Energy Management Systems (EMS) and Demand-controlled Kitchen Ventilation (DCKV) Energy Savings in Restaurants

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Project Managers: **Jeff Beresini**
Charlene Spoor
Pacific Gas and Electric Company

Prepared By: **Adam Cornelius**
Don Fisher
Elan Frantz
Angelo Karas
Fisher-Nickel, Inc.
12949 Alcosta Blvd., Suite 101
San Ramon, CA 94583

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ABBREVIATIONS AND ACRONYMS

AHRI	Air-Conditioning, Heating, and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
BAS	Building Automation System
CFM	Cubic Feet per Minute
DCKV	Demand-Controlled Kitchen Ventilation
DR	Demand Response
EEMS	Franke Expandable Energy Management System
EIS	Energy Information System
EMS	Energy Management System
ECM	Electronically-controlled Motor
ET	Emerging Technologies
ETCC	Emerging Technologies Coordinating Council
FNI	Fisher-Nickel, Inc.
FSTC	Food Service Technology Center
HAACP	Hazardous Analysis and Critical Control Points
HVAC	Heating, Ventilating, and Air Conditioning
IR	Infrared
kW	Kilowatt
kWh	Kilowatt-hour
MAU	Makeup Air Units
NAFEM	North American Association of Foodservice Equipment Manufacturers
PG&E	Pacific Gas and Electric Company
POS	Point of Sale
QSR	Quick-service restaurant
RTU	Roof Top Unit
SaaS	Software as a Service
TOU	Time Of Use
VFD	Variable Frequency Drive

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EXECUTIVE SUMMARY

An energy management system (EMS) is a computerized platform which allows operators to control and monitor energy-using equipment within a building. EMSs typically control a building's lighting and HVAC systems (excluding kitchen exhaust hoods). For commercial foodservice establishments, this scope of EMS may be extended to include refrigeration, cooking appliances, sanitation equipment, ice machines, hot water systems, and kitchen ventilation systems. Typical EMSs offer basic scheduling and alarm features that may reduce unnecessary energy expenditures and identify equipment malfunctions. Select EMS providers offer advanced energy-saving features as well as peak demand management and load-shifting measures.

EMS technologies have previously been vetted for energy savings in large office buildings. However, they have not been scrutinized for the energy saving and load shifting potentials in foodservice operations for the PG&E territory. The scope of this study was limited to the HVAC component of EMS systems for commercial foodservice establishments, examining the benefits and barriers to EMS systems that have been integrated with demand-controlled kitchen ventilation (DCKV) systems.

PROJECT DESCRIPTION

This study provided an assessment of the EMS market to determine the market's scope, the vendors that cater to the market, and the capabilities of the systems that are being offered. It also included a scaled field placement that demonstrated the efficacy of EMSs that were installed in conjunction with demand-controlled kitchen ventilation DCKV system for foodservice operations.

PROJECT GOAL

The overall goal was to examine the energy-saving capabilities of EMS in the context of foodservice operations. This goal was met through a two-pronged effort. The first phase was a market assessment and directory of EMS vendors including detailed specifications for the systems being applied to foodservice and restaurants. The second phase comprised a scaled field placement of EMS integrated with DCKV in three different restaurants.

PROJECT FINDINGS/RESULTS

The results of the market assessment portion of this study show that there is a wide diversity among products and features offered by EMS vendors. The core hardware capabilities of all systems observed were comparable; however, the individual software-driven features offered between products varied significantly. While a majority of systems focus on control and monitoring of HVAC and lighting, select providers offer additional areas of focus including DCKV integration, smart defrost, and other advanced energy saving features. EMS products were found not to be "out-of-the-box" solutions for foodservice and require extensive installation and commissioning at each site.

Previous FSTC research has shown that DCKV provides appreciable energy savings by reducing kitchen exhaust speeds when air extraction is not necessary. The results of this study confirmed previous findings based on the three test sites where an EMS has been integrated with the DCKV system. This assessment was conducted by comparing PG&E My Energy data and HVAC energy for the baseline and EMS-DCKV cases at each site.

In order to identify the specific energy savings attributable to the EMS-DCKV integration, granular data was analyzed from the DCKV as well as the rooftop unit (RTU). Exhaust fan motor savings were attributed to the DCKV systems were determined to be approximately 50%,. Correlated RTU electricity savings were also identified, although these savings were not as significant as the direct fan motor energy

savings found with DCKV. The combined energy savings as a percent of the overall restaurant energy use was found to averaged 2% for the test period examined.

The results of this study showed that energy savings of the EMS depend greatly upon the pre-existing equipment conditions, scheduling, and commissioning. Based on the field site analyses, market research, and surveys conducted in this study, EMS was found to be a viable tool for equipment maintenance and diagnostics. However, it was limited in respect to energy saving and load-shifting capabilities, at least within the context of the three sites chosen for this study. Energy and cost savings were only present for one of the three sites based on the PG&E My Energy data. The limited billing-level results may be partially attributed to the variable customer traffic, changing weather conditions, and other factors. Peak demand was successfully reduced at one of the three sites; however, this was not consistent throughout all of the test locations.

PROJECT RECOMMENDATIONS

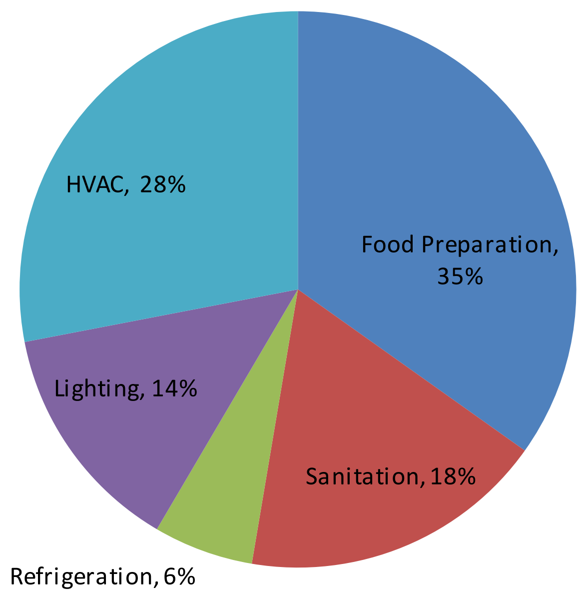
The benefits of EMS systems will vary significantly based on installation and commissioning, implementation of data-inspired corrective actions, and advanced energy-saving logic. While EMS products are often marketed as energy-saving tools, industry interviews indicate that such systems are effectively used for maintenance, diagnostics, and continuous commissioning. The largest opportunities for EMS systems to increase energy savings in the future are to integrate existing foodservice-specific energy-saving strategies into a single EMS package. In addition, anomaly detection, rather than simple alerts, will help to predict equipment failure or performance degradation in advance.

While this scaled installation of EMS integrated with DCKV was considered successful, the challenges in deploying the field placement and then holding to the project schedule were significant. Furthermore, meter-level energy savings were not quantified to the degree that can directly support a deemed rebate or energy efficiency program at this time. Continued assessment of EMS technologies combined with foodservice-specific measures by the California utilities is recommended.

Independent of the field results, the authors believe that EMS products have the inherent capability of achieving energy savings and load shifting that would otherwise be unattainable. Multiple energy-saving EMS strategies were examined and vetted in the study; however, it was clear that the efficacy of these systems is hinged upon commissioning, equipment maintenance, and programming (these can be changed). The requirements to establish a highly productive EMS are specific to the project site as well as the EMS product. Unfortunately, the results of this field study along with the high variability within the product category do not translate immediately to a California utility energy efficiency program.

