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Going the DCV Route

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No one is a stronger proponent of demand-controlled ventilation (DCV) for your commercial kitchen exhaust system than I am. But there are many instances where the retrofit of a DCV system is challenged by the return on investment. This is particularly the case for low-flow proximity-style exhaust hoods, when the cookline includes high-heat producing appliances such as charboilers, when the existing exhaust system is not working as designed or where there are multiple hoods on one exhaust fan. Simply stated, retrofitting DCV is, and will be, challenged by the ROI more so than the DCV technology itself.

Weighing the Costs

Let's discuss the economics of retrofitting a DCV system in a restaurant. It simply costs more to install the system in an existing facility than in a new restaurant. And this cost premium, which can be 100 to 200 percent higher than it would be for new construction, is a tough metric to run through the ROI calculator.

In addition to the premium on-site and late-night labor rates for the installation, there are upgrades to the existing commercial kitchen exhaust system that may not have been anticipated. For example, existing fan motors may not be VFD compatible and need to be (or should be) replaced. In cases where the makeup air is being brought in through outdoor air dampers from the rooftop HVAC units, they may not have electronically activated economizer motors that can be integrated with the DCV unit. So add another premium to the retrofit price as you upgrade the economizers.

Once the system is installed, the CKV-HVAC system should be re-balanced (another cost that is charged back to the DCV retrofit). And while the numerator of the payback equation (i.e., the installed cost) keeps getting larger, the denominator of the payback equation (i.e., the energy cost saving) may remain too small to justify the installation cost. Simply stated, labor and material costs in our economy are high, and our energy cost is still too low to provide the ROI that your CFO would like to see.

Energy Consumption

Even at today's utility rates, the conditioning of the outdoor air that is required to replace the air exhausted from the kitchen, along with the associated fan energy, imposes a significant energy burden—at least 50 percent of the total HVAC load in commercial foodservice facilities. This operating cost has stimulated energy-efficiency concepts such as DCV.

The value proposition for investing in DCV is often based on rule-of-thumb estimates using a dollar/CFM index (i.e., annual energy cost to operate the commercial kitchen exhaust system divided by the average exhaust ventilation rate), typically ranging between $1 and $3 per CFM per year. If the dollar/CFM indicator has been derived from a computer simulation of a similar project in a similar location (e.g., from a LEED project), its application may be appropriate and relatively accurate. However, if the index has been casually selected, the resulting estimate of the system operating cost may overstate the savings.

The magnitude of the energy consumption and cost of a commercial kitchen exhaust system (or the DCV savings) is a function of the actual exhaust ventilation rate, geographic location, operating hours of the system, static pressure and fan efficiencies, makeup air heating set point, makeup air cooling set point and level of dehumidification, efficiency of heating and cooling systems, level of interaction with the kitchen HVAC system, appliances under the hood and associated heat gain to space, and applied utility rates.

Not surprisingly, makeup air heating and cooling loads vary dramatically across the continent. The makeup air-heating load in Minneapolis and Chicago can be a significant cost component, while in San Diego and Miami it may not exist at all. The reciprocal is true for cooling. And the latent energy component in Miami quickly differentiates itself from the desert climates. Location matters: You may be able to justify retrofitting DCV in the Northeast but not in the Southwest. Determining actual energy cost savings is critical to the economic justification of a DCV system for a given project.

Calculating Outdoor Air Load

The need for an easy-to-use tool that would accurately determine the heating and cooling load for a given amount of outdoor (makeup) air led to the development of a no-cost, publicly available software tool referred to generically as the outdoor air load calculator: www.fishnick.com/ventilation/oalc/oac.php.

Since this tool does not model a complete building in detail, the minimal required input parameters are geographic location, outdoor airflow, operating hours, and the heating and cooling set points. With these basic inputs, the outdoor air load calculator is able to calculate monthly and annual heating and cooling loads as well as design loads (the maximum heating and cooling load that occurred during the year).

Through a "details" menu, it is possible to further customize the calculation setup for dehumidification, equipment lockout during parts of the year, and fan characteristics for estimating exhaust and makeup air fan energy consumption. The versatility of the outdoor air load calculator allows simulation of a wide variety of scenarios. But it also puts responsibility on the user. Casual selection of user inputs may result in unrealistic results. This tool was used as the foundation for an ASHRAE paper titled "Estimating the Energy Consumption and Cost of Commercial Kitchen Ventilation Systems" that can be downloaded from:

http://bookstore.ashrae.biz/journal/journal_s_article.php?articleID=325.

