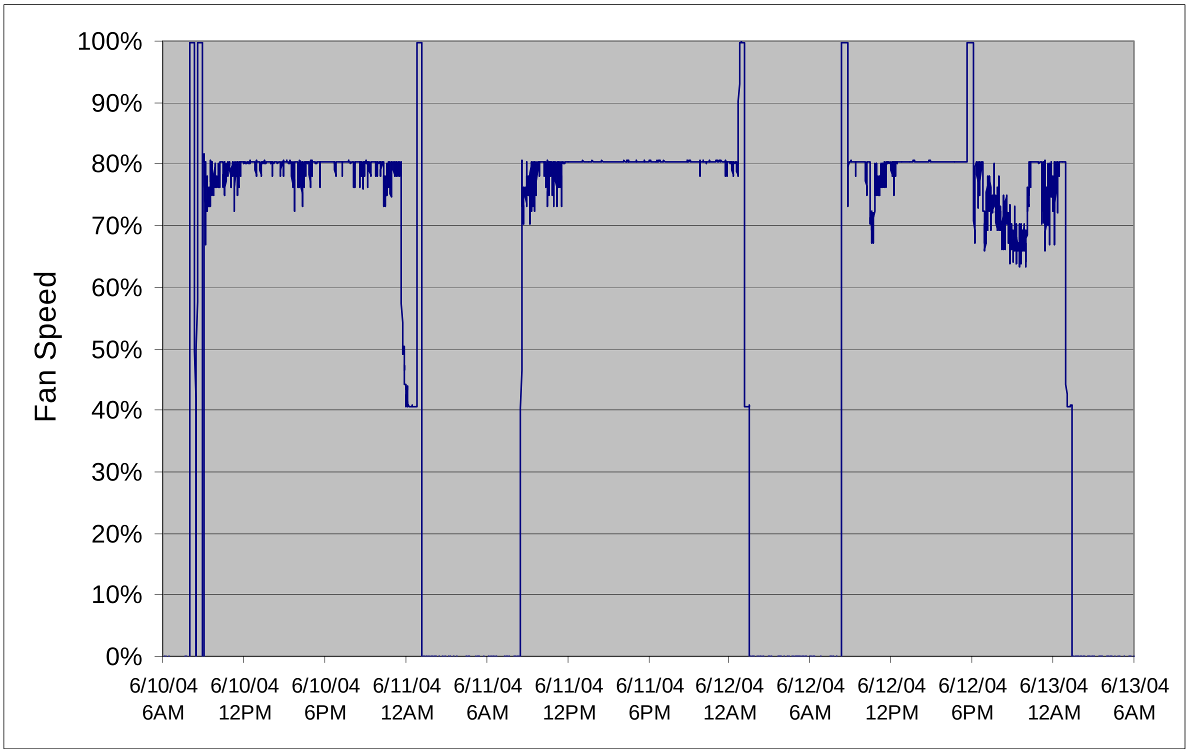

Figure 6. Fan Speed Profile – EF1

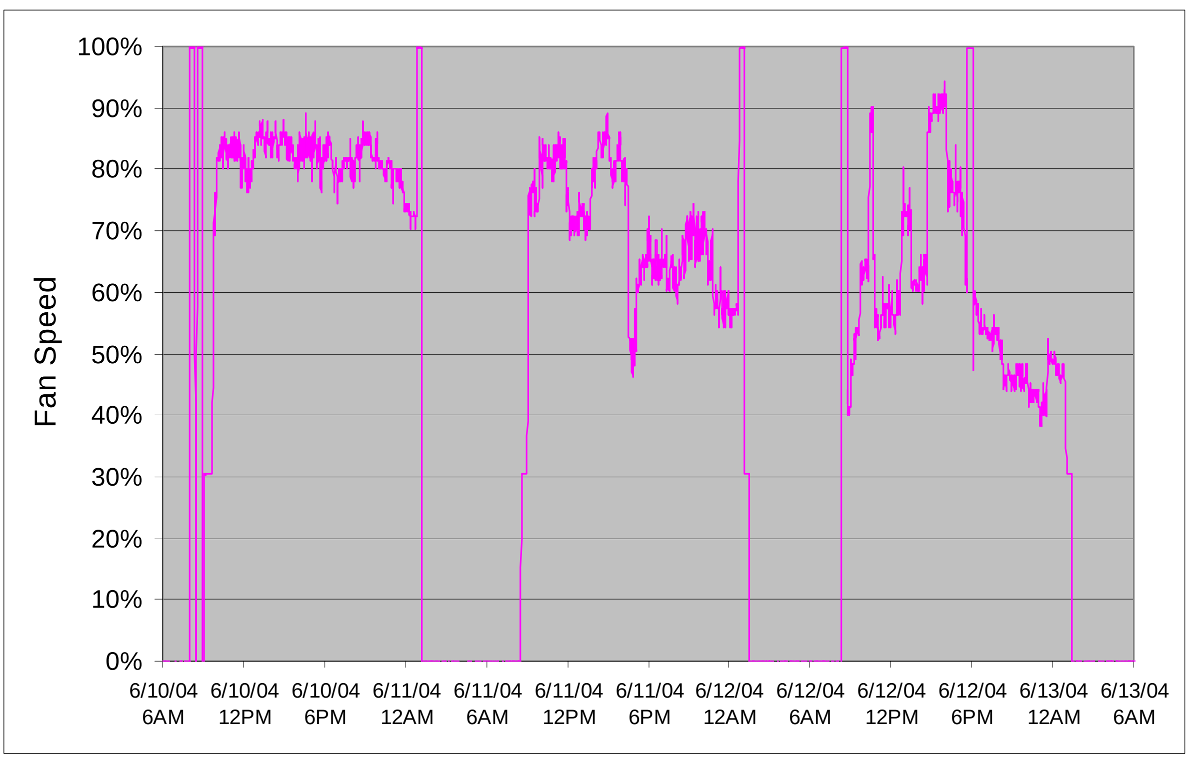

Figure 7. Fan Speed Profile – EF2

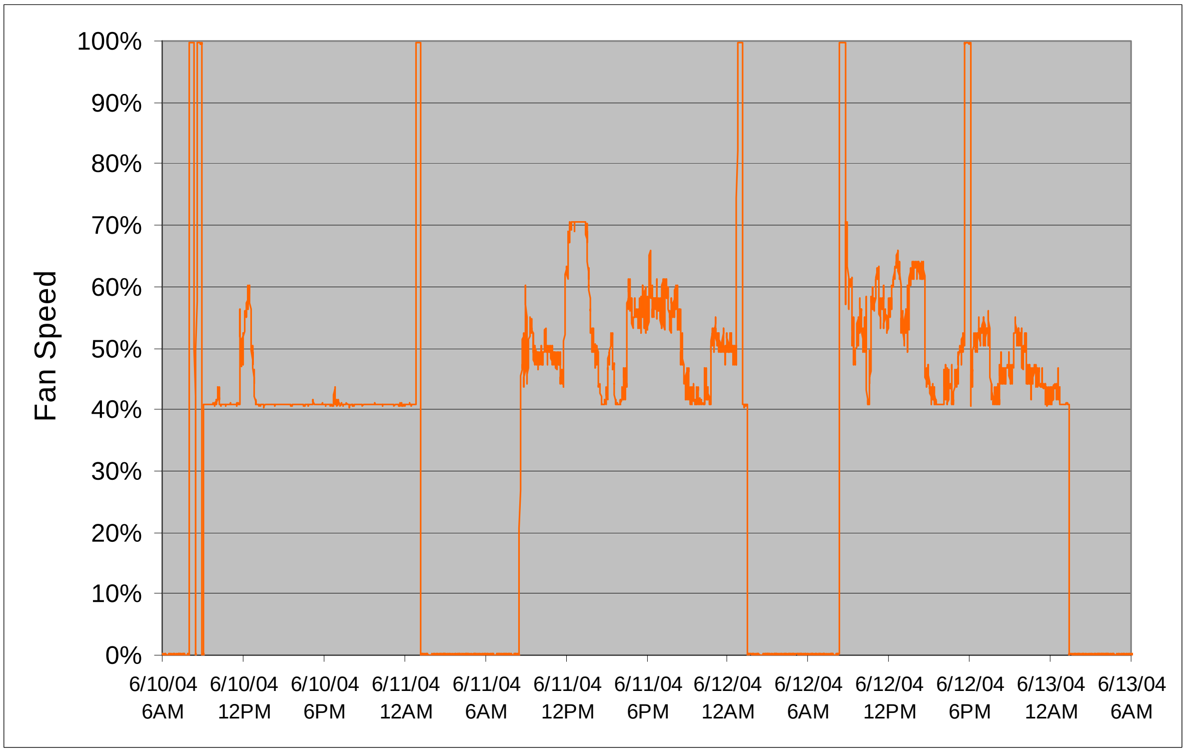

Figure 8. Fan Speed Profile – EF3

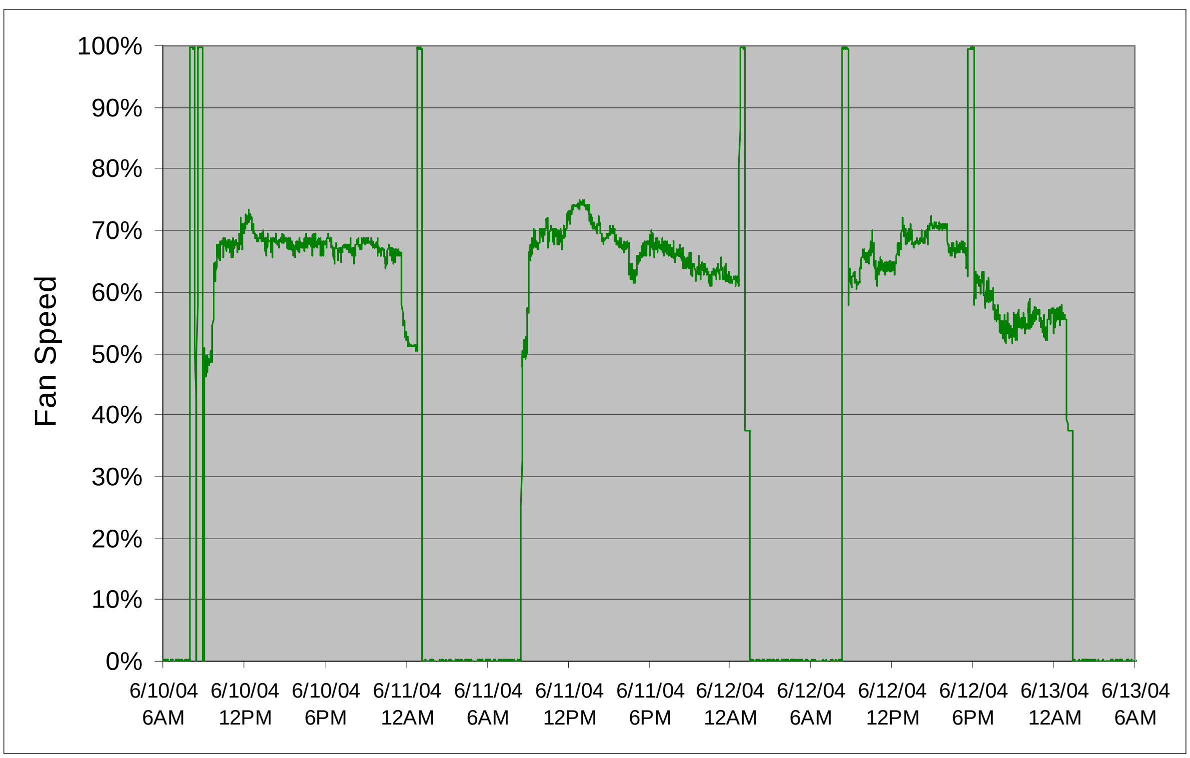

Figure 9. Fan Speed Profile – MUA

REDUCTION IN MAKEUP AIR HEATING LOAD

The reduction in makeup air heating load was assumed to be proportional to the reduction in exhaust and makeup airflow. To be conservative, the reduction in exhaust flow of 2230 cfm (versus the reduction in MUA of 2400 cfm) was used to calculate the reduction in heating load using the Outdoor Airload Calculator.[1] This software applies ASHRAE equations for heating and cooling of moist air to each of the 2190 weather data bins. Based on "operating hours" input, the software determines the time that the makeup air system is operating per weather data bin. It reports monthly heating & cooling energy use and peak 4-hour bin load for a year. The output for the Boston Pizza calculation is shown in Table 3, where (the reduction of) 2230 cfm of outdoor air showed an annual heating load (reduction) of 375,229 kBtu.