INTRODUCTION

Energy is a major expense for foodservice operations. As prices of energy increase and focus continues to be put on mitigating peak energy demand, restaurants have significant opportunity to embrace energy-saving and load shifting measures. Some of the large energy loads include food preparation, HVAC, sanitation, and lighting, as shown in Figure 1.



Source: FSTC

FIGURE 1. ENERGY CONSUMPTION BY END USE IN RESTAURANTS

Efforts to save energy in the foodservice industry have been focused on improving the efficiency of energy-using equipment and enacting behavioral and managerial changes. With the introduction of foodservice rebates and ENERGY STAR™ recognition, the efficiency of cooking equipment has steadily increased. Auxiliary equipment, including water heaters and HVAC equipment, have also seen technological efficiency gains due to design improvements. Examples of this include smart defrost cycles for walk-in freezers and demand control ventilation for kitchen exhaust systems. In addition to improving technologies, restaurants often look towards management techniques to minimize energy use. Creating strict schedules for lighting, HVAC settings, and cooking equipment can be very effective in minimizing energy costs.

While energy-efficient equipment becomes increasingly available and affordable to foodservice operators, persisting issues with commissioning, equipment maintenance, and scheduling stymie potential energy savings. Energy management systems (EMS) have been introduced as both an energy-saving platform as well as a means for maintenance oversight and continuous commissioning. While EMS has been vetted in the foodservice industry with mixed results, this study examined the current market status of EMS products as well as the energy-saving efficacies of available EMS technologies.

This study is divided into two segments: A market assessment of EMS products and services available for commercial foodservice establishments and a field study of the three sites where an integrated EMS-DCKV system was installed and evaluated. The specific methodology and results for each are detailed in the respective sections of this report.

BACKGROUND

An EMS is a computerized platform which allows operators to control and monitor energy-using equipment. The premise of this system is to reduce the unnecessary energy expenditures of equipment through scheduling, monitoring, and advanced controls. In addition, EMS is also used for oversight of equipment maintenance as well as automation of responsibilities which are typically delegated to shift managers. While EMS has become standard practice for larger office buildings, the penetration of such systems in the foodservice sector has been minimal.

The current EMS technologies applied to foodservice are similar to those traditionally used for large office buildings. These proceeding systems historically used for larger buildings are commonly known as Building Automation Systems (BAS). These systems typically monitor and control the lighting and HVAC systems, but may also extend to include security and fire systems. For BAS, there are three primary energy-saving strategies: demand control ventilation (of general spaces), advanced thermostatic control, and lighting scheduling.

EMS has had limited penetration in the foodservice sector, largely due to the diverse equipment inventory and installed system cost. While some chain restaurants have developed specifications for EMS, the vast majority of restaurants do not have EMSs. Other sites have had EMS systems installed which are no longer operational for reasons that may include:

- EMS vendors and support services often go out of business.
- The EMS call-in center service has been discontinued by the facility because of cost.
- EMS requires personnel who can be dedicated to managing the EMS.
- EMS programming has been overridden by managers or operators.
- High staff turnover causes loss of institutional memory.
- No culture of continuous commissioning or improper initial commissioning.

A recently issued BBA document, *Energy Management Systems (EMS) for Food Service Applications: Introduction to EMS and guidance document on project planning & implementation*, provides in-depth information for how to approach purchasing and testing an EMS system. Unfortunately, the industry-wide adoption of EMS has been minimal. Quick-service chain restaurants (QSRs) have been the largest demographic to test these products. However, a wide range of outcomes have left the industry split on whether EMS is ultimately valuable. While there is a range of claimed energy savings by EMS vendors, a third party has not conducted a study (at least published within the public domain) to investigate the actual savings potential in commercial foodservice.

Of relevance is the fact the energy management systems (EMSs) for small commercial buildings have been in existence for at least 30 years, while demand-controlled kitchen ventilation (DCKV) systems were conceived more than 15 years ago. Both systems share a common challenge; installed cost, unconfirmed energy savings, and the asociated impact on the ROI. Both EMS and DCKV systems individually exhibit installed costs that typically range from $10,000 to $30,000 depending on the size of the restaurant and the complexity of the system configuration. This economic barrier, along with the uncertainty with respect to actual energy savings, has kept these systems from becoming standard practice in restaurant design. While many chain restaurants have installed these systems as pilot project or as attributes within a LEED design, the FSTC has not identified any restaurants where both EMS and DCKV had been installed—either as stand-alone or integrated systems. Ironically, both EMS and DCKV derive energy savings from the HVAC piece of the energy pie.

The goal of this study was not only to explore the energy-saving potential of EMS, but also to characterize the operational and financial benefits of EMS. The field demonstration portion of this study focused on EMSs that are integrated with DCKV systems. Preceeding projects have investigated the EMS market space, as well as EMS best practices. This study focused on the energy-saving and load-shifting efficacies of EMS along with the added value of DCKV.

OBJECTIVES

The primary objective of the market assessment was to determine the current state of EMS technologies currently offered on the market. In addition, customer experience with EMS was captured through end-user surveys from the foodservice sites. The objective of the field study was to determine the efficacy of EMS integrated with DCKV through the collection of pre-EMS/DCKV data, and the analysis of post-EMS/DCKV installation and commissioning. The energy savings realized by this integration, at the building-level or as a result of any individual equipment managed under EMS, which could accelerate market adoption of EMS and DCKV (and, where applicable, integrated EMS and DCKV) would contribute to the ultimate goal of realizing statewide energy savings in the commercial foodservice sector.

MARKET ASSESSMENT

MARKET ASSESSMENT METHODOLOGY

Secondary market research, manufacturer interviews, and surveys were utilized to develop a project-specific database. Each product in this study was assessed for functionality, available services, and interoperability. The primary areas of assesment include the function and integration of the following capabilities:

- Hardware
- Services
- HVAC
- Kitchen exhaust
- Cooking appliances
- Hot water systems
- Refrigeration
- Ice machines
- Equipment interoperability and communication

Granular data was collected primarily through a product survey which was compiled by FSTC researchers. A sample of this survey is available in Appendix 1. In this survey, EMS vendors were asked multiple-choice questions to detail the above aspects of the product with areas provided for additional comments. The complete survey responses are available in Appendix 2.

Throughout the market research process, challenges were encountered both with connecting with EMS vendors and capturing the exact features offered with each product. Each vendor on the aggregated list was contacted both through email and by phone. The response rate for the survey was approximately 25%. An additional obstacle was differentiating the features that products *could* offer with the features that products *do* offer. It is common for EMS providers to add additional features as requested by the customer, making it difficult to characterize all features that a product offers. The strict definition of EMS as a product that can both control and monitor was relaxed for this study to include Energy Information Systems (EIS) as well as BAS's. EISs are commonly used to monitor energy and water use and display the data using a graphical user interface. Such systems only monitor activity and are not capable of controlling the building systems.

MARKET ASSESSMENT RESULTS

The three primary categories for product features are categorized as hardware solutions, software solutions, and consulting services. The primary systems integrated with EMS systems are HVAC and lighting. The availability of these primary features and functions by company is captured in Table 1 below.

