Commercial Kitchen Ventilation

An Energy Efficiency Program Administrator's Guide to Demand Control Ventilation

For more information, contact:
Kim Erickson
Program Manager
Commercial Kitchens Committee
kerickson@cee1.org
617-589-3949
Consortium for Energy Efficiency
98 North Washington Street, Suite 101
Boston, MA 02114

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1 Background

CEE launched the Commercial Kitchens Initiative in 2005 to provide clear and credible definitions in the marketplace as to what constitutes highly efficient energy and water performance in cooking, refrigeration and sanitation equipment and to help streamline the selection of products through a targeted market strategy.

Since 2005, CEE has developed a suite of specifications to identify energy and water efficient commercial kitchen equipment, tracked availability of commercial kitchen efficiency programs, and documented the approaches and impacts of existing programs. CEE members can find more information on the current direction and activities on the CEE web site. Additional resources and specifications have been developed by the ENERGY STAR® program, including specifications and guidance for operators and efficiency program administrators. For additional background information on the CEE Commercial Kitchens Initiative, see the CEE Commercial Kitchens Initiative Description.

2 Purpose

The purpose of this document is to inform program administrators of voluntary energy efficiency programs in the United States and Canada of available information, resources, and tools about demand control ventilation systems in commercial kitchen applications. This document was created by the CEE Commercial Kitchens Committee (the Committee) based on the Committee's working knowledge of commercial kitchen ventilation systems, program experiences to date, and information presented to the Committee by commercial kitchen ventilation system manufacturers (CaptiveAire, Green Energy Hoods, Halton, and Melink).

Unlike CEE equipment performance specifications, which are reviewed and approved by the CEE Board of Directors prior to finalization, this document is purely informational. It does not include or imply CEE Board of Directors policy or CEE recommendations on program design, strategies, or delivery approaches.

Where appropriate, the Committee includes references to publicly available information and test results from several sources including the Pacific Gas and Electric Company Food Service Technology Center, Southern California Edison, and the American Society of Heating, Refrigeration, and Air-Conditioning Engineers. The Committee does not endorse any particular tool that is referred to or referenced in the document. It merely seeks to identify those resources that are known and available.

This document was reviewed by engineering staff from several major commercial kitchen ventilation system manufacturers, including Avtec (Unified Brands), Green Energy Hoods, Greenheck, Halton, Melink, and Spring Air Systems, as well as by members of the American Society for Testing and Materials (ASTM) F26.07 Subcommittee on Commercial Kitchen Ventilation.

This document will be updated as desired by the Committee with consideration given to program advancements, performance metric and test procedure development, and the availability of additional product energy performance test and field monitoring data.

3 Definitions & Acronyms

This section includes a list of working definitions and acronyms used throughout this document.

British thermal unit (Btu): a unit of heat equal to the amount of heat required to raise one pound of water one degree Fahrenheit at one atmosphere pressure; equivalent to 251.997 calories

Commercial kitchen ventilation system (CKV system): hoods, fans, make-up air units, and other accessories that comprise the system for ventilating a kitchen

Cubic feet per minute (CFM): a volume flow rate, equal to a uniform flow of one cubic foot in one minute

Demand control ventilation system (DCV system): a control system that varies the amount of airflow a kitchen ventilation system exhausts and makes up based on the cooking load

Horsepower (HP): the unit of power equal to 550 foot-pounds per second, and approximately 745.7 watts

Make-up air (MUA): outside air brought into a building to replace exhausted air

Variable frequency drive (VFD): a system for controlling the rotational speed of an alternating current (AC) electric motor by controlling the frequency of the electrical power supplied to the motor

4 Document Overview

Heating, ventilation, and air conditioning (HVAC) account for 29% of energy consumption in food service facilities, or approximately 75,000 Btu/sq. ft. By way of comparison, this level of energy consumption is the same amount of energy that retail facilities consume on a per square foot basis for all energy end uses combined.[1] Up to 75% of this load can be directly attributed to the operation of the commercial kitchen ventilation (CKV) system, which often makes the CKV system the largest energy consuming system in a commercial food service facility.[2]

CKV systems are an integral part of food service operations; they are responsible for exhausting smoke, flue gases, byproducts of cooking, and heat related to both cooking

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[1] Department of Energy Commercial Building Energy Consumption Survey, 2003.

