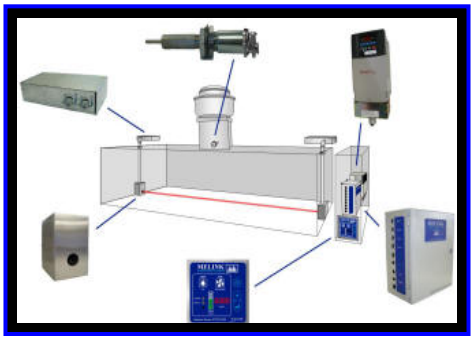
Customer Advanced Technologies Program
Technology Evaluation Report



Prepared by

Dave Bisbee, CEM

Energy Efficiency, Customer Research & Development
Sacramento Municipal Utility District
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About the Customer Advanced Technologies Program…

SMUD's Customer Advanced Technologies (C.A.T.) program works with customers to encourage the use and evaluation of new or underutilized technologies. The program provides funding for customers in exchange for monitoring rights. Completed demonstration projects include lighting technologies, light emitting diodes (LEDs), residential building shell construction, geothermal heat pumps, indirect/direct evaporative cooling, non-chemical water treatment systems and a wide variety of other technologies.

For more program information, please visit: http://www.smud.org/education/cat/index.html

Introduction

Lurking in commercial kitchens throughout the world are some voracious beasts. Each year they gobble up vast amounts of energy and profits. In fact, according to the American Gas Association, they waste more than ***2 billion dollars*** of energy each year in the U.S. food-service industry alone[1]. What are they? Commercial ventilation systems! In this technology report we will take a closer look at some of the principles of proper ventilation and Melink Corporation's Intelli-Hood® system.

Kitchen Ventilation 101

Successful restaurants know that they're not just selling food – they must create a pleasant overall dining experience for their customers. This is why they spend big bucks on creating the right atmosphere through the use of furniture, lighting, music and decorations. They must also keep customers comfortable - not too hot or cold and keep unwanted cooking odors from straying into the dining areas. An important part of this equation is the kitchen ventilation system.

"According to the American Gas Association, ventilation systems waste more than **two billion** dollars of energy each year in the U.S. food-service industry alone[1]."

A typical commercial kitchen ventilation system consists of hoods, exhaust fans (EF) and "make-up" air handling units (MUA). A well designed ventilation system should accomplish the following objectives:

1. Remove heat and smoke from cooking areas
2. Prevent cooking odors from escaping to dining areas
3. Work in conjunction with the building's HVAC system to keep customers and staff comfortable
4. Meet all applicable fire protection codes and air quality standards
5. Be energy efficient by providing just the right amount of ventilation air required under various operating conditions.

In the past, it was common practice to design ventilation systems with make-up air units sized to provide only 80 to 90 percent of the total exhaust air flow requirements. This means that 10 to 20 percent of the make-up air comes from conditioned spaces. While this approach helps the kitchen maintain a negative pressure (with respect to the seating areas), it wastes energy –particularly if the exhaust air is excessive. Furthermore, if a ventilation system is severely

[1] Source: "Kitchen Hoods Using Demand Ventilation", by Stephen K. Melink, ASHRAE Journal, December 2003, page 24

unbalanced, it may cause drafts, hot and cold spots, and allow cooking odors to invade the dining area **(see Figure 1)**. Needless to say, this isn't good for business. To make matters worse, customers are not the only ones affected…think about the kitchen staff. After all, who wants to work long hours in a smoke-filled, overly hot kitchen for a bunch of grumpy customers?