TABLE 1. EMS VENDOR DATABASE

	Product Features			Integrated End-use Systems	
Company	Hardware Solutions	Software Solutions	Consulting Services	HVAC	Lighting
Adura Technologies	X	X			X
Building IQ		X	X	X	
Comverge	X	X	X	X	X
Cypress Envirosystems	X	X		X	
Delta Controls	X	X		X	X
Ecobee	X	X		X	
Energent	X	X		X	X
EnerNoc	X	X	X	X	X
EnTouch	X	X	X	X	X
FieldServer Technologies	X	X		X	X
First Fuel		X		X	X
Honeywell	X	X	X	X	X
Johnson Controls	X	X	X	X	X
Kite & Lightning	X	X	X	X	X
Lucid		X		X	X
Millenial Net	X	X		X	
Novar		X	X	X	X
Optimum Energy		X	X	X	
Powerhouse Dynamics		X		X	X
PlotWatt		X			
Profile Systems	X	X		X	X
Pulse Energy		X	X	X	X
Shneider Electric	X	X		X	X
Siemens	X	X	X	X	X

Source: FNI

The summary in Table 1 above suggests that all EMS services incorporate some level of software solution. Not all respondents indicated that a hardware solution was offered, implying that the product is either an EIS solution or leveraging existing hardware from a previous EMS system to connect with the new software logic.

EMS data is often processed in-house or outsourced to a third-party energy consulting firm to translate the raw data into meaningful results. Processed data can be used to to discern equipment malfunctions, to identify significant energy loads, and to direct behavioral changes. "Consulting services" in Table 1 refers to the aforementioned services, which are typically conducted by experienced energy managers. Most EMS vendors are specifically technology companies, and as such do not commonly offer these types of consulting services. The services offered by EMS vendors may pertain more to servicing the technology itself rather than energy consulting for the entire building.

Control and monitoring of HVAC and lighting, which are the two primary areas of EMS focus, are often offered individually by EMS providers or together as a package. These equipment categories have been the focus of EMS in larger buildings. The fundamental technology historically used for larger buildings is typically transferred directly to restaurants, although the HVAC profiles for restaurants can deviate significantly from those of larger buildings.

Current State of EMS Technologies

The granular survey results are displayed in Appendix 2. Based on these results, the current status of EMS technologies was assessed. The section below will characterize typical EMS packages with respect to software, hardware, and services.

Typical EMS Packages

Software

Nearly all respondents indicated that their EMS product offered some level of software solution. Within the granular survey results displayed in Appendix 2, it can be seen that certain software features are consistently offered with EMS products. These features, in addition to less common features, will be expanded upon below.

- **Dashboard –** The dashboard is the central access point for operators to view monitoring data and control equipment. Typical dashboards will feature a schematic of the installed EMS equipment in the restaurant, a list of logged data points, configurable schedules, and equipment controls.
- **Equipment Monitoring –** The EMS serves as a data logging platform for all of the connected sensors.
- **Equipment Control –** Equipment may be controlled through the EMS system. The most common type of automated control is equipment on/off scheduling, which is typically established in the dashboard. Lighting, exhaust fans, HVAC unoccupied mode, and cooking equipment are commonly scheduled with EMS systems.
- **Alarms –** Alarms are configured to alert operators when monitored equipment is operating abnormally, or if a programmed threshold is reached that requires action by a manager or operator (such as when internal temperatures of refrigeration equipment rise above safe levels for a period of time). Alarms and fault detection thresholds may often be configured by the user along with the method of contact and the frequency of alarms.
- **Anomaly Detection –** Beyond setting alarm thresholds, certain EMS products feature adaptive logic which can detect equipment anomalies based on normal usage patterns. While this feature is not common with current EMS products, this integrated logic presents a great potential for identifying malfunctioning equipment.
- **Advanced Energy-Saving Logic –** Advanced energy-saving logics improve control of equipment to reduce energy expenditure. Examples of this include, but are not limited to:
    - Demand control ventilation

- Lighting dimming
- Smart defrost
- Economizer control
- Water heater output temperature control and setback
- Recirculation pump control
- Booter heater night-time shut off
- Load shifting

Focused technologies have offered solutions to each of the aforementioned energy-saving strategies. These features, however, are not typically offered in EMS packages.

- **Demand Response –** Certain EMS systems can be used to shift load off of utility peak usage periods. For larger groceries and warehouses, EMS may be used to pre-cool walk-in freezers to allow the units to "coast" through peak hours. In addition, ice machines may be load-shifted to produce at night and store throughout the day. Demand response is not commonly found with current EMS packages, although certain products are beginning to interface with the utility OpenADR demand response protocol.
- **Building Peak Demand Management –** Certain EMS providers have integrated features to reduce building peak demand charges for restaurants. Such strategies include preventing simultaneous condenser cycling between multiple rooftop units. While EMS is a viable platform for managing building peak usage, this feature is not commonly used with current EMS products.
- **Multiple Communication Protocols –** Mismatched protocols are a common issue for interoperability between EMS and other restraint equipment systems. For this reason, several EMS providers accept multiple communication protocols to widen the range of accepted equipment. Unfortunately, incompatible communication protocols remain a hurdle for integrating EMS with existing equipment and systems.

HARDWARE

In order to be considered a true EMS product, some level of hardware must be available. Respondents who indicated that hardware was not provided are either offering an EIS or are applying EMS software to existing sensors and controls from a legacy EMS at the building site. The types of hardware offered with typical EMS products are detailed below:

- **Thermostat** – Most EMS packages will have a designated thermostat required for the system. Thermostatic setpoints as well as unoccupied mode scheduling may be controlled through the in-store thermostat or through the online dashboard. Lockout controls can be configured to allow employees the ability to adjust the setpoint temperature within a few degrees of the programmed setpoint.
- **Control Panel** – The control panel is an in-store touchscreen access point to the online dashboard. While the dashboard may also be accessed through mobile devices and online, the in-store control panel offers managers oversight of the equipment operations on-site.
- **Module Boxes** – Sensors and actuators connect to voltage and pulse channels on central module boxes. Each module box features multiple channels and can interface with a number of sensors and actuators. These modules may be connected through

hardware or wirelessly to the EMS and may be scaled as necessary to monitor and control all desired points. Most EMS will have designated modules for lighting control as well as equipment monitoring and control.

- **Sensors** – EMS vendors will typically supply sensors for the system. Nearly any sensor can be integrated with an EMS provided that the pulse or voltage output may be read by the monitoring module. Common monitored values with EMS products include temperature, humidity, energy, gas usage, water flow, walk-in door status, and economizer position. End-users will typically customize a sensor package to the desired application of the EMS. This option makes EMS products highly adaptive. However, the required customization of each system prevents EMS from being an out-of-the-box solution.
- **Actuators** – Equipment may be controlled remotely through actuators. Relays connected to the HVAC and lighting circuits are the primary actuators found with such systems.
- **Wireless Modem** – Modern EMS's commonly offer wireless modems to connect between components of the EMS as well as communicate with the central EMS dashboard.

SERVICES

An array of services are purchased along with the physical EMS to establish the system and provide continuous support. The standard pricing structure involves purchasing the hardware and software up front and then paying for continuous support and services. Certain companies now offer EMS as a Software as a Service (SaaS) package where the system is purchased through a continuous subscription.