[2] EPRI, *The Role of Commercial Kitchen Ventilation in Foodservice Operations*, 1994.

and sanitation processes. CKV systems contribute to ventilation energy consumption through the operation of fan motors required to operate the exhaust and make-up air (MUA) systems. They contribute to heating and air conditioning energy consumption when MUA is tempered (heated or cooled) before reintroducing the air into the building, through either the building HVAC system or dedicated MUA units.

Energy consumption related to CKV systems can be significantly reduced when the exhaust rate of the CKV system is reduced. Reducing the exhaust rate means that exhaust and MUA fans work less and, if MUA is tempered, that heating and cooling loads are lower. Reductions in CKV system exhaust rate can be accomplished in a number of ways, including the following:

- Reducing peak exhaust rates by engineering hoods based on the exhaust rate for the specific cooking application, hood type and features, and make-up air system (versus applying rule of thumb exhaust rates)
- Reducing nonpeak exhaust rates through the addition of a demand control ventilation (DCV) system, an optional element for CKV systems that automatically adjusts the exhaust rate based on CKV needs.

This document provides information relevant to energy efficiency program administrators who are considering program offerings that would support the addition of DCV systems to CKV systems. The Committee chose to develop resources related to DCV due to a number of factors, including (1) the relative simplicity of DCV technology compared to the complexity of CKV systems as a whole, (2) the availability of field and modeled data demonstrating significant energy savings potential, (3) the applicability of DCV to both new construction and retrofit applications, and (4) the proliferation of DCV energy efficiency programs and pilot programs in recent years.

During its investigation of DCV for CKV systems, the Committee also reviewed the potential for a binational program template (a consensus based performance specification) for DCV systems that would meet the collective needs of U.S. and Canadian energy efficiency program administrators. The Committee found that there is currently insufficient field or laboratory test data to establish the technical basis to support a specification approach at this time. In the absence of sufficient data to develop a binational program approach, the Committee developed this guide to aid program administrators in understanding the DCV savings opportunity in CKV should local conditions be favorable for program development.

This document covers the following topics for commercial kitchen DCV systems:

- Equipment Description
- Product Use and Lifetimes
- Energy Performance Specifications, Test Methods, and Case Studies
- Market Characterization
- Price Differential

- Nonprice Barriers
- Energy Savings
- Additional Program Considerations
- Additional Resources

5 Equipment Description

CKV systems are intended to exhaust smoke, flue gasses, and heat from food service operations. CKV systems include hoods, system controls, ductwork, exhaust fan motors, drives, grease filters, and make-up air (MUA) systems. Traditional CKV systems use a simple on/off fan motor control, which results in the system operating at full power and maximum exhaust rate whenever it is on, regardless of the amount of heat, smoke, and flue gases generated at any one time. DCV systems can be added to CKV systems to enable the exhaust rate (and corresponding energy consumption) to modulate and match the needs of kitchen operations, which results in energy savings. Systems can be controlled based on the time of day, appliance energy usage, feedback from cooking appliance(s), exhaust temperature, smoke or steam produced by cooking processes, or combinations of these factors.[3]

DCV systems typically include sensors, a processor, variable frequency drive(s) (VFDs) or variable electronically commutating motors, and a user interface. Additional components to keep sensors clean may also be included to help extend the operational life of the equipment and reduce maintenance costs. Detailed drawings of CKV and DCV systems can be found in *Demand Control Ventilation for Commercial Kitchen Hoods*, by Southern California Edison.

