



**Demand Ventilation in Commercial Kitchens  
An Emerging Technology Case Study**

**Melink *Intelli-Hood*<sup>®</sup> Controls  
Supermarket Application**

FSTC Report 5011.06.13

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## Executive Summary

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The objective of this case study was to evaluate the Melink *Intelli-Hood*<sup>®</sup> *Controls* demand ventilation control (DVC) package that was installed on the commercial kitchen ventilation (CKV) system in a supermarket in Northern California. Within the scope of the State-Wide Emerging Technologies Program and under the direction of PG&E, the study examined and compared the energy consumption and demand of the kitchen ventilation fans with and without the DVC system in operation.

The kitchen utilized three cooking lines with an exhaust hood over each: a rear deli line with a 9500 cfm hood, a front deli line with 5800 cfm hood and a Chinese cuisine line with two 4250 cfm side-by-side hoods, for a total exhaust ventilation rate of 23,800 cfm. Each cooking line also had a makeup air unit that supplied untempered outside air through ceiling diffusers.

The Melink *Intelli-Hood*<sup>®</sup> *Controls* system is designed to reduce fan energy consumption by slowing the exhaust and makeup air fans whenever full speed is not needed. It modulates the speed of motors with variable frequency drives (VFDs) based on input that it receives from two sources: (1) a temperature sensor(s) mounted in the exhaust duct and (2) an infrared (IR) beam that spans the length of the exhaust hood. An increase in the exhaust duct temperature or a disturbance in the IR beam signals the controller to increase the fan speed until the heat, smoke or steam is removed. As a function of the average fan speed and resultant airflow reduction, the energy required for makeup air heating and cooling is also reduced.

Implementation of this demand ventilation control strategy was shown to significantly reduce the energy consumption, electrical demand and cost associated with operating this supermarket CKV system. The average daily fan energy consumption was reduced by 74%—from 118 kWh/day without demand ventilation controls to 31 kWh/day with the controls. This represents an annual energy reduction of 31,370 kWh and cost savings of \$3,770. The average fan power decreased from 8.5 kW to 2.3 kW for a 6.2 kW reduction, and the peak load reduction coincident with the statewide summertime peak demand hours of 12:00 noon to 6:00 pm decreased from 8.5 kW to 2.7 kW, a 70% demand reduction of 5.8 kW, which yielded a demand charge savings of \$550 per year.

Figure ES-1 illustrates the combined exhaust fan power profile over the course of a typical operating day, with dashed lines indicating the average power with and without DVC. Figure ES-2 illustrates the total average daily fan energy consumption as well as the average reduction.