- **Installation –** The EMS installation involves positioning sensors, actuators, and system modules according to the wiring diagram. Designated contractors and service technicians are qualified to conduct this work. The process may involve extensive wiring and require that certain systems be momentarily disengaged.
- **Commissioning –** Commissioning of the hardware and software is necessary for a properly-functioning EMS. Sensors and actuators must be commissioned to ensure accurate operation of the hardware. Furthermore, each signal must be processed and summarized to the operator in the dashboard. Installed EMS systems vary in size and scope; therefore, each project requires the EMS provider to adjust the dashboard settings to the specific site.
- **Training –** Communicating the full potential of the EMS is important for realizing energy and cost savings. Training for end-users in crucial to ensure that the system is being used to its potential.
- **Call Centers –** Continuous customer service is a critical feature for ongoing success with EMS. Certain EMS service providers will offer 24-hour call-in services and may even dedicate a project manager to the site.
- **Warranty –** Warranties for EMS products, both for the hardware and for the installation, range significantly.
- **Consulting Services –** Determining corrective actions from granular equipment data is difficult and labor-intensive. Because most EMS systems do not have adaptive learning and logic-based consulting, energy consulting is often outsourced to the EMS provider or to a third-party consulting firm. The data is then compiled and presented to the end-user in a meaningful way.

BENEFITS

Although the "Energy Management System" title for the product category implies that energy saving is the primary benefit, discussions with industry professionals have revealed that the benefits of EMS are not limited to energy reduction. In fact, certain end-users find energy savings to be a positive byproduct of the other, more impactful benefits of EMS.

The list below highlights the main benefits associated with EMS. The site-specific benefits will depend greatly on the type of foodservice operation, the scope of the EMS system, and the extent to which the available data is utilized.

- **Maintenance, Diagnostics, and Repair –** Abnormal equipment activity may be detected and diagnosed using the data provided by the EMS. Alarms may be established as well as advanced anomaly detection if the service provides this feature. Issues may be assessed remotely rather than sending a technician to the site. An example of a potential alarm may be a prolonged increase in the walk-in box temperature.
- **Energy Savings –** EMS may save energy through improved equipment maintenance and advanced controls and scheduling. Furthermore, data may reveal areas where shifting employee procedures can save additional energy. Aside from reducing the overall building energy footprint, energy savings during peak demand periods will minimize energy used when electricity is more expensive.
- **Improved indoor environment** – EMS can help improve the indoor air environment by ensuring that the multiple HVAC and kitchen exhaust systems work in concert to control the indoor temperature, humidity, and pressure. In addition, EMS data allows operators to identify malfunctioning equipment.
- **Demand Response –** Several EMS systems are currently compliant with the OpenADR demand response protocol. As PG&E and other utilities expand demand response programs, EMS may serve as a central control station for load-shifting technologies throughout the building.
- **Building Peak Demand Management** – Certain systems have enabled features to minimize the max building peak and associated costs, which may not coincide with the utility peak. One stragety for this is to cycle the RTU activity such that multiple condensers are not active at the same time.
- **HACCP Recording –** Temperatures for refrigeration units and hand sinks are often manually logged to ensure that the systems are compliant with food handling requirements. EMS is capable of logging these temperatures automatically.
- **Technology Bundling –** EMS can perform the functions of several focused technologies on a single platform. Rather than individually purchasing multiple technology solutions, the EMS can centralize all monitoring, control, and data collection functions.

MARKET BARRIERS

EMS has had limited adoption in the foodservice industry. Although restaurants are highly energy-intensive, several operational, technological, and financial barriers prevent EMS from being a standard practice in foodservice.

FINANCIAL BARRIERS

- **Initial Cost** – The installed cost of EMS and DCKV is the largest barrier for restaurant operators. In additiona to the cost of the product itself, initial cost may also include installation, commissioning, and training.
- **Unknown Payback Period –** The financial payback for EMS is highly variable depending on the restaurant operation. The monetary savings based on equipment monitoring and preventative maintenance is often difficult to quantify; therefore, payback time for EMS is typically predicted based on energy savings alone.
- **Ongoing Service Fees –** EMS services will often require ongoing service fees to provide customer support and keep the system online. More recently, EMS has been featured as a SaaS product. Under this scheme, end-users subscribe to the EMS software and analytics rather than purchasing the product outright.
- **Data Analysis Costs –** While an EMS may be capable of producing large volumes of granular data, an energy manager must be responsible for interpreting this data into meaningful conclusions and actionable items. If an in-house EMS manager is not staffed, third-party energy consultants often partner with EMS companies to do such work.

OPERATIONAL BARRIERS

- **Installation and Commissioning –** Installation of the EMS entails applying sensors to the target components, connecting the sensors to central modules, and networking the entire system to the central dashboard. While this process is not necessarily intrusive to operations, operators may be concerned that the installation process will disrupt the restaurant activity—especially with a retrofit.
- **Technology Adoption –** Remotely controlling equipment in the restaurant may be a difficult practice for certain operators to adopt. A common theme in foodservice is to keep procedures and equipment simple. The technological capability of EMS may be ahead of what the average restaurant operator is willing to adopt.
- **Procedural Changes**: Some of the potential savings with the EMS may come as actionable items for the management and personnel to execute. Behavioral and schedule changes in the restaurant will rely on employee compliance. In addition, the manager will need to incorporate information from the EMS in addition to his current load of work. Integrating procedural changes creates a barrier to realizing the complete benefits of EMS.

TECHNICAL BARRIERS

- **Hardware Reliability –** The effectiveness of an EMS is hinged upon the operation of sensors, controls, and actuators. One example of a potential equipment failure is the RTU economizers, which have been found to malfunction regularly. The ability for an EMS to save HVAC energy may be negated without a properly-operating economizer. Fortunately, the data provided by EMS can typically be used to identify equipment anomalies and corrective action can then be taken.
- **Foodservice Building Conditions –** Restaurants have a large amount of equipment in a relatively small building space. Installation of EMS components can be made especially difficult in foodservice esablishments due to limited working space, grease buildup, and aged equipment.

- **Proprietary Communication Protocols –** EMS will often integrate auxiliary technologies from different companies, especially DCKV. Different communication languages may be used for the DCKV system and the EMS system, preventing intercommunication. While efforts such as the NAFEM protocol have attempted to standardize the communication languages for foodservice, companies still use proprietary languages which inhibit universal equipment integration.
- **Security –** The EMS is typically connected to the restaurant intranet and is a potential channel for hackers to access important data. Potential breeches into financial information may be a concern for restaurant operators.

FOODSERVICE HVAC AND COMMERCIAL KITCHEN VENTILATION BACKGROUND

HVAC accounts for approximately 30% of energy use in foodservice establishments. A central goal of this project was to investigate how integrated EMS-DCKV systems can reduce HVAC energy expenditures while maintaining comfortable indoor environments. The study examined the relationships between the HVAC, kitchen exhaust, makeup air units, and how an integrated system can affect environmental conditions including air balance, humidity, and temperature. This section will serve as an introduction to the various components to foodservice HVAC and exhaust and strategies that may allow EMS-DCKV to optimize these systems.

AIR BALANCE

Air balancing is the commissioning process of measuring HVAC airflows and adjusting to design specifications. If commissioning is conducted properly, the HVAC and exhaust systems will be set to introduce enough air to compensate for exhausted air. A slightly positive pressure in the building is desired to keep insects out and to prevent outside air from coming in when doors and windows are opened. The three mechanical components which contribute to restaurant air balance are the exhaust fans, the makeup air units (MAU) and the rooftop units (RTU). While some systems may use pressure sensors to actively monitor and control the air balance, the vast majority of systems in restaurants are set only during the original commissioning process. While the design airflow rates are typically set to maintain slightly positive indoor pressure, the actual air balance can deviate significantly due to improper commissioning, malfunctioning equipment, and outside influences—Including opening doors and cooking heat load. Furthermore, the original design exhaust airflow rate specifications may not be near the optimum values that balance the best performance with the least energy use.