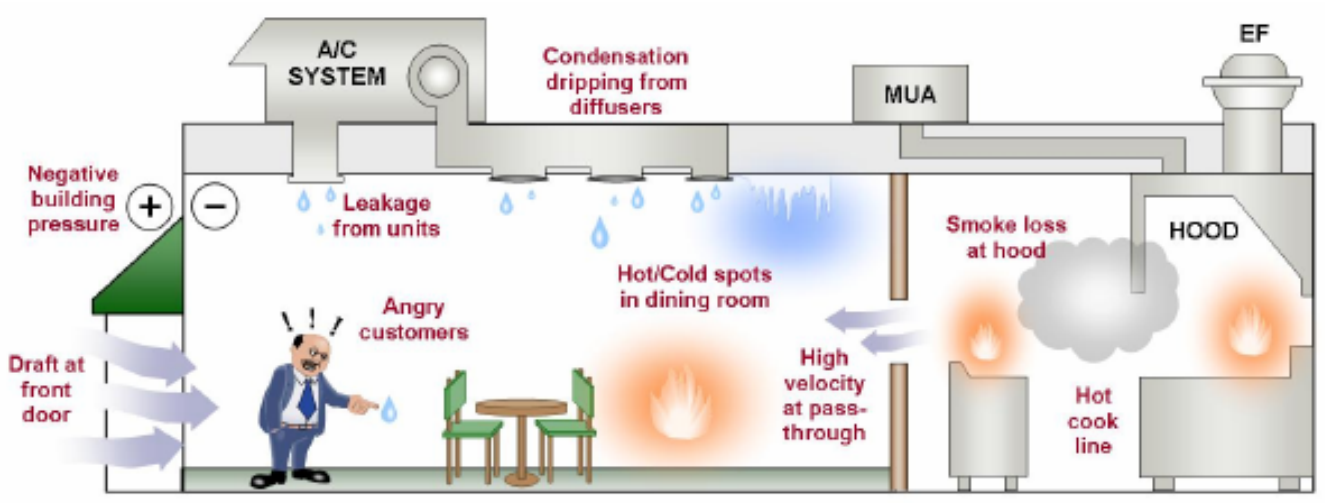

Figure 1: Unbalanced ventilation systems waste energy and may cause a variety of comfort and air quality problems that affect both customers and staff. Drawing provided courtesy of Melink Corporation.

The Problem with Constant Speed Fans

Many commercial kitchens are equipped with single-speed exhaust fans. Typically, kitchen staff will turn on the cooking appliances and exhaust hoods at the beginning of the day and will leave them on until closing time. Unfortunately, this practice wastes energy since case studies show that full speed operation is only needed for a few hours each day. The graph depicted in **Figure 2** shows fan speeds for a ventilation system equipped with Melink Corporation's Intelli-hood® system. The Intelli-Hood system varies the speed of the fans based upon the amount of heat and smoke present. As you can see, most of the time the fans ran at only part speed. This is because a lot of cooking equipment was idle for several hours each day, so the ventilation requirements were reduced.

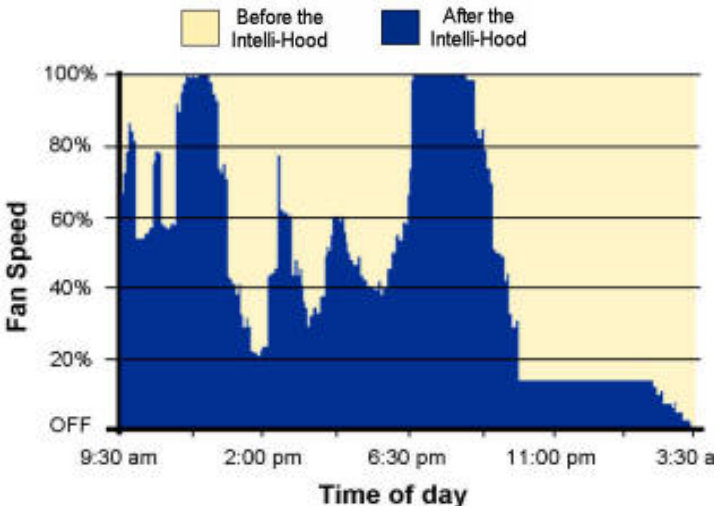

Figure 2: This graph shows the fan speeds for a ventilation system equipped with Melink's Intelli-Hood controls. Note that the fans run at part speed the majority of the time. Source: Melink Corporation.