# Executive Summary

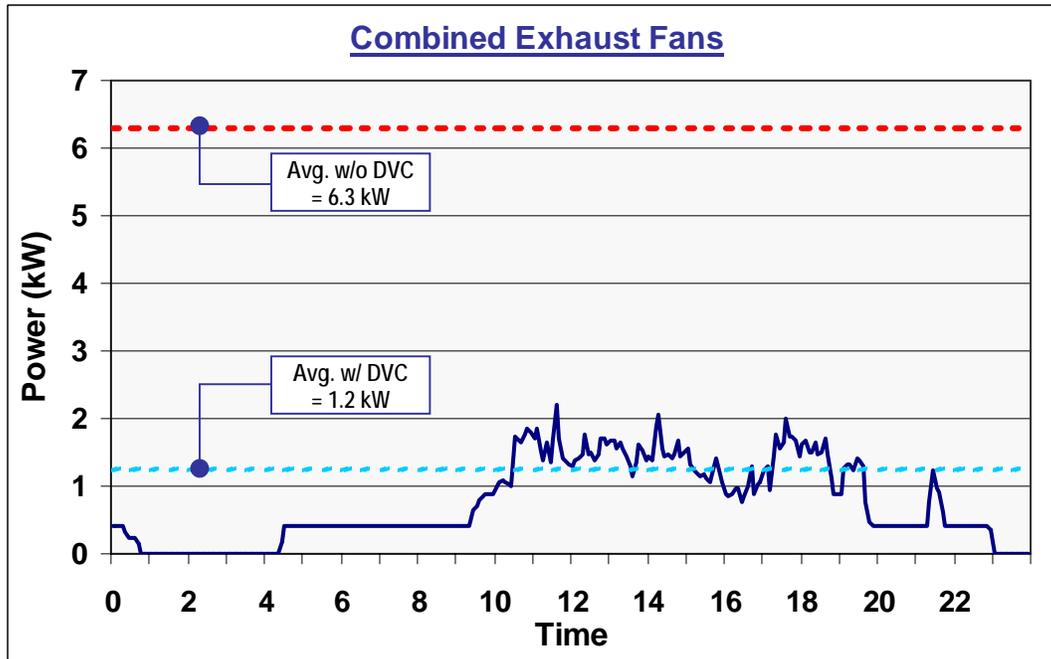


Figure ES-1. Combined Exhaust Fan Typical-Day Power Profile with DVC

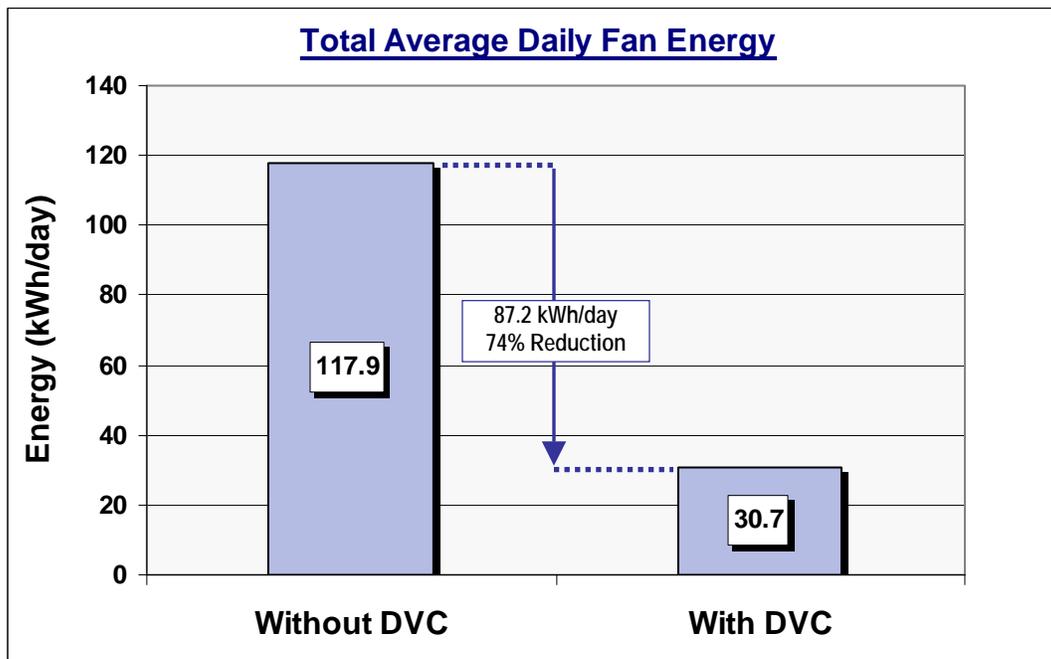


Figure ES-2. Total Average Daily Fan Energy Consumption with and without DVC

## Executive Summary

Additional cost savings were derived from the makeup air heating and cooling energy load reduction. The average exhaust (and associated makeup) airflow reduction was calculated to be approximately 40% (or 9,520 cfm), based on the measured average fan power reduction, using the applicable fan law. The calculated energy saved by subtracting this portion of makeup air was 3,800 therms/yr for heating and 9,900 kWh/yr for cooling, which yielded another \$4,990/yr savings.

Combined total yearly operating cost savings derived from the fan energy reduction, demand reduction, and makeup air heating and cooling load reduction were \$9,310. The installed cost of this Melink *Intelli-Hood*<sup>®</sup> *Controls* system for this application was approximately \$18,000, which results in a payback period in the order of 1.9 years. Table ES-1 presents a summary of the demand ventilation control system energy and cost savings.

**Table ES-1. Energy and Operating Cost Savings Summary**

	Exhaust	Makeup Air	Total
Yearly Fan Energy without DVC (kWh)	32,920	9,510	42,430
Yearly Fan Energy with DVC (kWh)	6,300	4,755	11,060
<b>Yearly Fan Energy Reduction (kWh)</b>	<b>26,620</b>	<b>4,755</b>	<b>31,370</b>
Yearly Fan Energy Cost without DVC	\$3,950	\$1,140	\$5,090
Yearly Fan Energy Cost with DVC	\$750	\$570	\$1,320
<b>Yearly Fan Energy Cost Savings</b>	<b>\$3,200</b>	<b>\$570</b>	<b>\$3,770</b>
Demand Reduction (kW)			5.8
<b>Yearly Demand Charge Savings</b>			<b>\$550</b>
Yearly Heating Load Energy Reduction (therms)			3,800
Yearly Cooling Load Energy Reduction (kWh)			9,900
<b>Yearly Heating and Cooling Energy Cost Savings</b>			<b>\$4,990</b>
<b>Total Yearly Operating Cost Savings</b>			<b>\$9,310</b>
DVC System Installed Cost			\$18,000
<b>Pay Back Period</b>			<b>1.9 years</b>

Calculated using \$0.12/kWh, \$8.00/kW monthly demand, \$1.00/therm, operating 360 days per year (All values are rounded)

# Introduction

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## Objective and Scope

The purpose of this field study was to measure the electrical energy and demand reduction realized from the installation of the Melink *Intelli-Hood*<sup>®</sup> *Controls* system—an emerging demand ventilation control (DVC) technology—at a supermarket kitchen in Northern California. The scope of the study included calculating the associated makeup air heating and cooling load reductions.

Within the State-Wide Emerging Technologies Program and under the direction of PG&E, the FSTC monitored energy consumption of the exhaust and makeup air fans with and without the demand ventilation in operation. The results of this case study can be used as another example that demonstrates the cost benefit of a commercial kitchen, demand ventilation control package.

## Demand Ventilation Control (DVC) System Description

The Melink *Intelli-Hood*<sup>®</sup> *Controls* package (Figure 1) is a demand-ventilation-based energy management system for commercial kitchen exhaust hoods that minimizes fan energy use by reducing the exhaust and makeup air fan speed when little or no cooking is occurring. Furthermore, as a function of the fan speed and associated airflow reductions, makeup air heating and cooling energy is also reduced; in addition, the kitchen ambient noise level is significantly decreased.