ROOFTOP UNITS

RTUs serve to maintain the indoor temperature within a range set at the thermostat. In addition, the RTU is often responsible for providing a designated amount of outdoor air. The outdoor-air damper on the RTU is responsible for introducing fresh outdoor air into the building. For restaurants, a minimum of 15 cubic feet per minute (CFM) per person must be drawn in to comply with Title 24 standards (Building Energy Efficiency Standards for Residential and Nonresidential Buildings, 2012). Restaurant designs will typically integrate multiple RTUs to provide adequate temperature and air balance conditions. Figure 2 shows the schematic of a typical RTU.

The RTU collects air from both inside the restaurant, known as return air, as well as outside air or replacement air. This combination of outside air and return air, known as mixed air, is typically drawn into a plenum by a single-speed fan which runs continuously during hours of operation. A logic controller uses a set of temperature and humidity sensors to dictate if the mixed air should be heated, cooled, or untempered to achieve the targeted thermostat setpoint and indoor humidity. The collected air passes over a heating coil and a cooling coil which will provide the adequate air tempering. The conditioned air, known as supply air, then passes through ducting into the conditioned space.

For restaurants, the large heat loads generated in the kitchen typically require active cooling from the RTU for many hours of the year. The main focus of HVAC energy savings strategies is typically to minimize the amount of mechanical air conditioning that must occur to keep the space at the proper temperature. This is often done by using alternative heating and cooling strategies as well as minimizing the required air volume being conditioned. In addition, an "unoccupied" mode is utilized at nighttime. Unoccupied mode typically involves adjustiing the setpoint temperature to minimize the heating or cooling of the unoccupied building. In addition, the fans will only cycle if the heating or cooling cycle is active, rather than constant fan operation as is such in occupied mode.

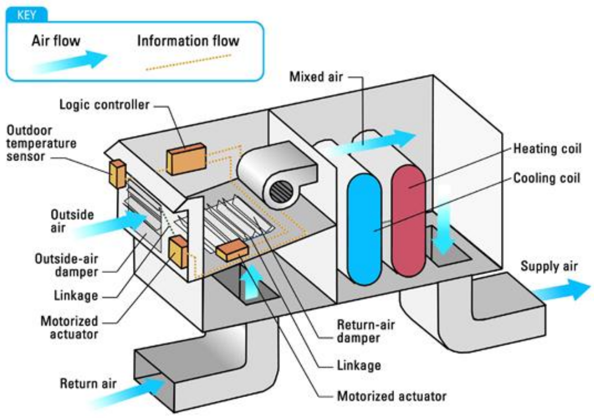


Photo Credit: Energy Star™

FIGURE 2. RTU SCHEMATIC

ECONOMIZER AND FREE COOLING

Certain RTU packages will have an outdoor air economizer. The economizer is an automated outdoor air damper system intended to modulate the amount of outdoor air brought into the building. Economizers are primarily an energy-saving tool used to increase the amount of outdoor air when the outdoor air conditions are within the range that promotes "free cooling".

The range of temperature and humidity conditions when free cooling is possible is known as the economizer or "free cooling" window. During this time, the economizer will open up fully in order to draw in more outdoor air. This practice can be likened to opening a window when the temperature inside is greater than the temperature outside. The bulk of the PG&E territory exists in a climate where approximately 8,000 hours of free cooling are available each year. This estimate is based on the time of the year where the dry bulb temperature is less than 81°F and the dewpoint is less than 59°F. (Air-Side Economizer: ENERGY STAR 1999). Specific information for determining the economizer window can be found using the ASHRAE guidelines for certain climate zones. A RTU with an economizer will use either dry bulb or wet bulb temperature sensors to determine the outdoor conditions are within the economizer window. If the logic controller determines that the outdoor air is within the free cooling window, it will open up the economizer to allow in more outside air. This way, rather than mechanically conditioning the indoor air, "free" outdoor at a lower temperature can be brought in to maintain the thermostatic setpoint.

The effectiveness of free cooling is dependent upon the operation of the economizer. While buildings in the PG&E territory have reported up to 60% savings through air-side economization , many economizers are nonoperational. A field study conducted in 2003 reported that 64% of economizers were found to not operate properly (Jacobs, 2003).

There are two ways an EMS can assist with economizer mode energy savings. The first is for the EMS to monitor the activity of the economizer and to verify proper function. Fault detection diagnostics may be programmed to alert critical equipment failure Furthermore, the collected data can be leveraged to determine the energy-saving efficacy of the economizer. Alternately, the EMS can serve as the master controller for the economizer. Controlling the RTU gives operators additional oversight of the HVAC through the EMS. For some EMS systems with integrated DCKV, the economizer is controlled to allow adequate makeup air for the variable kitchen exhaust systems.

MAKEUP AIR UNIT

Makeup air for most foodservice operation cooklines is provided through a dedicated MAU. This air compensates for air removed by the exhaust fans to maintain the air balance. The MAU products are configured to either provide tempered or untempered air into the kitchen. Typical tempering techniques include heating, mechanical cooling, and evaporative cooling.

A common issue in restaurants is simultaneous heating and cooling between the RTU and the MAU. This typically occurs because the thermostats for each unit are programmed separately (some MAUs have only a duct-mounted thermostat that is not accessible remotely) and are reading different air temperatures. If, for example, the outdoor air temperature is 50°F, and the MAU's duct-mounted thermostat is set to 70°F, the outdoor air will constantly be heated before introducing it into the space. Meanwhile, the RTU in the kitchen will be actively cooling the space to mitigate the heat load in the kitchen. An EMS may be used to monitor and control a communication channel between these two units to ensure that simultaneous heating and cooling does not occur.

DEMAND-CONTROLLED KITCHEN VENTILATION

DCKV systems are capable of varying the hood exhaust rate based on temperature sensors that measure the heat load, by using a optical sensors to detect the presence of effluent generated by cooking equipment, or by a combination of the two. If the system detects a high heat load, steam or smoke, it will operate at an increased exhaust fan speed high enough to remove the effluent. When there is little or no cooking activity under the full exhaust fan capacity is not necessary, the fan speed is reduced to minimize the fan motor energy used to exhaust the kitchen space as well as energy required to condition the makeup air.

A variety of ventilation companies now offer DCKV options. Table 2 is a compilation of market research for the current DCKV products available. This list is subject to change as additional products and features are identified.