The Intelli-Hood® System

Overview

Melink Corporation's Intelli-Hood Control system is designed to control the speed of exhaust hood fans and the make up air handler to match actual ventilation requirements. The Intelli-Hood® system uses optical (infrared) and temperature sensors to detect the presence of smoke and heat (two byproducts of cooking), and varies the speed of the fans accordingly. One of the features that make Intelli-Hood® unique is the use of "air-purge units." These miniature blowers create an air curtain across the face of the optical sensors to prevent smoke and grease from collecting on the sensor lenses. Fan motor speed is controlled through the use an I/O processor and variable frequency drives (VFDs). Finally, a keypad is provided to enable kitchen staff to turn on the exhaust fans and hood lights and provide operational feedback. **Figure 3** provides an overview of system components.

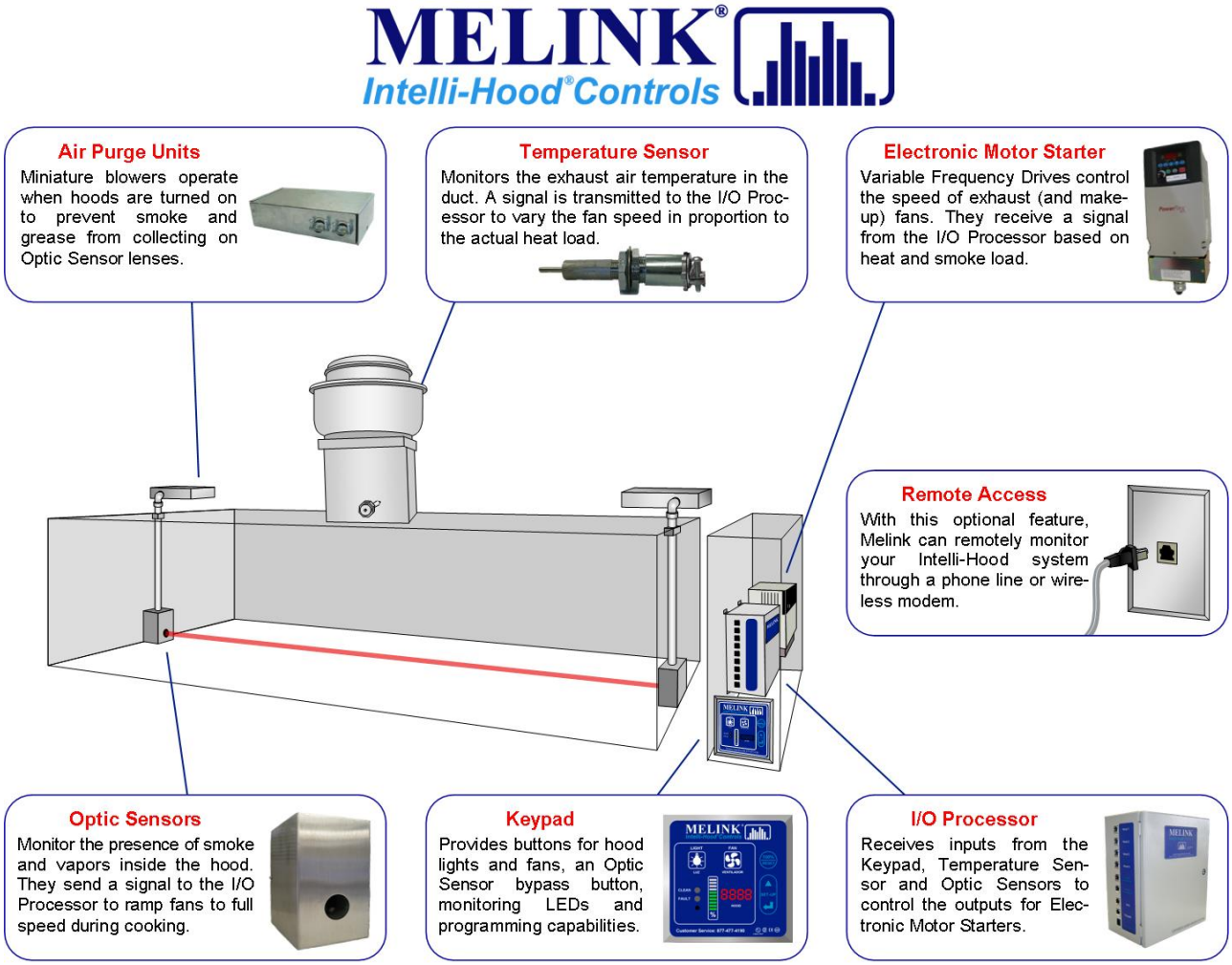

Figure 3: Overview of the Intelli-Hood® system. Photo provided courtesy of Melink Corporation.