Unique Needs

Let's get back to the topic of retrofitting DCV in your facilities. We all recognize that commercial kitchen ventilation systems do not need to be operating at full-speed, all day long. A primary component of all DCV systems is the variable frequency drives on both the exhaust and makeup air fans. Integrated with a sensing system to monitor the heat and/or smoke being produced by the cooking equipment, the DCV system will modulate the exhaust and makeup air fans in concert with the level of appliance use.

I talked with the head engineer for a major QSR chain who felt that the DCV theory is obviously correct—there is absolutely no reason for full-speed exhaust when there is no cooking going on. But execution is another issue. This engineer was concerned that if the appliance "intelligence" was used as an input to the DCV computer, it would need to be wireless. He believed that the cable connecting each appliance to the DCV system would become a "broken link" as appliances were moved in and out for cleaning. He also suggested that simple "time of day" control should not be overlooked, possibly using the building EMS with an integrated override. But that said, this chain has not pursued DCV technology outside of their LEED projects.

Temperature-only DCV

What about temperature-only DCV versus optics/cooking activity combined with temperature DCV? This is an escalating debate within the industry as DCV systems gain more traction. What do I think? First and foremost, I think any DCV system is better than no DCV system (assuming the payback can be justified). I also believe that the potential turn-down (average CFM reduction) for the more sophisticated DCV systems is greater than the temp-only systems. This belief is founded on the fact that the fan speed reduction during no-load (no cooking) periods can be greater for the optics-based DVC systems (e.g., 50 percent versus 20 percent). And if the cookline does not have a high heat producing, nonthermostatic appliance like a charbroiler, this potential may be realized during the off-peak times of the day.

But it is also a fact the temp-only DCV systems are significantly less expensive than the optics/temp-based systems. So, my recommendation to a facility management team is to pilot the different options, monitor the fan power or speed reduction and overall satisfaction with each system, and make your own decision for both new design and facility retrofit.

Variable Frequency Drives

As mentioned, the corner stone of a DCV system is the variable frequency drives that allow the DCV computer to modulate the exhaust and makeup air fan speed in response to appliance usage. A variable frequency drive is essentially an electronic motor starter that replaces the magnetic starter. It also provides speed adjustment necessary if a direct drive fan is to be used in foodservice.

Without a variable frequency drive, usually the speed of a direct drive fan cannot be field adjusted and the ability to balance airflow on a CKV system is virtually impossible. It has been my position for many years that restaurant operations consider using direct drive fans with variable frequency drives regardless of whether they plan to pursue DCV technology.

I talked with a colleague who provides field-engineering support to another major QSR chain. He reported that they have been using direct drive fans and variable frequency drives on new construction for more than five years, and that the direct drive specification was being embraced by the corporate operated stores for fan/motor replacement. No more belt maintenance, no more broken belts, and with the belt slip out of the picture, they achieved up to a 15 percent increase in fan efficiency. Variable frequency drives also facilitate air balancing with the turn of a dial, not the change of a pulley.

When asked about temperature-only systems, my colleague felt that their low-temperature cooking platform made it difficult for the DCV system to differentiate between cooking and non-cooking. When this chain moves toward DCV, he anticipates that communication between the appliances and the DCV system will be the technology path that they follow. He also mentioned the fact that the VFD can be set up to incorporate a high/low setting rather than the infinite adjustment, a potential attribute to simplifying the DCV package.

Simple is Better

Universally, my industry colleagues that I talked to while writing this article expressed the “simple is better” philosophy. The more complicated the controls, the more likely they are to be overridden. I’m preaching to the choir on this one, but the ability for the line cooks to hit the “red” override button can easily become standard practice within the kitchen. And one of my pet peeves relates to the fact that the exhaust hood needs to effectively capture and contain the heat and smoke generated by the cooking equipment when the hood is at its full speed—before installing DCV. Furthermore, education of staff is a key ingredient to successfully retrofitting DCV controls. If they don’t understand the value, and existing hood problems are not fixed, they will quickly learn how to override the system.

The facility management side of the business must take ownership if DCV technology is to be successful deployed. We find during our restaurant field trips that DCV systems are either working just fine or have been decommissioned. And we have also learned that effective commissioning of a DVC system can maximize its performance (which is often a neglected piece of the installation package).

While DCV has been a key measure incorporated within LEED projects in pursuit of maximum energy credits, I believe that demand controlled ventilation will someday become standard practice. But the journey is far from over. Until the industry adopts direct-drive fans with variable frequency drives as an independent value proposition and the cooking equipment develops the “intelligence” to communicate with a DCV computer, the cost of retrofitting DCV will continue to hamper industry-wide adoption of the technology. I look forward to the future.

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