TABLE 2. DCKV PRODUCT DATABASE

Manufacturer	Product Name	VFD Capable of 50% Speed Reduction	Optical / Infrared Sensors	External Connection Capabilities	Alert System	Warranty
Accurex	Vari-Flow	Yes	No	Yes	Yes	Yes
CaptiveAire	SC-EMS	No	No	Partially	Yes	Yes
Gaylord	DCV-AV Air Vantage	Yes	No	Yes	Yes	Yes
Gaylord	DCV-F	Yes	No	Yes	Partially	Yes
Gaylord	DCV-R	Yes	No	Yes	Partially	Yes
Green Energy Hoods	TEL Kitchen Control System	Yes	Yes	Yes	Yes	Yes
Halton	MARVEL	Yes	Yes	Yes	Yes	Yes
Hood Depot	On Demand Ventilation	Yes	No	Yes	Partially	*
Melink	Intelli-Hood	Yes	Yes	Yes	Yes	Yes
Noveo	EcoHood	*	Yes	Yes	*	Yes
Spring Air	TruFlow	Yes	No	Yes	Yes	Partially
Streivor	DemandAire	No	No	Yes	No	*
Intellinox	ConceptAZUR	*	Yes	Yes	Yes	*

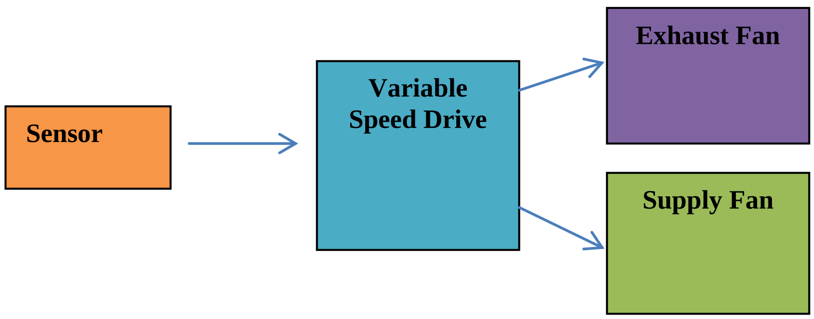
Source: FNI

Table 2 highlights the features of DCKV systems with respect to the operation, sensing, and connectivity of the listed systems. Nearly all DCKV systems are capable of reducing the exhaust fan speed to 50% of the maximum. While this does not correlate to a 50% reduction in airflow rate, it does significantly decrease the air removed from the kitchen. Optical sensors can be utilized to detect heat rising from the cooking equipment or to remotely probe the temperature of cooking surfaces. Nearly all systems will feature direct air temperature measurements at several points within the hood and in the exhaust duct. For the purposes of EMS, most DCKV controllers are capable of external connections; however, the communication protocol between EMS and DCKV systems may be mismatched, resulting in a communication impasse between the two products.

While there is no ENERGY STAR category for DCKV systems, EPA has identified DCKV for an Emerging Technology award for 2015. This award will provide a foundation for expanded utility rebates.

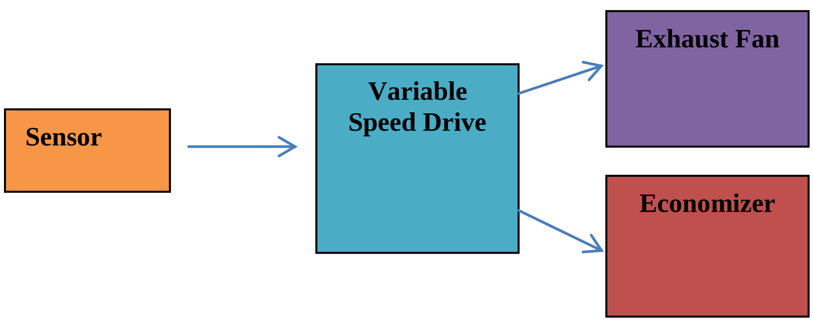
AIR BALANCE WITH DEMAND-CONTROLLED KITCHEN VENTILATION

Due to the variable exhaust, DCKV systems must be paired with a variable flow makeup air system to maintain air balance. There are two methods of supplying variable flow makeup air. The first is to use variable speed fans in dedicated makeup air units. In this configuration, the variable frequency drives control the fan speed of both the exhaust fan, and a direct fan energy reduction is claimed on both fans. This configuration is depicted in Figure 3. Alternately, some operations (without dedicated MAUs) link the DCKV to the RTU outside air damper to draw in a proportional amount of outdoor air to the air being exhausted. When the exhaust rate is increased, the damper will open to allow more outside air in to maintain the air balance. This configuration is depicted in Figure 4.



Source: FNI

FIGURE 3. DCKV AIR BALANCE CONFIGURATION USING VFDS TO MODULATE EXHAUST AND SUPPLY FANS IN TANDEM



Source: FNI

FIGURE 4. DCKV AIR BALANCE CONFIGURATION USING VFDS TO CONTROL OUTDOOR AIR THROUGH THE ECONOMIZER

DCKV systems can exhaust less air and bring in less makeup air on average than traditional single-speed systems. Reducing the makeup air volume may reduce the energy required to condition the space when the outdoor air temperature is outside of the economizer window. For example, if the temperature outside is significantly greater than the setpoint, the outdoor air must either be conditioned by the makeup air unit or enter the space and add to the head load of the kitchen RTU. In this situation, minimizing the amount of outdoor air drawn into the restaurant may result in mechanical cooling savings as well as fan energy savings. As stated earlier, the most effective way to reduce HVAC energy is to minimize the use of mechanical heating and cooling. This same principle applies in the opposite situation for outdoor air which is has a significantly lower temperature than the setpoint and outdoor air must be heated.

Energy Reduction – Applying DCKV results in a direct energy reduction from the fans. Fan power is proportional roughly to the cube of fan speed. For example, a 20% fan speed reduction results in nearly a 50% reduction in fan power. Because DCKV systems reduce the average ventilation rate, the reduced makeup air volume will reduce the outdoor air load energy required to condition the air—either directly by the makeup air unit—before entering the kitchen, or indirectly by the kitchen RTU to condition the resultant load to the space (during ambient conditions outside of the economizer window). In this situation, minimizing the amount of outdoor air drawn into the restaurant will result in outdoor air load savings as well as fan energy savings.

DCKV also affords a more precise and flexible method of commissioning or further tuning the exhaust system that would otherwise involve a belt pulley adjustment. Sometimes exhaust rates are set excessively high for the cooking process even at full production, so in these situations the maximum fan speed setting can be readily decreased through the DCKV controller and/or the VFD itself. The flexibility in initial fan sizing is also increased because a slightly larger fan can be specified to allow for an airflow safety factor without fear of an energy penalty since the speed setting can be decreased during commissioning and increased later if necessary.

When the outdoor air conditions are within the economizer window, researchers have questioned whether the reduced exhaust rate with DCKV will negatively affect the HVAC energy by bringing in less "free cooling" air through the economizer. Reducing the intake of outdoor air in the economizer may increase the indoor heat load, which must then be cooled by the RTU. While the DCKV has been vetted for energy savings related to the exhaust fan motor, the correlated RTU energy has not been quantified before this study.

EMS-DCKV Integration

Combining or integrating the two platforms has significant merit, the first being a reduced system cost by eliminating one of the processing units and by sharing remote communication pathways. A second value of integration would be the ability to observe and control DCKV function from the EMS dashboard. The third and more subtle aspect of integration could be the ability of the EMS to override DCKV function when the HVAC system was operating within the economizer or "free cooling" window. Alternatively stated, maintaining exhaust hood airflow at its design may encourage increased flow of outdoor air through the RTU economizer. However, this strategy would reduce exhaust fan energy savings, potentially nullifying any "free cooling" benefit derived by maintaining hood airflow at maximum.

Only two EMS vendors currently offer DCKV as an integrated feature within their system. Both of these manufacturers are companies that are known for their commercial kitchen ventilation (CKV) experience and DCKV products. As such, both vendors were selected for evaluation within this scaled field study.

DCKV and EMS each offer energy-saving capabilities that are otherwise unattainable, even with the best facility manager and employees. Integrating these two systems add additional insight into each system and allows for continuous commissioning of the elements of the HVAC and exhaust systems.