Potential Benefits

According to the manufacturer, Intelli-Hood® offers the following benefits:

- ✓ Reduced energy costs: saves energy by reducing the exhaust and make-up fan speeds during idle cooking times. Typical annual savings are $1,500 to $5,000 per hood with a payback of one to three years.

- ✓ Improved fire safety: may improve fire safety by monitoring the exhaust air temperature. If the temperature approaches the fusible link rating of the fire suppression system, an alarm can sound and / or the cooking appliances be turned off.

- ✓ Improved indoor air quality: Intelli-Hood® Controls can also improve indoor air quality inside a store by monitoring the CO2 levels in the dining area. The exhaust and outside air quantities can be increased to 100% if the level exceeds a certain threshold

- ✓ Improved kitchen comfort:
  - o Reduces the amount of hot and humid make-up air during idle cooking periods.
  - o May be used as an economizer when indoor and outdoor conditions are right for free cooling (e.g. late night or early morning).
  - o Reduces fan noise: reduces hood noise in the kitchen by up to 90 percent when the fans slow down.

Although Intelli-Hood alone will not fix air balance issues, it provides an opportunity to identify and correct problems associated with imbalanced exhaust and make-up air flows. Melink Corporation offers air balancing services to help correct problems identified during the process of surveying the ventilation system.

System Cost and Savings Potential

The overall installed cost of the system will depend on a variety of factors including the number and size of the hoods, type and size of the make-up air handler, local labor rates, accessibility and so forth. Data from showcase projects featured on Melink Corporation's Web site and local demonstration projects are shown in Figure 4). Key observations:

1. Several of the Intelli-Hood case studies featured on Melink's website were installed by factory personnel before the hoods were delivered to the job sites (identified in Figure 4 as "new construction"), so labor costs were minimal. Simple paybacks for these sites range from 1.3 to 2.8 years. Since small restaurants generally prefer paybacks of less than two years, and labor costs for field retrofits typically double overall project costs, these sites appear to be best suited for new construction applications only.

2. A large percentage of the savings for this technology comes from reducing the amount of cooling and heating needed for tempering the make-up air during low cooking demand periods. Consequently, savings will vary tremendously depending on climate and the type of heating and cooling equipment used. However, even if the make-up air is not heated or cooled, most commercial kitchen ventilation systems draw 10 to 20% of the required make up air from conditioned space[3]. Fortunately, Fisher-Nickel Inc. has developed the Outdoor Air Load Calculator (OALC) - a no-cost, publicly available tool to help calculate energy savings. The OALC may be accessed via the Internet at www.archenergy.com/ckv/defult.htm

Store	Location	New construction or retrofit?	Total HP controlled	Cost	Annual Savings	Simple payback (yrs)
Hyatt Regency Hotel	Sacramento, CA	retrofit	50.5	$36,852	$28,363	1.3
Chili's (restaurant)	Houston, Texas	new construction	3.75	$5,029	$3,592	1.4
Cub Foods	Chicago, Illinois	new construction	3.0	$5,914	$2,112	2.8
Applebee's (restaurant)	Los Angeles, California	new construction	8.0	$5,950	$2,380	2.5
Hyatt Regency Hotel	Schaumburg, Illinois.	new construction	5.0	$5,964	$4,588	1.3
Raley's (grocery store)	Brentwood, California	retrofit	9.0	$18,000	$9,310	1.9
Inter-Continental Mark Hopkins Hotel	San Francisco, California	retrofit	35	$19,370	$24,213	9 months
Sacramento City College	Sacramento, CA	retrofit	30	$38,068	$6,099	6.2