DCV systems can provide several benefits in commerical kitchens, including energy savings, noise reduction, increased occupant comfort, and reduced wear on HVAC equipment. Energy savings potential and the variables on which energy savings depend are addressed in detail in Section 11 (Energy Savings) of this document. Noise reduction is achieved through the lower exhaust rates that result from implementing DCV systems.[4] For example, when hood exhaust fans run at 80% speed, the air noise generated at the grease filters decreases by approximately 50%; when the fans run at 50% speed, air noise is virtually eliminated. The quieter kitchen environment may increase occupant comfort. The addition of DCV systems can also reduce wear on HVAC equipment as soft starting hood fans with VFDs extend belt life and as reduced

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[3] Don Fisher, *Field Studies in Demand Ventilation Control (DVC)*, ASHRAE Seminar 25, Long Beach, CA, June 25, 2007.

[4] Fan power and sound pressure level are exponentially proportional to the cube of fan speed and airflow. Fan Law 3: (W1/W2) = (D1/D2)5 (N1/N2)3 (ρ1/ρ2) where W=Power, D=Fan Size, N=Rotational Speed, and ρ=Gas Density.

outside air load on the kitchen air conditioning units reduces compressor run time, thereby extending the life of air conditioning units, as well.[5]

There are three main DCV system types available today:

1. Temperature sensors only. These systems ramp ventilation up and down based solely on the temperature from the cooking activity as measured in the ductwork or capture tank of the hood.
2. Temperature and optical sensors. These systems offer the same functionality as systems with only temperature sensors plus the ability to change the ventilation rate based on the presence of smoke or steam.
3. Temperature and infrared cooking sensors. These systems offer the same functionality as systems with only temperature sensors plus the ability to measure temperature at the cooking surface to ramp ventilation up and down based on when cooking starts.

Sufficient research has yet to be conducted to compare the different types of DCV systems on the market in terms of energy performance and responsiveness or to determine performance metrics for these dimensions. Industry experts generally acknowledge that the systems that incorporate additional optics and infrared sensors have the potential to be more responsive to cooking activity, thereby permitting increased reductions in exhaust rate during periods of light or no cooking.[6] On the other hand, systems with additional sensors may require more maintenance than those that operate based solely on temperature sensors. Some manufacturers also strategically place temperature sensors in locations that aim to improve response time and energy performance; there are no publicly available studies substantiating claims to this effect, however.

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[5] Wisconsin Focus on Energy, *Kitchen Exhaust Hoods Variable Volume Control Fact Sheet*, 2006.

[6] Manufacturer and industry expert interviews, March 2010.

6 Product Use and Lifetimes

CKV and DCV systems are generally in use throughout the operating hours of a facility.[7] Operating hours and days can vary by market segment. Table 1 includes mean operating hours data by market segment.

Market Segment	Mean Operating Hours per Week
Education*	50
Food Sales	107
Food Service	86
Health Care	168
Lodging	167

Table 1. Operating Hours by Market Segment[8]

*Educational institutions include both K-12 and higher education facilities. K-12 institutions typically have a lower mean operating hours per week; higher education facilities typically see higher mean operating hours per week.[9]

According to industry experts, the lifetime for CKV systems is typically about 20 years, though this can vary based on market segment.[10] DCV technology has been available less than 20 years. Industry experts estimate the minimum life expectancy for DCV systems to be 10-15 years based on the life expectancy of other control systems. Manufacturer warranties for DCV systems are typically for 1-3 years. Industry experts estimate the life expectancy for VFDs to be about 20 years (approximately 100,000 hours mean time between failure), though this can also vary by manufacturer and is important to verify when selecting a VFD.

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[7] Fisher, Don. (June 2003). Predicting Energy Consumption. ASHRAE Journal, K8.

[8] Department of Energy Commercial Building Energy Consumption Survey, 2003.