Integrated EMS-DCKV systems present multiple opportunities to save energy and costs:

- Reduce exhaust fan energy.
- Reduce MAU fan energy.
- Reduce mechanical heating and cooling outside of the economizer window by reducing exhaust airflow through the DCKV system.
- Reduce mechanical heating and cooling inside the economizer window by increasing exhaust airflow through the DCKV system or through power vents.

FIELD STUDY

FIELD STUDY TEST METHODOLOGY

The test plan called for three separate EMS platforms were to be installed in three restaurants within the PG&E service territory. The target sites were ideally high-traffic chain restaurants where there was the potential to scale the test to other facilities. Restaurants that have had experience with EMS or DCKV (though not both together) were identified in order to study the synergistic benefits of EMS-DCKV integration. Of six potential site candidates, ultimately the three selected for field testing represented a range of foodservice operations—from quick-service to full-service.

The EMS technologies included in this study were sourced from three companies with extensive expertise in the foodservice sector: Kite & Lightning, Franke, and Halton. Each system was configured to monitor and control multiple systems within the facility—including HVAC and lighting, and depending on the site, the water heater, cooking equipment, refrigeration systems, and ice machines. The respective DCKV technologies were provided by Gaylord, Franke, and Halton.

A test methodology was developed for each site in order to identify energy savings attributable to the installed EMS. While the focus of the study was to examine the DCKV system as it linked with the building HVAC system, data was analyzed both at the DCKV and HVAC submetered level and at the billing data level. This granular data on the equipment level allowed researchers to directly identify key areas of energy-savings (or to determine areas were energy savings might not be realized despite the EMS). It also indicated whether the individual equipment being controlled realized any savings, as well as how much of an impact operators could expect to see on their energy bill.

The monitoring and analysis approach specific to each of the three sites is presented in the results section following the site descriptions below. It is important to note the pre-existing condition of some of the systems in the facilities, particularly the varying state of disrepair or operation of many of those systems. The savings associated with the remediation of any malfunctioning item or the tuning of any poorly-performing item can be attributed to the EMS-DCKV installation and would be aggregated with the energy saving of the EMS-DCKV systems themselves.

SITE DESCRIPTIONS AND ASSESSMENTS

SITE 1: QSR (BURGER-BASED MENU)

Site 1, located in San Jose, is a franchisee-owned quick-service restaurant. The primary cooking appliances included two separate sets of fryers and a pair of clamshell griddles, ventilated by three back-shelf hoods with a separate exhaust fan on each. The restaurant also contained an ice machine, multiple refrigeration systems, and various other preparation and holding appliances. A fryer bank at Site 1 is shown in Figure 5; the cookine is shown in Figure 6. The HVAC system consited of one RTU for the kitchen and another for the dining area. Makeup air was also supplied through these units.

Photo Credit: FNI

FIGURE 5. FRYER BANK AT SITE 1

Photo Credit: FNI

FIGURE 6. COOKLINE AT SITE 1

EMS Pre-Installation Survey Summary. The following are the key points of the HVAC and kitchen exhaust system inspection performed by EMS manufacturer personnel. The correspondence can be found in Appendix 3:

- The Kitchen & Dining RTUs' economizers were not in working condition. Both would need new economizer modules and would likely need new damper actuators.
- An air balance was required; There was very negative air pressure, primarily because the fresh air dampers were barely open. Additionally, the exhaust fan speeds alsowould need adjusting. The gridlle hood was drawing about 25% more air than needed, the filet fryer hood was drawing about 35% more air than needed, and fry fryer hood was drawing only about 75% of its rated flow. All of this would be addressed with the air balance to be performed in concert with the EMS-DCKV system installation.
- The old lighting control panel timer was not working, and the staff was merely turning everything on/off with the breaker that controls the contactor coils. The new system would return automation to the store lighting.

SITE 2: QSR (CHICKEN-BASED MENU)

Site 2, located in Walnut Creek, is a quick-service restaurant that focuses on chicken-based dishes. The kitchen featured an entirely electric cookline including fryers, range tops, a griddle, and a convection oven.

The kitchen was ventilated through four fans which exhausted three hoods. A total of five RTUs shown in Figure 7 conditioned the air in the space—including one in the kitchen, three in the dining area, and one in the play area. Makeup air was supplied through the kitchen RTU.

The restaurant origanally was equipped with a lighting control panel with a smart relay controlling automated occupied and unoccupied schedules for the lighting, RTUs and exhaust fans. The EMS replaced all these components. Benefitted by the fact that the restaurant was less than two years old, all systems in the facility were operating properly.

Photo Credit: FNI

FIGURE 7. EXHAUST FANS AT SITE 2

The historical billing data for Site 2 consisted of only a two–month period and, due to the short timespan, did not implicate the efficacy of the EMS.

SITE 3: CASUAL DINING RESTAURANT

Site 3 is a full-service chain restaurant specializinge in pies and American fare. The Livermore location in this study is open 24 hours a day. The natural gas cookline featured multiple fryers, range tops, griddles, and an underfired charbroiler. The cookline was ventilated by a canopy hood with a partition separating two cookline sections using separate fans. One fan and hood set covered the main griddle-range pairing, and the other set covered the charbroiler, fryers and a second griddle-range pairing, which was used only during busy times. A dedicated evaporative cooler MAU supplied replacement air to the cookline area.

The cookline at Site 3 is illustrated in Figure 8. The HVAC system was comprised of one RTU for the kitchen and two RTUs for the dining area.

During the site survey preceding the EMS installation, it was discovered the that the RTU economizers were in disrepair and were subsequently remedied by the EMS installation contractor. Also, the makeup air unit was not functioning, which was subsequently replaced prior to the DCKV system installation.

Photo Credit: FNI

FIGURE 8. COOKLINE AT SITE 3

TECHNOLOGY / PRODUCT EVALUATION

Table 3 lists the EMS and DCKV systems installed at each site.

TABLE 3: FIELD STUDY EMS AND DCKV PRODUCTS

		Site 1—QSR (Burger)	Site 2—QSR (Chicken)	Site 3—Casual
EMS	Manufacturer	Franke	Halton	Kite & Lighting
	Product Name	EEMS	F.O.R.M.	Unity
DCKV	Manufacturer	Franke	Halton	Gaylord
	Product Name	VariVent	M.A.R.V.E.L.	DCV-R

Source: FNI

SITE 1—QSR (BURGER)

The Franke EEMS (Expandable Energy Management System) that was installed at Site 1 is a Lonworks-based platform intended for small commercial applications. The user interface for monitoring and controlling equipment may be accessed at the restaurant or remotely through the Internet.

A Franke VariVent DCKV system was integrated with the EEMS. The VariVent controller receives signals from sensors installed in the cooking appliances that indicate operating status (cooking or idle). Makeup air was provided through the kitchen RTU, and for DCKV it was controlled by linking the Varivent MUA output to the economizer controller. When the DCKV system increased the speed of the exhaust fans, the economizers opened to allow in more air and maintain the desired indoor pressure. The Franke DCKV system adjusted the site's three exhaust fan speeds independently up and down throughout the day based on real-time cooking activity while dynamically adjusting the MUA economizers at the same time.

Aside from the integrating with the DCKV, the EEMS was monitoring and controlling several other aspects of the restaurant. The hardware components of this system included one thermostat for the kitchen RTU and another for the dining room RTU, relay control modules for lighting control and automation, a multi-phase electrical power meter, and a user interface panel. The thermostats for the EEMS were the central hub for monitoring and controlling temperatures for the indoor space and the relay module was the hardware interface to switch all lighting equipment. Both were controlled via the dashboard. The multi-phase meter received current sensor inputs and also made the power and energy use information available on the user interface. The system also had the ability to integrate refrigeration controllers for walk-in coolers and freezers.