The *Intelli-Hood*<sup>®</sup> system processor controls the speed of the exhaust and makeup air fans through variable frequency drives (VFDs) based on input signals it receives from two sensor sources: temperature probes placed in the exhaust duct collars, and optic sensors with an infrared (IR) beam that crosses the bottom of the exhaust hood. As a temperature probe senses a rise in temperature, the controller signals the fans to increase proportionally from a predetermined minimum speed to a controlled setpoint speed that is based on the temperature range programmed into the system; an appliance in either a cooking or a standby mode of operation can generate varying levels of temperature rise, and the fan speed is adjusted accordingly. The optic sensor IR beam can be broken by either smoke or steam produced by the cooking process; when this beam is sufficiently obstructed, the fans will go to 100 percent speed (or a preset maximum speed) until the smoke or smoke or steam is cleared.

Since the fans will operate at full speed only when required, the DVC system allows for ventilation rate safety factor for intermittent peak cooking load situations without sacrificing the reduced energy consumption of a lower average ventilation rate.

# Introduction

Effective controller programming that is tailored for each equipment line and accompanying hood during system commissioning achieves optimized performance and savings. Each *Intelli-Hood*<sup>®</sup> processor can receive inputs from up to four separate hoods and then output control signals to VFDs for each hood's respective exhaust and supply fans. Cost-effectiveness increases proportionally with the ventilation system total airflow, applied fan power and operating time.

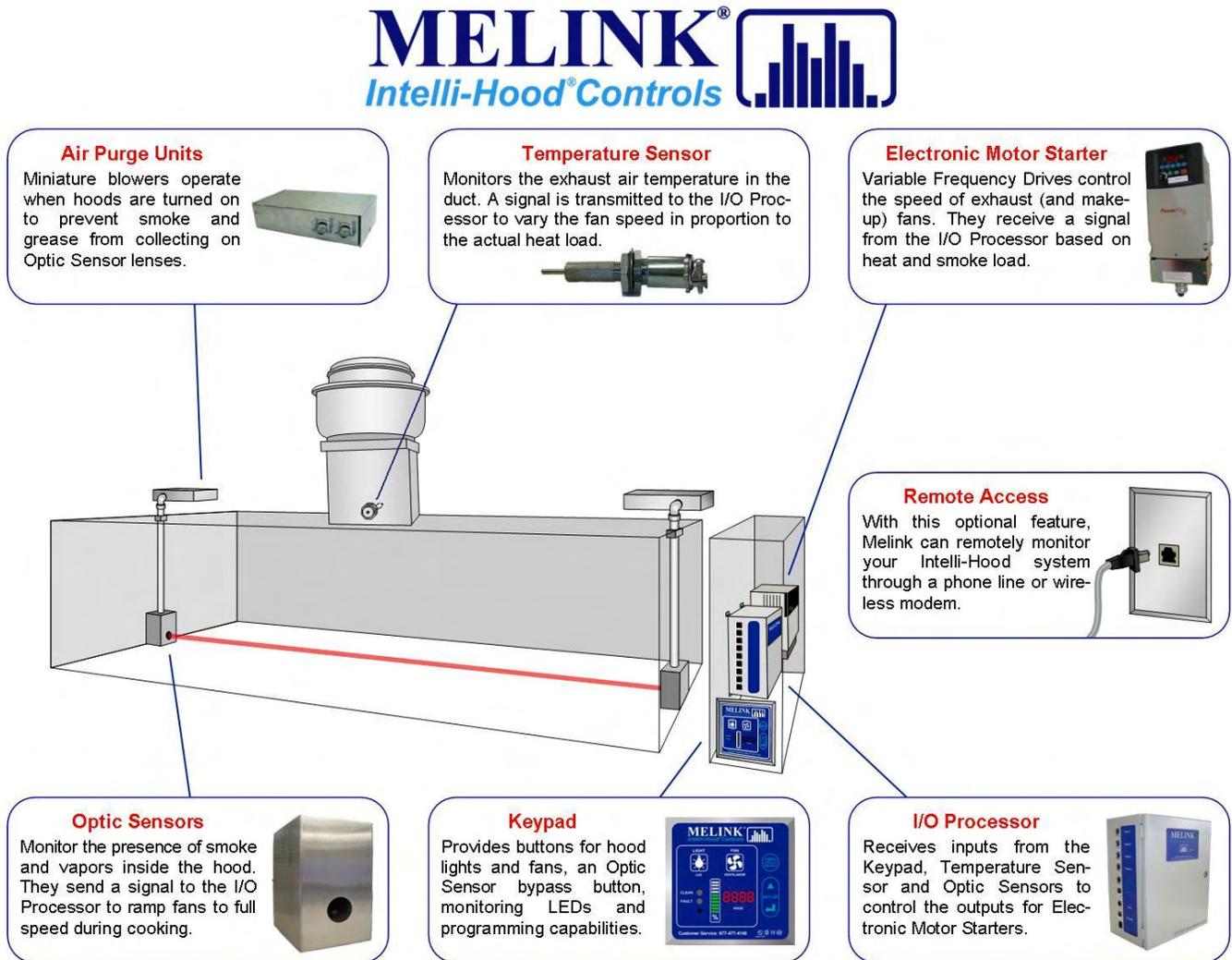


Figure 1. Melink Intelli-Hood<sup>®</sup> Controls System (Courtesy of Melink<sup>®</sup>)

# Introduction

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## Site Description

This supermarket kitchen utilizes three cooking lines with wall-mounted canopy exhaust hoods: a rear deli cooking line with a 9500 CFM hood, a front deli cooking line with 5800 CFM hood and a Chinese cuisine cooking line with two 4250 CFM side-by-side hoods (designated Left Wok and Right Wok), for a total exhaust ventilation rate of 23,800 cfm. The kitchen also uses dedicated, un-tempered makeup air units, switched on via interlock with the exhaust fans, that supply outdoor air through ceiling diffusers. Figures 2 through 4 show each cooking line and hood configuration.