Table 3. Outdoor Airload Calculator.

Result summary for Boston Pizza
Location: Toronto, Ontario
Elevation: 568 ft
Operating Hours: 8:00 o'clock until 2:00 o'clock
Hours of Operation: 18
Makeup Air Flow: 2230 cfm
Thermostat Setpoints: Heating = 68 F, Cooling = 72 F

The Heating Design Load is: 186.2 kBtu/h
The Cooling Design Load is: 40.6 kBtu/h

Calculated Monthly loads:

Month	Heating Load	Cooling Load
January	66,616 kBtu	0 kBtu
February	59,895 kBtu	0 kBtu
March	51,511 kBtu	0 kBtu
April	32,772 kBtu	69 kBtu
May	17,179 kBtu	111 kBtu
June	6,595 kBtu	2,073 kBtu
July	2,455 kBtu	3,794 kBtu
August	3,074 kBtu	2,497 kBtu
September	11,038 kBtu	782 kBtu
October	27,040 kBtu	32 kBtu
November	39,810 kBtu	0 kBtu
December	57,245 kBtu	0 kBtu
Total Year	375,229 kBtu	9,358 kBtu

Assuming 95% heating efficiency for the direct-fired makeup air furnace, and applying a representative gas cost of $0.33/m^3 ($0.90/therm), a $3500 per year heating load saving was calculated. This dollar saving translates to approximately $1.60 per cfm, which is in line with rule-of-thumb estimates for climate zones like Toronto.