Figure 4: Cost and savings estimates for Intelli-Hood® system projects. Source: Melink Corporation

Showcase Project

Project Location: Sacramento City College
3835 Freeport Boulevard
Sacramento, CA 95822

Sacramento City College

Background: The Sacramento City College Cafeteria offers food services to approximately 16,500 students. The kitchen has three cooking lines and operates from 5:30 a.m. to 10:30 p.m. thirty-six weeks per year (2,700 hours per year). Los Rios Community College District hired CulinAire Systems of El Dorado Hills, California, to perform a feasibility study. The ventilation system consists of:

- ✓ Eight single-speed, rooftop exhaust fans (total =15 HP; 18,500 cfm).
- ✓ One single speed, rooftop exhaust fan dedicated to the dishwasher area (not included in this project).
- ✓ Two single-speed make-up air supply fans (total of 3 HP, 11,753 CFM). These fans have previously been disconnected (see note 1 below).
- ✓ One constant volume, Modine make-up air handler (15 HP; 10,000 cfm). Unit has an evaporative precooler and natural gas heating.

During the study, CulinAire Systems made the following discoveries:

1. There was a significant mismatch between the make up air (10,000 cfm) and the exhaust (18,500 cfm). The two make up air supply fans were previously disconnected because they do not include provisions for cooling, and were causing extreme discomfort in the kitchen areas. Consequently, the exhaust fans were drawing 8,500 cfm from conditioned areas of the building.

2. One of the hoods (above a gas grill) was experiencing capture problems (**see Figure 5**). CulinAire Systems recommended installing a stainless-steel panel on the back side of the hood to help alleviate this situation.

   Existing modular-core supply diffusers were located too close to the face area of the kitchen exhaust hoods. This can create problems with proper exhaust hood effluent capture. CulinAire Systems recommended replacing the diffusers with a

Figure 5: This hood was experiencing capture problems. CulinAire (the contractor) recommended installing a stainless steel back panel to help alleviate this problem.

perforated face type diffuser and removing the internal deflectors.

3. All existing fan motors are premium efficiency units. Therefore no replacement motors were recommended.

Project Summary

The Los Rios Community College District chose to implement the Intelli-Hood system and have the back plate installed on the hood above the gas grill. The Intelli-Hood system included nine VFDs (eight for the exhaust and one for the make up air handler fan), two keypad controls, eleven temperature sensors, two I/O processors: and six optical sensors. According to CulinAire Systems, this installation was somewhat of a challenge since the VFDs had to be located in a cramped attic space next to the make-up air handling unit (see Figure 6). The system took approximately 170 man-hours to install.

Figure 6: The VFDs and I/O processors had to be installed in a cramped attic mechanical room. This made installation a challenge.

Monitoring Results

SMUD hired ADM Associates Inc. to monitor the exhaust fans and the make up air handler unit for a period of 45 days to determine the energy savings.

Monitoring revealed that only two of the eight fans needed to run at full speed more than 10% of the operating hours (See Figure 7). The result was a dramatic 63% reduction in energy consumption - not including any allowances for reduced heating and cooling loads!

	Sacramento City College - System 1					Sacramento City College - System 2					
Fan Speed	VFD-1	VFD-2	VFD-3	VFD-4	System 1 Average	VFD-5	VFD-6	VFD-7	VFD-8	System 2 Average	Combined Average
50%	72%	76%	71%	99%	65%	99%	99%	97%	97%	95%	71%
60%	1%	17%	8%	0%	14%	0%	0%	0%	1%	3%	18%
70%	10%	6%	5%	0%	10%	0%	0%	1%	1%	1%	10%
80%	0%	2%	1%	0%	9%	0%	0%	0%	0%	0%	0%
90%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%
100%	16%	0%	15%	0%	0%	0%	0%	3%	1%	0%	0%

System 1 Average Speed: 57%

System 2 Average Speed: 51%

Combined Average Speed: 54%

Figure 7: Monitoring results. Note that only two of the eight fans needed to run at full speed more than 10% of the operating hours.