The kitchen ventilation system was originally equipped with manual fan control with individual wall switches at each hood. It was then retrofitted with a Melink *Intelli-Hood*<sup>®</sup> *Controls* demand ventilation control system, which was configured for fully automatic operation that would turn the fans on upon first detection of heat or smoke and then off at the end of the day after the equipment cooled.



*Figure 2. Rear Deli Cooking Line*

# Introduction

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*Figure 3. Front Deli Cooking Line*



*Figure 4. Chinese Cuisine Cooking Line*

## Procedure

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Prior to the installation of the supermarket kitchen DVC system, full-speed exhaust and makeup air fan motor power values were measured and recorded with a Summit Technology PowerSight power analyzer. After the DVC system was installed and operating, data loggers were installed to record power and energy consumption – tracking the varying load profiles generated by the control system. Dent Instruments ElitePro data loggers, placed in the electrical service panel feeding each exhaust fan motor, recorded measurements at 5-minute intervals for a period of two weeks.

As part of the demand ventilation control strategy applied to this kitchen, by effectively lowering the average exhaust rates with the DVC system, the makeup air units were switched off, and the decreased requisite amount of makeup air was supplied by the supermarket main floor HVAC system air handler unit. Since the main air handler fan assumed the energy load of the makeup air fans, the associated makeup air fan energy reduction could not be directly measured and was therefore estimated.

Daily without-DVC fan energy consumption was calculated using the full-speed power readings multiplied by daily operating time. Due to inconsistent on-off time operating patterns while the exhaust fans were still manually controlled by the kitchen staff (before the DVC system installation), it was decided that the daily operating times that were recorded with the DVC system in operation would also be applied to the without-DVC exhaust fan energy consumption calculations, to allow for a more direct and normalized comparison of the equipment, independent of any variability in kitchen operating patterns. Yearly energy consumption was calculated using the average daily energy consumption values multiplied by 360 operating days per year.

# Results and Discussion

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## Monitoring Results

Once the recorded data was collected and analyzed, power and energy consumption comparisons were made between the kitchen ventilation system with and without demand control. The exhaust fans running at full speed, while in manual control, operated at a continuous 6.3 kW total. With the demand controls in operation and the exhaust fan speeds varying in response to the cooking processes, the average exhaust fan power total decreased to 1.2 kW, for a 5.1 kW, 81% reduction.

The makeup air fan power reduction conservatively was estimated at 50% (compared to the 81% exhaust fan power reduction), and a 12-hour average daily operating time was used to calculate the combined makeup air fan energy savings. (It was not possible to directly measure the makeup air fan power reduction as the dedicated makeup up air units had been turned off as part of the DVC installation. Post DVC installation, all makeup air was supplied from the main building HVAC system.) Factoring the original makeup air fan power of 2.2 kW and the estimated 50% 1.1 kW power reduction, the combined total average fan power dropped from 8.5 kW down to 2.3 kW, for a 6.2 kW reduction. The combined-fan peak demand coincident with the statewide summertime peak hours of 12:00 noon to 6:00 pm decreased from 8.5 kW to 2.7 kW, yielding a demand reduction of 5.8 kW.

The average daily fan energy consumption was decreased from 91.5 kWh/d to 17.5 kWh/d for the exhaust fans and from 26.4 kWh/d to 13.2 kWh/d for the makeup air fans, yielding a 74% combined total fan energy savings of 87.2 kWh/d or 13,370 kWh/yr.

In addition to the fan energy savings gained from use of the DVC system, the reduction in exhaust and corresponding makeup airflow also resulted in less energy required to condition the supplied outdoor makeup air. Furthermore, in this application, where the reduced volume of supplied air now came through the main floor, it also greatly improved overall kitchen comfort, notably during cold mornings and hot afternoons, as the untempered makeup air that was originally supplied directly overhead or in close proximity of kitchen personnel was no longer being introduced into the kitchen.

Based on the measured average exhaust (and associated makeup) fan power reduction and using the applicable fan law, the average airflow reduction was calculated to be 40%, or 9,520 cfm. The heating and cooling load reduction derived from the decreased outdoor airflow was calculated by inputting the airflow and temperature values into the Outdoor Airload Calculator (OAC), a web-based tool developed by the FSTC (available at [www.foodservicetechnologycenter.com](http://www.foodservicetechnologycenter.com)), which generated a model of the annual heating and cooling load in kBtu based on ASHRAE weather data accessed by the calculator.