[9] Manufacturer and industry expert interviews, March 2010.

[10] Manufacturer and industry expert interviews, March 2010. For example, some chains may have a shorter schedule for restaurant refresh whereas some institutions may plan for significantly longer periods between kitchen renovations.

7 Energy Performance Specifications, Test Methods, and Case Studies

There are currently no test methods in the United States or Canada to test or compare the relative energy performance of DCV systems in a laboratory setting. There are also currently no broadly supported energy performance specifications for DCV systems in the United States or Canada.

There are several case studies quantifying fan energy savings resulting from the installation of DCV systems in specific applications. These include a case study on a hotel and another on a supermarket produced by the Food Service Technology Center (FSTC) and three hotels and three quick service restaurants produced by Southern California Edison. There is also a PIER report available for a university campus facility.

The Committee encourages manufacturers of the systems for which case studies are not currently available to work with local efficiency programs and develop case studies for their systems. The Committee will update this section with additional links to publicly available case studies as appropriate.

8 Market Characterization

It is estimated that there are over 1,000,000 CKV systems installed across the United States[11] exhausting about three billion cubic feet per minute (cfm) of air.[12] Industry experts estimate that less than 1% of these systems have DCV systems installed.[13] Between approximately 89,000 and 125,000 CKV systems are sold each year,[14] and industry experts estimate that between 0.5% to 10% of new systems are purchased with DCV systems.[15] Industry experts also estimate that less than 0.5% to 1% of existing CKV systems are retrofitted with DCV systems each year. One manufacturer estimates that approximately 700 systems are retrofitted each year, with the majority of projects taking place in universities, hotels, and supermarkets.

CKV systems are typically sold through kitchen equipment dealers and distributors and directly by local fabrication shops. DCV systems for new CKV systems are typically sold with the CKV system, through the hood manufacturers and equipment dealers. Retrofit DCV systems are typically marketed directly by the manufacturer to the customer. Manufacturers often partner with local installers for installation services, though it is not common for local installers to sell DCV systems at this time.

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[11] ENERGY STAR Market and Industry Research Report, 2002.

[12] EPRI, *The Role of Commercial Kitchen Ventilation in Foodservice Operations*, 1994.

[13] Don Fisher, FSTC, March 2010.

[14] NAFEM 2006 and 2008 Size and Shape of the Industry Reports.

[15] Manufacturer interviews, March 2010.

As of August 2010, there were seven manufacturers promoting seven DCV systems in the U.S. market: Accurex, CaptiveAire, Green Energy Hoods, Greenheck, Halton, Melink, and Spring Air. Two additional suppliers market systems in Canada: Aerco Industries Ltd and Noveo. Building owners with direct digital control systems can also purchase and install components that integrate into their existing control system, creating a custom DCV system.

The key difference between the DCV systems offered by different manufacturers is the quantity, type, and placement of sensors. DCV systems manufactured by Green Energy Hoods, Melink, and Noveo include optical sensors (for smoke detection) and temperature sensors. The Halton system includes infrared sensors and temperature sensors. Greenheck and Accurex promote two systems, one with temperature sensors and one with both temperature and optic sensors based on application. Aeroc Industries, CaptiveAire, and Spring Air systems include only temperature sensors.

9 Price Differential

DCV systems vary in price depending on the complexity of the job, including factors such as number of hoods, MUA system, and whether or not VFDs are in place. Every installation must be custom designed and installed to operate with the unique configuration of the kitchen equipment and HVAC system. New installations are typically less expensive than retrofits, as kitchen and HVAC configuration can be designed up front for DCV. Systems with dedicated MUA units are typically less expensive than those without dedicated MUA units due to the added complexity of interfacing with the building HVAC system. Systems without VFDs in place are typically more expensive than those that already have VFDs.[16]

The cost of the DCV systems in the existing case studies ranged from $8,000 for a new installation with two hoods to $28,000 for a retrofit installation with six hoods. Three manufacturers state that systems can cost as little as $2,000 for basic installation of a system with temperature only sensors on a ten foot hood. Another manufacturer stated that for an installation on an average hood with a single IR beam in need of VFDs, the retrofit cost is generally around $7,500-$10,000.[17] Purchasing components to integrate into an existing direct digital control system can often reduce system costs compared to stand alone DCV systems provided by specialized manufacturers.[18]

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[16] According to 2008 RS Means data, small VFDs typically cost about $1000 per HP (installed cost).