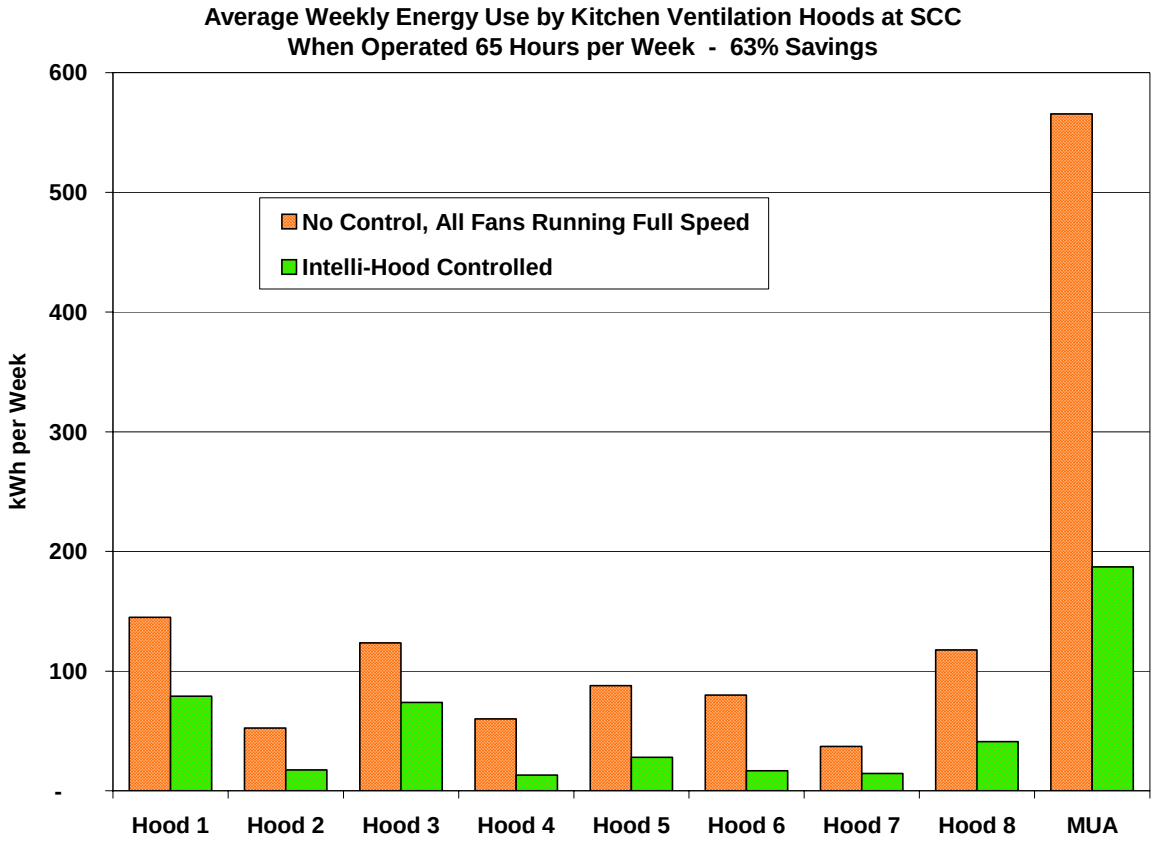

Figure 8: Measured energy savings for the fan motors only. Note that these values do not include the additional heating and cooling savings resulting from exhausting less air.

Financial Summary

- Project cost: $38,068
- Customer Advanced Technologies Program grant: $15,000
- Net project cost: $23,068
- Estimated energy savings: 38,311 kWh / year (based upon monitoring data)
- Estimated annual cost savings: $3,831/ year (based upon monitoring data and a hypothetical energy rate of $0.10)
- Simple payback: 5.9 years

Customer Feedback: "The Melink Intelli-Hood Controls installed by CulinAire Systems has proven to save energy while improving the working environment in the kitchen. The ancillary benefits of reduced noise, improved smoke control and cooler kitchen temperatures are just as compelling as the energy savings."