## Results and Discussion

OAC input assumptions included heating the makeup air to 65°F and cooling the makeup air to 76°F while dehumidifying to 70% RH. The generated energy reduction values (shown in Appendix A) were 265,429 kBtu/yr for heating and 101,211 kBtu/yr for cooling. Applying a 70% heating efficiency and a cooling COP of 3.0, the estimated makeup air heating and cooling load reduction was calculated to be approximately 3800 therms/yr and 9,900 kWh/yr, respectively.

Table 1 lists the measured fan power values, operating times and energy consumption with and without the DVC system, the average daily energy reduction and percent reduction, and the yearly outdoor airload energy savings.

**Table 1. Fan Power and Energy Consumption**

	Rear Deli Exhaust	Front Deli Exhaust	Left Wok Exhaust	Right Wok Exhaust	Total Exhaust	Total Makeup Air	Combined Fan Total
Ventilation Rate (cfm)	9,600	5,800	4,250	4,250	23,800	---	---
Full-Speed Power without DVC (kW)	2.42	1.64	1.05	1.18	6.29	2.20	8.49
Average Power with DVC (kW)	0.41	0.40	0.21	0.22	1.23	1.10	2.33
<b>Average Power Reduction (kW)</b>	<b>2.01</b>	<b>1.24</b>	<b>0.84</b>	<b>0.96</b>	<b>5.06</b>	<b>1.10</b>	<b>6.16</b>
Average Daily Operating Time (hr)	17.8	11.5	13.2	13.3	---	12	---
Average Daily Energy without DVC (kWh)	43.1	18.8	13.9	15.7	91.5	26.4	117.9
Average Daily Energy with DVC (kWh)	7.21	4.61	2.79	2.88	17.5	13.2	30.7
<b>Average Daily Energy Reduction (kWh)</b>	<b>35.9</b>	<b>14.2</b>	<b>11.1</b>	<b>12.8</b>	<b>74.0</b>	<b>13.2</b>	<b>87.2</b>
<b>Percent Energy Reduction (%)</b>	<b>83.3</b>	<b>75.5</b>	<b>79.9</b>	<b>81.6</b>	<b>80.9</b>	<b>50.0</b>	<b>74.0</b>
Yearly Heating Load Energy Reduction (therms)							3,800
Yearly Cooling Load Energy Reduction (kWh)							9,900

Figure 5 illustrates the combined exhaust and makeup air fan total average daily energy consumption with and without the DVC system in operation and the reduction achieved with DVC. Figures 6 through 10 illustrate the typical-day power profile of the exhaust fans. They include dashed lines indicating the higher, full-speed fan power before DVC and also the reduced average fan power resulting from DVC. The typical-day profiles were chosen so that the daily energy consumption of each profiled day most closely matched the average daily energy consumption value.