[17] Manufacturer presentations, 2009.

[18] Building owners taking this approach should be very familiar with the safety regulations and standards for commercial kitchen hood operation.

The payback period for installation of a DCV system typically ranges from six months to five years.[19] Manufacturers of systems with temperature sensors only generally claim shorter payback periods than manufacturers of systems with additional sensor types. Manufacturers of systems with additional sensor types generally claim higher annual and lifetime energy savings, however. Payback calculations can vary based on whether both fan energy and HVAC savings are taken into account or whether solely fan energy savings are taken into account.

It is important to note that in some cases, there may be additional costs to upgrade existing equipment. For example, for retrofit applications without a dedicated MUA unit, there may be additional costs for integrating the system with the building HVAC system or, if MUA was not accounted for at all, for adding a MUA system that will properly balance the building. Adding a MUA system to an existing CKV system can have significant costs and challenges associated with it. For systems with multiple hoods connected to one fan, balancing dampers may also be added to enhance the savings; while the payback time for the system may go down in this case, the upfront cost will go up.

10 Nonprice Barriers

While price can be a barrier to adding DCV systems, there may be additional barriers to the uptake of DCV. Based on the experiences of energy efficiency program administrators, the distribution chain for DCV systems may not be well developed in some areas. Similarly, it may be difficult to find experienced installers in some areas.

11 Energy Savings

Heating, ventilation, and air conditioning (HVAC) account for 29% of energy consumption in food service facilities.[20] Up to 75% of this load can be directly attributed to the operation of the commercial kitchen ventilation (CKV) system, making the CKV system often the largest energy consuming component in a commercial food service facility.[21] CKV systems contribute to ventilation energy consumption through the operation of fan motors required to operate the exhaust and make-up air (MUA) systems. They contribute to heating and air conditioning energy consumption when MUA is tempered (heated or cooled) before introducing the air into the building, through either the building HVAC system or dedicated MUA units.

DCV systems deliver energy savings by reducing the exhaust rate of the CKV system when the full exhaust rate is not needed (based on cooking operations). Reducing the

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[19] Manufacturer presentations, 2009.

[20] Department of Energy Commercial Building Energy Consumption Survey, 2003.

[21] EPRI, *The Role of Commercial Kitchen Ventilation in Foodservice Operations*, 1994.

exhaust rate results in exhaust and MUA fans working less and a reduction in the amount of MUA needed to balance the building.

11.1 Fan Energy Savings

Case studies conducted to date document fan energy savings of 37-74% from installation of Melink DCV systems on CKV systems which, prior to installation of the DCV system, were operated using manual on/off controls.[22] Case studies on DCV systems manufactured by other manufacturers have not yet been published.[23]

The potential energy savings for a specific application depend on a number of factors, which program administrators can consider as they seek applications with higher savings potential. These factors include the following[24]:

- Type of hoods controlled: Because hoods listed by Underwriters Laboratories (UL) can be engineered and approved to operate at lower exhaust rates than unlisted hoods, applications with unlisted hoods may have higher energy savings potential than applications with listed hoods.[25, 26]
- Number of hoods controlled: Because a larger number of hoods typically indicates higher exhaust rates, applications with larger numbers of hoods may have higher energy savings potential than applications with smaller numbers of hoods.
- Amount of horsepower (HP) controlled: Because higher amounts of CKV system horsepower typically indicate higher exhaust rates, applications with larger

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[22] Southern California Edison, *Demand Control Ventilation for Commercial Kitchen Hoods*; Food Service Technology Center, Report 5011.04.17 (Intercontinental Mark Hopkins Hotel); Food Service Technology Center, Report 5011.06.13 (Supermarket Case Study); Don Fisher, Food Service Technology Center, *Field Studies in Demand Control Ventilation*, San Ramon, CA, April 24, 2008.