[1] The Outdoor Airload Calculator, OAC, was developed by Pacific Gas and Electric Company and is freeware available for download through the Food Service Technology Center website (http://www.fishnick.com/tools/oalc/).

RETURN ON INVESTMENT

The cost of the Melink-installed demand ventilation control system for this Boston Pizza was $10,500. With calculated fan energy savings of $1500 and calculated makeup air heating savings of $3500, the total energy cost saving would be in the order of $5000 per year. This would return the investment in approximately 2 years (i.e., simple payback = 2.1 years).

CONCLUSION AND RECOMMENDATION

The demand ventilation control reduced the restaurant's total exhaust airflow (and calculated cost) by 30%, with an associated reduction in fan power (and calculated cost) of 61%. Based on the projected 2-year payback, Boston Pizza should consider this technology within its specifications for new facilities.

It is recommended that Boston Pizza give consideration to optimizing the hood specification for the short-order line. If Exhaust Hood 1 had been installed as a wall-canopy hood, possibly with the inclusion of partial end panels, the demand ventilation system may have been able to reduce the ventilation rate during non-cooking periods more than the 20% as demonstrated in this study for Hood 1. Conceptual modifications to the Hood 1 are illustrated in Figure 10.

Figure 10. Conceptual Modifications to Hood 1

In today's world of automated HVAC control, the commercial kitchen ventilation (CKV) system is still operating in the dark ages—*you turn it on, you turn it off, and in between it operates at full speed!* It is estimated that there are 50 million cfm being exhausted by single-speed systems from restaurants and institutional kitchens in Enbridge service territory alone. The potential for demand-side management of gas load through widespread application of demand ventilation control in commercial kitchens is significant.

This retrofit case study demonstrated an average reduction in exhaust and makeup airflow of approximately 2200 cfm. The associated makeup air heating load reduction was equivalent to 10,600 m^3 of natural gas consumption, reflecting an annual heating-load-reduction index approaching 5 m^3 per cfm (of reduced airflow).