## Results and Discussion

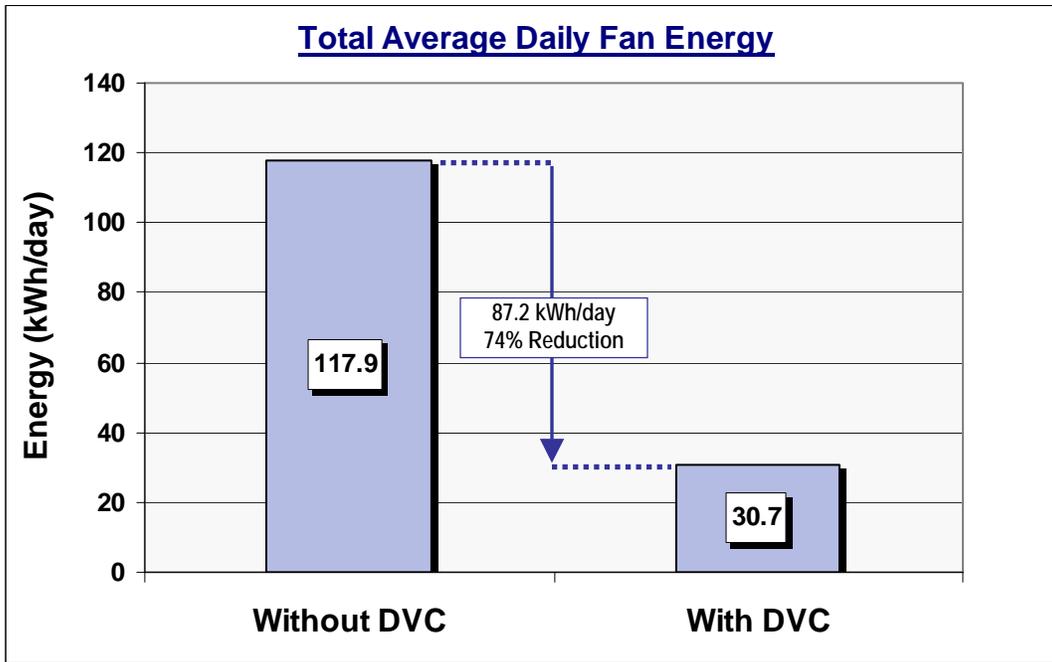


Figure 5. Total Average Daily Fan Energy Consumption with and without DVC

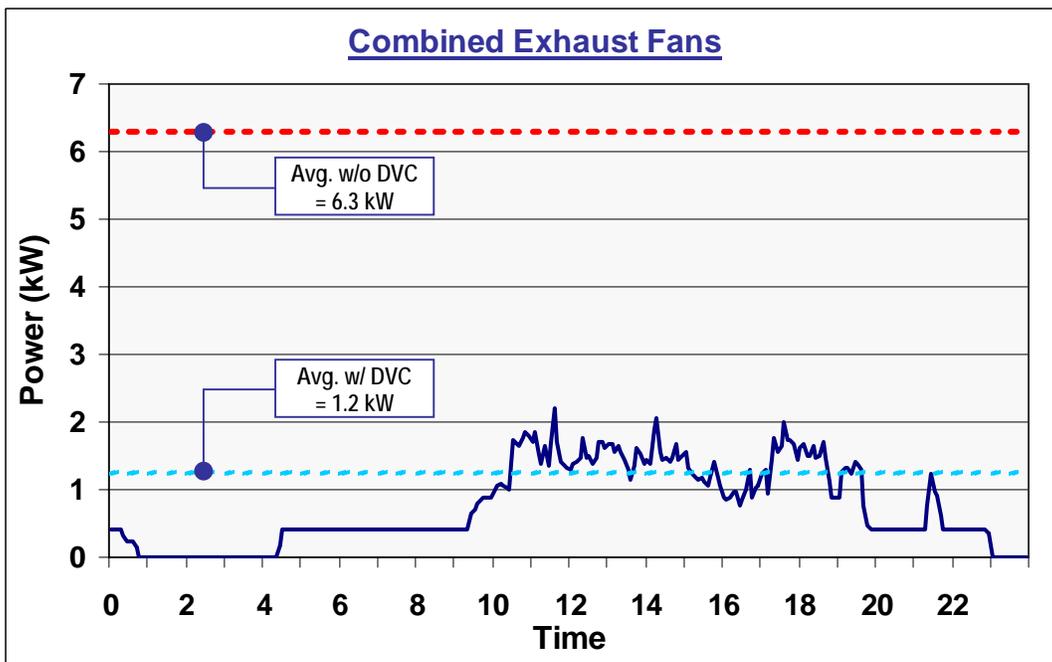


Figure 6. Combined Exhaust Fan Typical-Day Power Profile with DVC

# Results and Discussion

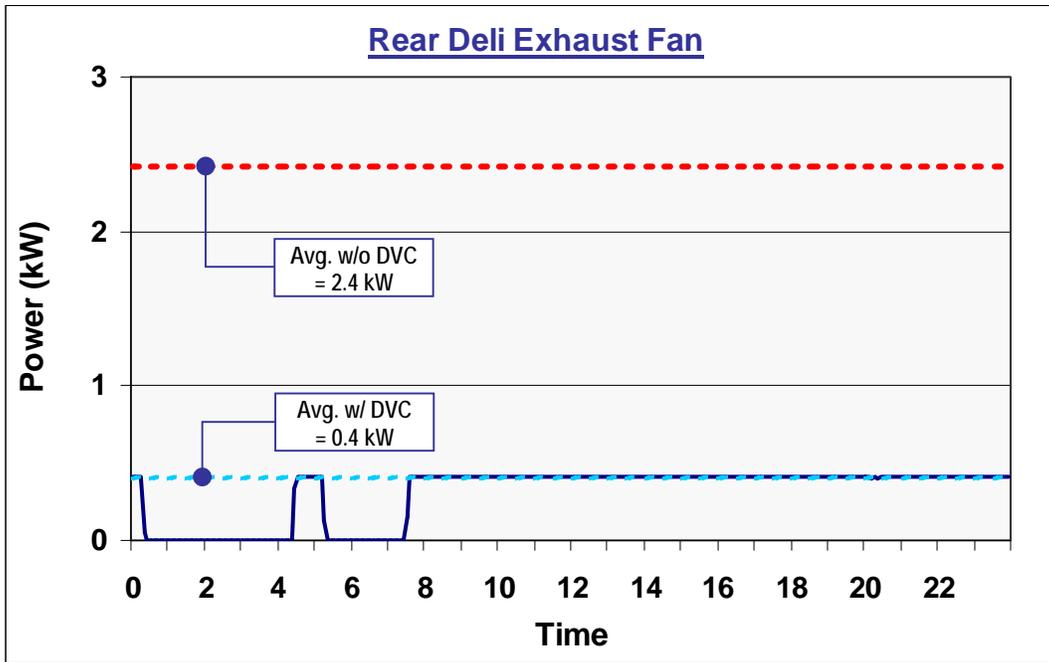


Figure 7. Rear Deli Hood Typical-Day Power Profile with DVC

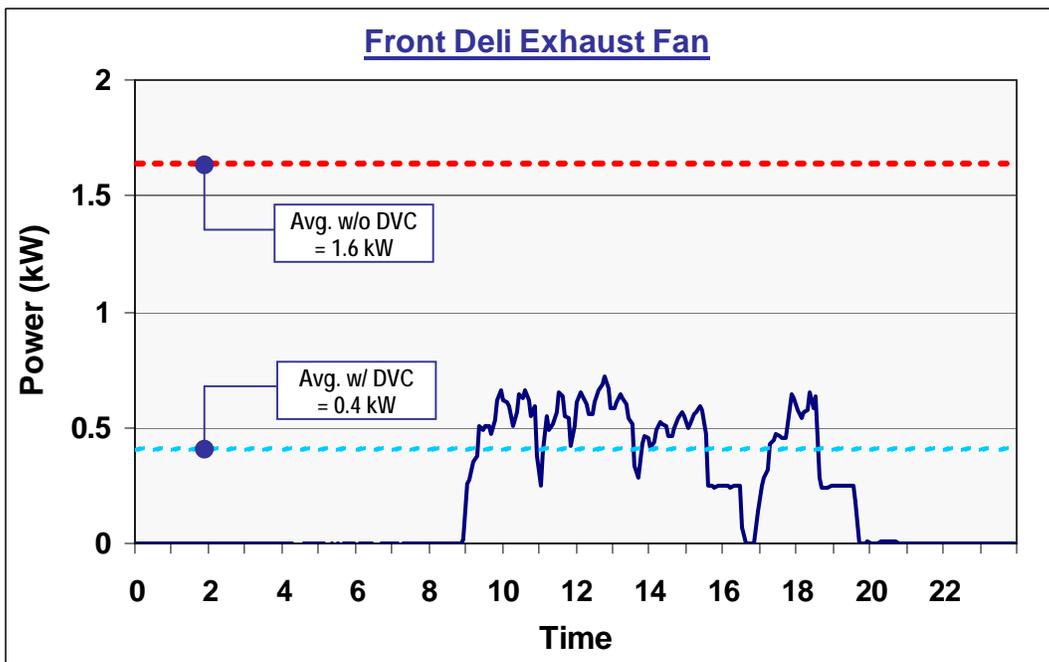


Figure 8. Front Deli Hood Typical-Day Power Profile with DVC

## Results and Discussion

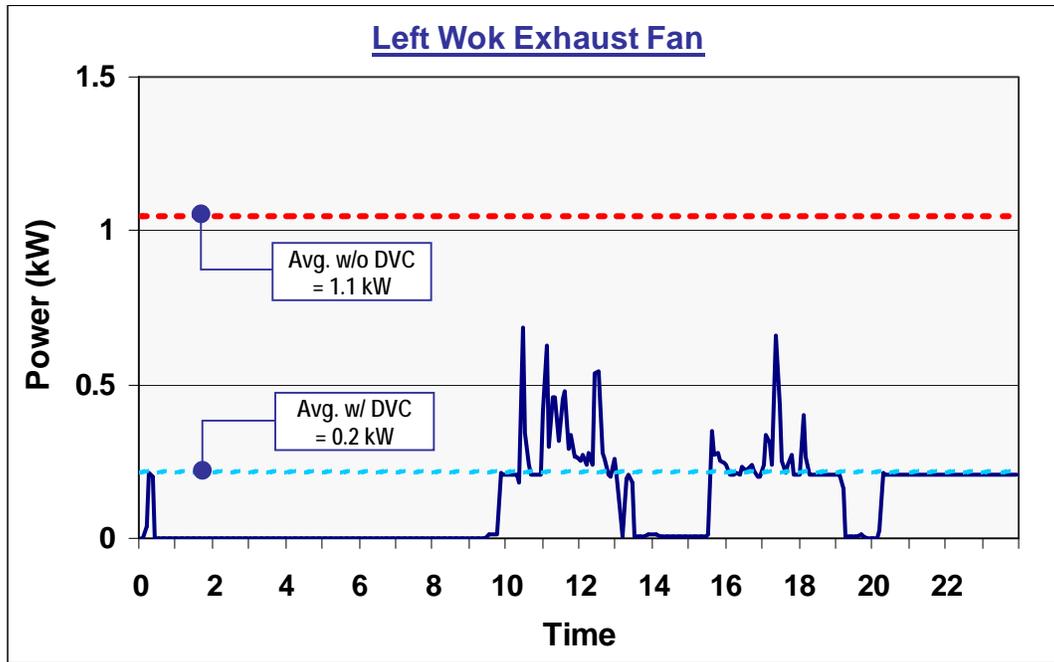


Figure 9. Left Wok Hood Typical-Day Power Profile with DVC

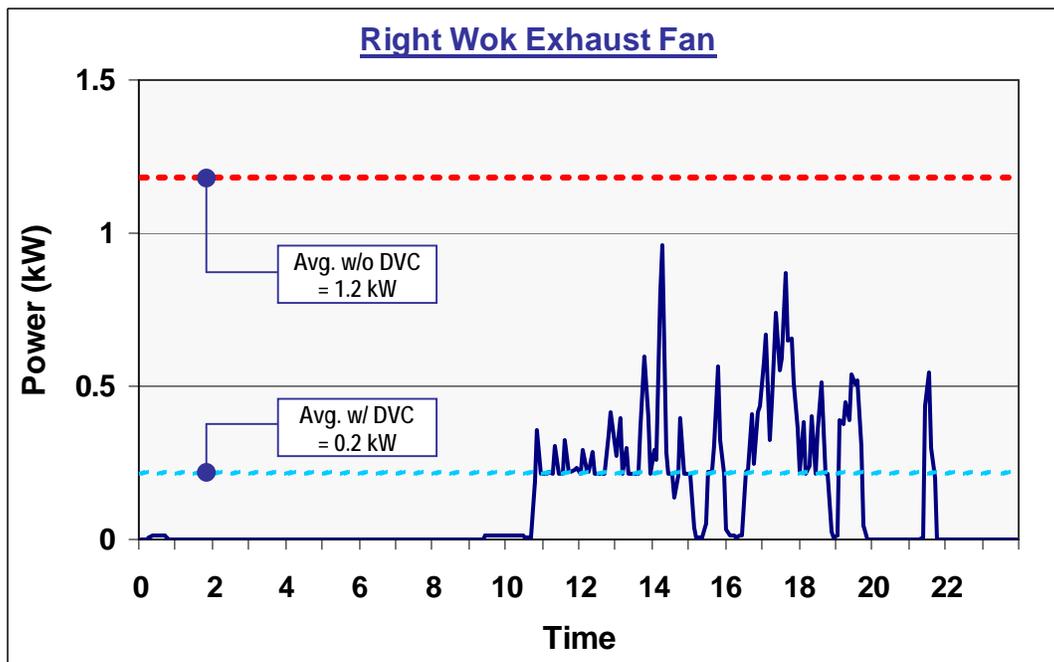


Figure 10. Right Wok Hood Typical-Day Power Profile with DVC

## Results and Discussion

### Energy Cost Savings and Payback

The 31,370 kWh per year total fan energy reduction yielded annual cost savings of \$3,770, and the demand charge savings achieved from the 5.8 kW demand reduction were \$550 per year. Additionally, the 9,520 cfm average ventilation rate reduction lowered the outdoor-air heating load by an estimated 3,800 therms per year and the cooling load by an estimated 9,900 kWh per year, for operating cost savings of \$3,800 and \$1,190, respectively. Combining the fan energy, demand charge and outdoor-air load cost savings together, the overall annual operating cost of this supermarket kitchen was reduced by \$9,310 per year. The installed cost of the Melink *Intelli-Hood*<sup>®</sup> *Controls* system in this facility was approximately \$19,000, which makes the calculated simple payback period for this DVC installation 1.9 years. Table 2 summarizes the overall energy savings, cost savings and the simple payback period achieved with the DVC system retrofit.