Mike Goodrich
Director Energy/Utilities
Los Rios Community College District

Showcase Project

Project Location: Hyatt Regency Hotel Sacramento
1209 L Street
Sacramento, CA 95814

Figure 9: Hyatt Regency Hotel Sacramento

Background: The Hyatt Regency Hotel in Sacramento features over 500 guest rooms and is located in downtown Sacramento directly across from the State Capitol and Capitol Park. Hotel guests enjoy dining at the hotel's Dawson's American Bistro and Martini Bar serving comfort foods and specialty martinis, as well as a large outdoor pool and whirlpool, and health club.

According to a survey performed by CulinAire Systems, the Hyatt's ventilation system consists of:

- ✓ Five single-speed, rooftop exhaust fans (total = 30.5 HP)
- ✓ One constant-volume, make-up air system with a 20 HP supply fan motor and natural gas heat supplying a hydronic heating coil.

Figure 10: One of the cooking lines at Hyatt Regency Sacramento.

Project Summary

The Hyatt chose to implement the Intelli-Hood system including six VFDs (five for the exhaust fans and one for the make up air handler fan), 1 keypad control, 14 temperature sensors, 1 I/O processor, and 4 optical sensors. Most of the VFDs were located in the parking garage (see Figure 11). The system took approximately 120 man-hours to install.

Monitoring Results

Once again SMUD hired ADM and Associates to monitor the exhaust fans and the make up air handler unit. The systems were monitored for a period of 28 days to determine the energy savings.

Monitoring showed an impressive 57% reduction in electrical energy consumption (187,067 kWh) and an estimated natural gas savings of 9,578 therms (based upon Architectural Energy Corporation's Outdoor Air Load Calculator (OALC) www.archenergy.com/oac.

Figure 11: VFDs used to control the four of the exhaust fans and the make-up air handler fan.