[23] There are additional studies under way for additional DCV systems. This document will be updated periodically to take into account new data and findings.

[24] Southern California Edison, *Demand Control Ventilation for Commercial Kitchen Hoods*.

[25] Because UL listed hoods can be engineered and approved to operate at lower exhaust rates than unlisted hoods, which must meet the minimum exhaust flow rates required per the International Mechanical Code, the use of engineered hoods is another energy efficiency opportunity. The savings opportunity represented by engineered hoods is outside the scope of this document. The Committee plans to investigate additional savings approaches, including the use of engineered hoods, in the future. The Food Service Technology Center has conducted extensive testing on several engineered hoods.

[26] Energy efficiency programs promoting DCV for new CKV applications may want to consider the relative benefits of promoting DCV and engineered hoods. Both approaches aim to reduce the exhaust rate of the system, however, where DCV aims to reduce the exhaust rate during non-peak periods, engineered hoods aim to reduce the peak exhaust rate.

amounts of CKV system HP may have higher energy savings potential than applications with smaller amounts of CKV system HP.

- Hours of CKV system operation: Because longer hours of CKV system operation typically indicate higher daily or annual exhaust rates, applications with longer hours of operation may have higher energy savings potential than applications with shorter hours of operation.
- Appliance types: Because heavier duty appliances radiate large amounts of heat even in idle conditions, limiting the ability to reduce exhaust rates, applications with lighter duty appliances under the hood may have higher energy savings potential than applications with heavier duty appliances under the hood.
- Cooking process: Because batch cooking processes typically result in more idle time in a given day than made-to-order cooking processes, applications using batch cooking processes may have higher energy savings potential than applications using made-to-order cooking processes.
- Make-up air (MUA) system: Because it is easier to match dedicated MUA units with exhaust modulations than with building HVAC systems, which may require consideration of additional factors (such as how much outdoor air intake can be reduced to maintain health and comfort requirements), facilities with dedicated MUA units may have higher savings potential than facilities relying on the building HVAC system for MUA.
- Presence of dampers on CKV systems with multiple hoods connected to a single exhaust fan: Because balancing dampers individually optimize flow rates for each hood on CKV systems with multiple hoods connected to a single exhaust fan, applications with multiple hoods connected to a single exhaust fan with dampers may have higher energy savings potential than multiple hood applications connected to a single exhaust fan without dampers.
- Use of multiple exhaust fans on CKV systems with multiple hoods: Because using multiple exhaust fans on CKV systems with multiple hoods optimizes flow rates for individual hoods (or for a smaller number of hoods, in cases where a single exhaust fan is still connected to more than one hood), multiple hood applications connected to multiple exhaust fans may have higher energy savings potential than multiple hood applications connected to a single exhaust fan.

11.2 HVAC Energy Savings

Energy savings from reducing the need for tempered make-up air (e.g., HVAC savings) can be significant, depending on the climate zone and MUA system in place. Indeed, in some cases, modeled scenarios show that HVAC savings can far outweigh electric fan energy savings.[27] There are no publicly available field data available to substantiate these savings at this time, however.

There are a few resources available that may be used to estimate HVAC related energy savings. The Committee does not endorse any particular tool referenced in this document at this time. The Outdoor Air Load Calculator hosted by the Food Service Technology Center may be used to model local HVAC savings based upon a host of assumptions.[28] Many manufacturers have also developed tools to model both fan energy and HVAC savings.