**Table 2. Energy and Operating Cost Savings Summary**

	Exhaust	Makeup Air	Total
Yearly Fan Energy without DVC (kWh)	32,920	9,510	42,430
Yearly Fan Energy with DVC (kWh)	6,300	4,755	11,060
<b>Yearly Fan Energy Reduction (kWh)</b>	<b>26,620</b>	<b>4,755</b>	<b>31,370</b>
Yearly Fan Energy Cost without DVC	\$3,950	\$1,140	\$5,090
Yearly Fan Energy Cost with DVC	\$750	\$570	\$1,320
<b>Yearly Fan Energy Cost Savings</b>	<b>\$3,200</b>	<b>\$570</b>	<b>\$3,770</b>
Demand Reduction (kW)			5.8
<b>Yearly Demand Charge Savings</b>			<b>\$550</b>
Yearly Heating Load Energy Reduction (therms)			3,800
Yearly Cooling Load Energy Reduction (kWh)			9,900
<b>Yearly Heating and Cooling Energy Cost Savings</b>			<b>\$4,990</b>
<b>Total Yearly Operating Cost Savings</b>			<b>\$9,310</b>
<b>DVC System Installed Cost</b>			<b>\$18,000</b>
<b>Pay Back Period</b>			<b>1.9 years</b>

Calculated using \$0.12/kWh, \$8.00/kW monthly demand, \$1.00/therm, operating 360 days per year (All values are rounded)

## Conclusions and Recommendations

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The savings resulting from this Melink *Intelli-Hood*<sup>®</sup> *Controls* system installation affirmed that demand ventilation control (DVC) can be a cost-effective solution to reducing the energy load and cost of operating exhaust ventilation systems in foodservice operations.