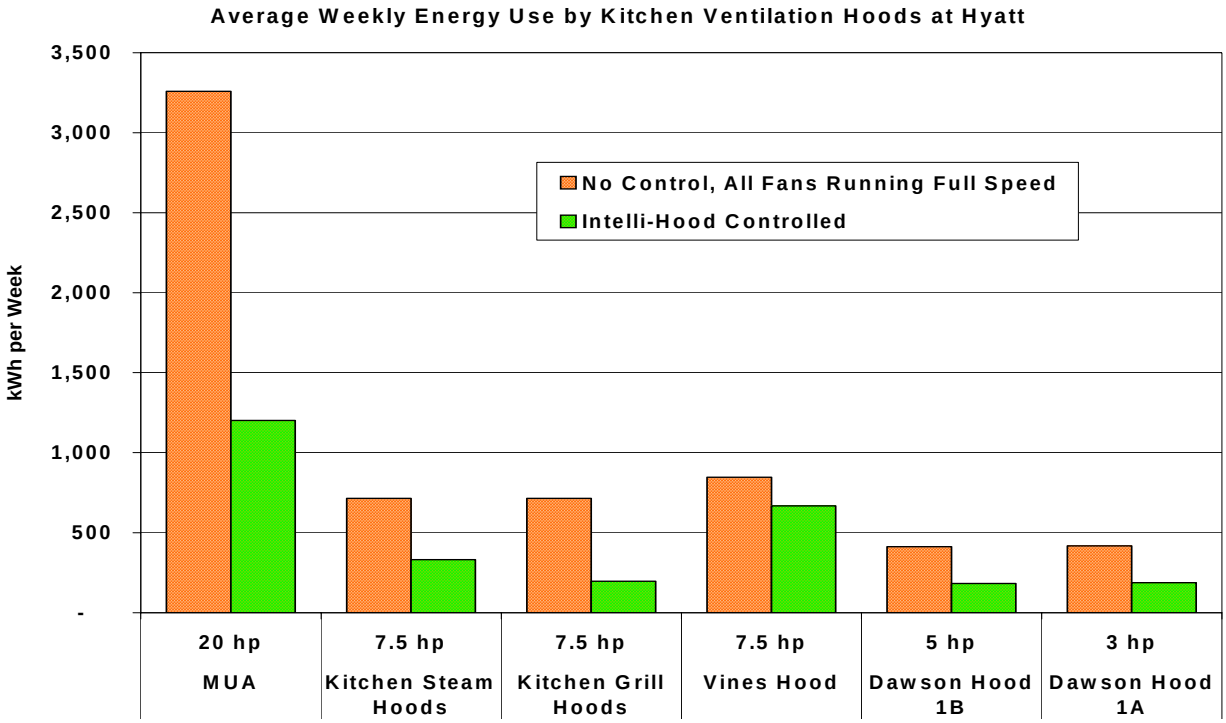

Figure 12: Graph of measured energy savings for the fan motors only. Note that these values do not include the additional heating and cooling savings resulting from exhausting less air.

Based on normal hood operation	MUA	Kitchen Steam Hoods	Kitchen Grill Hoods	Vines Hood	Dawson Hood 1B	Dawson Hood 1A	Total
Size, hp	**20 hp**	**7.5 hp**	**7.5 hp**	**7.5 hp**	**5 hp**	**3 hp**	
Baseline 100% Operation, kWh/week(1)	3,259	715	715	846	413	418	6,365
Intelli-Hood, Average kWh/Week(2)	1,202	331	196	668	183	188	2,768
Savings, kWh/week	2,057	383	518	178	230	230	3,597
Percent Savings, %	63%	54%	73%	21%	56%	55%	57%

Energy Savings	**56.5%**	**Notes**
		(1) No Control, All Fans Running Full Speed
Baseline kWh (annual)	330,990 kWh /year	(2) Intelli-Hood Controlled
Estimated kWh with Intelli-Hood	143,923 kWh /year	
Annual Savings	**187,067 kWh /year**	

Figure 13: Measured energy savings for the fan motors only. Once again please note that these values do not include the additional heating and cooling savings resulting from exhausting less air.

Financial Summary

- Project cost: $36,852
- Estimated fan energy savings: 187,067 kWh / $17,771 per year (based upon monitoring data and an energy rate of $0.095 / kWh).
- Estimated annual cost savings from reduced make-up air: heating = $9,984; cooling = $659
- Total estimated annual savings = $28,414 per year
- Simple payback: 1.3 years

Fan Speed	MUA S-2 Projected Average	Main Kitchen (E-27)	Main Kitchen (E-30)	Vines (E-25)	Dawson's (E 29, E-26)
30%	0%	0%	0%	0%	0%
40%	0%	0%	0%	0%	0%
50%	13%	68%	89%	13%	74%
60%	34%	0%	1%	1%	1%
70%	25%	0%	1%	3%	0%
80%	19%	0%	0%	6%	0%
90%	8%	0%	0%	19%	0%
100%	1%	31%	8%	57%	24%

Figure 14: Projected operating conditions for the exhaust fan motors and the make-up air handler fan. The average overall speed for all motors was 68%. Note that the 20 HP make-up air fan motor is expected to run at full speed only about 1% of the time. After the Intellihood controls were installed.

Conclusion

Intelli-Hood appears to be a viable, cost-effective technology for larger restaurants, hotels, college cafeterias, and supermarkets. However, significant energy efficiency incentives (rebates) may be needed to help make this technology attractive to smaller restaurants and business owners that tend to gravitate towards very short payback periods--particularly in retrofit applications. Incorporating Intelli-Hood as a factory-installed option when purchasing new hoods will often yield rapid returns since labor costs are minimal.

Intelli-Hood is commercially available and is eligible for SMUD's energy efficiency incentive (rebate) programs. For more information, please contact SMUD's Commercial Contact Center at 1-877-622-SMUD (7683) or send an e-mail to commercial@smud.org

Acknowledgements

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1. Melink Corporation www.melinkcorp.com
2. Michael Dean of CulinAire Systems Inc.: www.culinairesytems.com
3. ADM Associates Inc.
4. Los Rios Community College District
5. Hyatt Regency Hotel Sacramento