Factors that impact the potential HVAC energy savings for specific applications include all of those that impact fan energy savings. Additional factors impacting HVAC energy savings specifically include the following:

- Climate zones: Because MUA is often tempered in climate zones with significant heating or cooling needs, applications in less temperate climates may have higher HVAC energy savings potential than applications in more temperate climates.
- MUA system: Because dedicated MUA units often deliver either untempered MUA or MUA that is tempered only in the winter to temperatures lower than the building HVAC set points, applications relying on the building HVAC system for MUA may have higher savings potential than applications with dedicated MUA units.
- Whether or not the kitchen is air conditioned: Because tempered MUA requires energy to heat or cool the air, applications with tempered MUA may have higher HVAC savings potential than applications with untempered MUA.
- Cooling system efficiency: Because MUA may be cooled to maintain minimum comfort requirements, applications with lower cooling system efficiency may have

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[27] Fisher, Don. (June 2003). Predicting Energy Consumption. ASHRAE Journal.

[28] Documentation for the Outdoor Air Load Calculator can be found at http://www.energy.ca.gov/reports/2002-01-10_600-00-029.PDF. The design and monthly heating and cooling loads are based on loading equations in ASHRAE's 1997 to 2009 *Handbook of Fundamentals* Chapter on Nonresidential Cooling and Heating Load Calculations. The US weather files were created from Typical Meteorological Year 2 (TMY2) data files, provided by the National Renewable Energy Laboratory (NREL). The Canadian weather files were based on Weather Year for Energy Calculations (WYEC) data. Both data sets were converted to four-hour bin format as described in the documentation. The following variables in the modeling tool are user-customizable: set points, dehumidification, reheat, lockout months, hours of operation, flow rates, and fan and motor efficiencies. The program does not calculate the energy input to the heating and cooling equipment, only the loading on the equipment, so while additional calculations can be done to convert the outside air loads to the required energy inputs, heating and cooling system efficiencies need to be defined for these calculations.

higher HVAC savings potential than applications with higher cooling system efficiency.

- Heating system efficiency: Because MUA may be heated to maintain minimum comfort requirements, applications with lower heating system efficiency may have higher HVAC savings potential than applications with higher heating system efficiency.

12 Additional Program Considerations

12.1 System Efficiency Considerations

DCV is one piece of a CKV system. There are many other energy savings measures that can be taken to improve the efficiency of the system as a whole, and DCV may not always be the best approach to improving system level efficiency for a given application. The FSTC has conducted testing on a number of these measures to quantify the savings of individual and combined measures.

12.2 Target Market Considerations

There are no data at this time indicating a preferred target market segment (restaurants, schools, institutions, etc.) for DCV systems based on energy savings potential. Indeed, it is not uncommon to find significant differences among facilities within any given market segment impacting the energy savings potential of DCV in CKV systems. For example, two restaurants with similar food concepts and operating hours may have significantly different energy savings potential based on cooking approach (batch versus made-to-order). Two universities with similar food service operations may have different MUA strategies impacting energy savings potential, with one university relying on the tempered air from the building HVAC system for MUA and the other relying on dedicated MUA units providing untempered air.

At the same time, many DCV manufacturers target institutions over restaurants. Yet this tends to be related to the acceptability of longer payback timelines in these segments rather than any significant homogeneity across the factors that impact energy savings potential of DCV in CKV systems.

13 Additional Resources

- The FSTC has compiled the most comprehensive collection of publicly available CKV information, including design guides and ASHRAE, Foodservice Consultants Society International (FCSI), University of Minnesota, and PIER studies and reports. The FSTC also hosts an Outdoor Air Load Calculator, which can help to estimate heating and cooling loads and savings potential based on location.

- Wisconsin Focus on Energy and Union Gas have developed marketing materials to promote DCV systems to customers.

- The CEE Commercial Kitchens Program Summary includes a list of CEE members offering DCV programs for CKV systems.