In addition to the fan operating cost and heating/cooling load energy cost savings, there were the added benefits of a significant reduction in the noise level generated in the kitchen by the exhaust ventilation system and more comfortable ambient temperatures due to the elimination of the unconditioned hot/cold outside makeup air. Although the positive benefit of a quieter and more comfortable kitchen is not as easily quantified, this is undoubtedly an overall improvement to the kitchen environment that could potentially lead to happier and more productive kitchen personnel.

With all these advantages in mind, the Food Service Technology Center supports the application of commercial kitchen demand ventilation control and initiatives by California utilities to encourage market transformation through targeted education and/or financial incentives for this emerging technology.

## Appendix A: Outdoor Air Load Calculations

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Result summary for Calculation Number: 1

Location: SACRAMENTO, California  
Elevation: 26 ft  
Operating Hours: 8:00 o'clock until 20:00 o'clock  
Hours of Operation: 12  
Makeup Air Flow: 9520 cfm  
Thermostat Setpoints: Heating = 65 F, Cooling = 76 F

Dehumidification was set to limit the Relative Humidity to: 70 %  
Based on a Space Temperature of: 76 F, with Reheating Option

Calculated Monthly loads:

Month	Heating Load	Cooling Load
January	66,541 kBtu	0 kBtu
February	38,518 kBtu	0 kBtu
March	38,226 kBtu	0 kBtu
April	17,149 kBtu	472 kBtu
May	2,402 kBtu	7,951 kBtu
June	440 kBtu	16,567 kBtu
July	0 kBtu	29,289 kBtu
August	433 kBtu	29,025 kBtu
September	25 kBtu	15,201 kBtu
October	2,772 kBtu	2,705 kBtu
November	32,266 kBtu	0 kBtu
December	66,656 kBtu	0 kBtu
Total_Year	265,429 kBtu	101,211 kBtu