SITE 2—QSR (CHICKEN)

The Halton F.O.R.M. EMS installed at Site 2 in Walnut Creek actively monitors and controls multiple systems. The refrigeration, HVAC, kitchen exhaust, ice machine, water heater, lighting, and outdoor ambient air temperature, humidity and light level are monitored and viewable through the dashboard displayed in Figure 9. Controlled components include the five RTU's, exhaust fans, lighting, ice machines and water heater. Equipment status, alarms, reports, and schedules can be accessed through the online portal, along with weather information uploaded to the portal host. All system components are hard-wired. The EMS uses a digital communication protocol between the master EMS controller and the RTUs and each of the four hood controller modules, which receive all the hood sensor connections and send the speed control voltage signals to the fan motors.

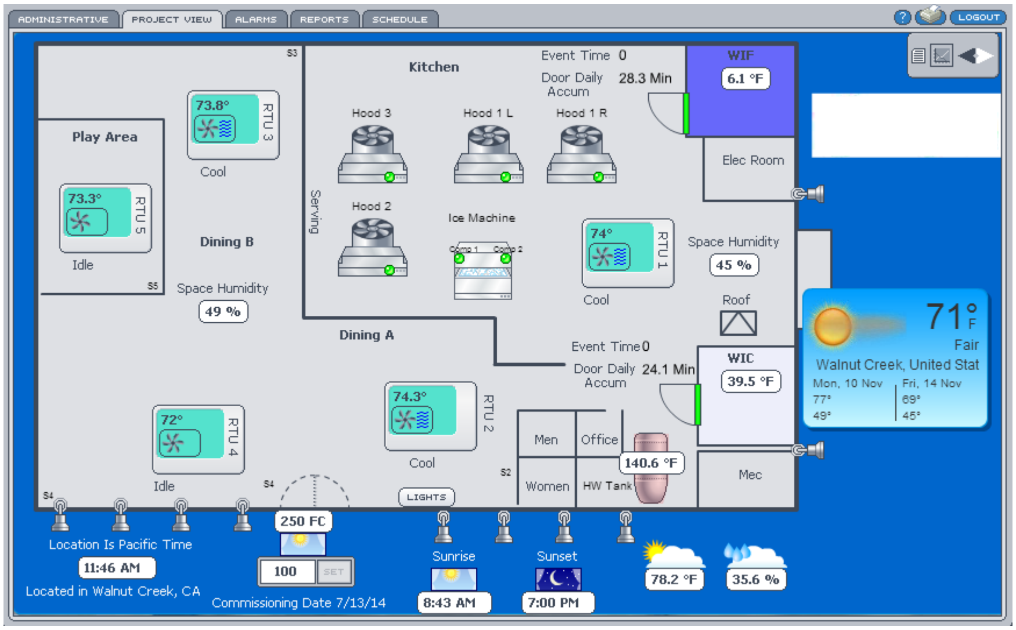


Photo Credit: Halton Inc.

FIGURE 9. HALTON F.O.R.M. SYSTEM DASHBOARD AT SITE 2

The Halton M.A.R.V.E.L. demand control ventilation system utilizes infrared temperatures sensors, differential pressure sensors, in addition to duct and room temperature sensors. A controller computes the appropriate exhaust fan speed and damper settings using these inputs. The M.A.R.V.E.L system at Site 2 was integrated with the kitchen RTU to modulate the economizer position based on the MUA demand.

As part of the retrofit, instead of installing VFDs on the pre-existing fans, the four original belt-drive upblast exhaust fans were replaced with equivalent direct-drive ECM (Electronically Commutated Motor) fans, which could accept the 0-10V control signal directly. All the hoods were outfitted with temperature sensors in the duct collars, and optical infrared (IR) sensors were installed over the griddle, open-vat fryer and range top. Additionally, each of the four electric pressure fryers (because they do not emit a heat signature with the lids down) were outfitted with a wiring harness connecting an internal cook status switch to the associated hood control module.

This Halton M.A.R.V.E.L system utilizes a static pressure sensor in each hood plenum to determine the actual exhaust airflow rate using pressure vs. airflow data derived from lab testing of the hoods, which were also manufactured by Halton, with the design airflow rates taylored specifically for this restaurant chain application.

SITE 3—CASUAL DINING

The Kite & Lighting Unity EMS installed at Site 3 offers energy monitoring and control solutions for HVAC and air balance, lighting, refrigeration, and additional energy consuming and generating equipment. The Unity system communicates wirelessly between its hardware components and actively updates the information to a control unit as well as online to remote access points. Figure 10 shows an interactive dashboard detailing the controlled and monitored systems at the site. The components controlled include the functions of the three RTUs, the indoor and outdoor lighting, and the ice machine (for peak load-shifting). Additional monitoring points include, walk-in and evaporative cooler temperatures, refrigerator door positions, as well as energy use at a whole-building power meter installed as part of the EMS.

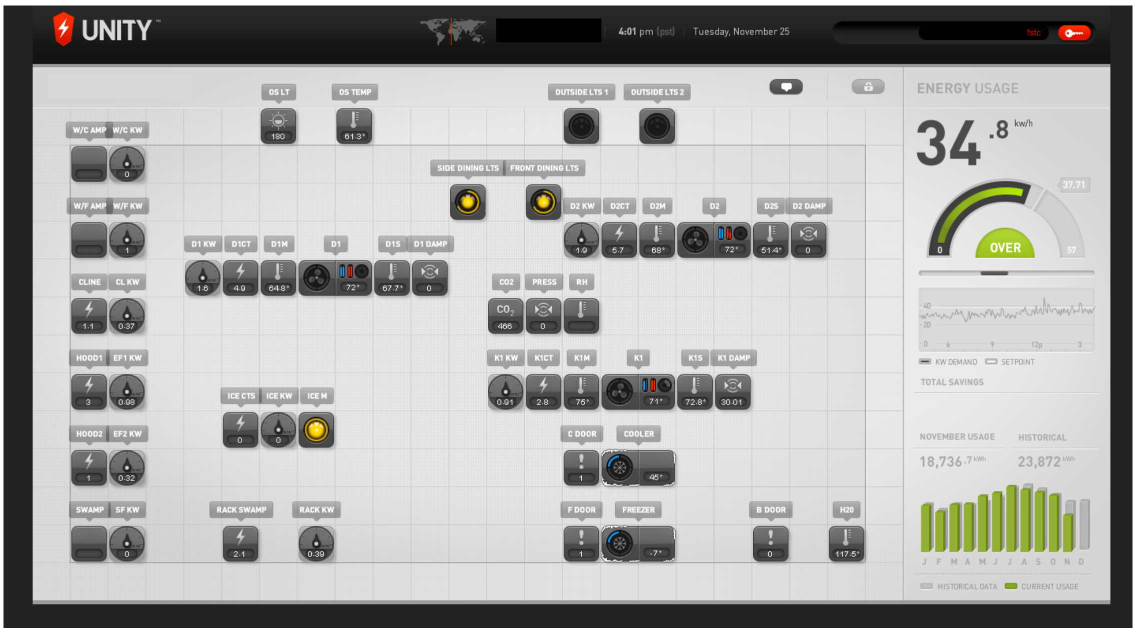


Photo Credit: Kite & Lightning

FIGURE 10. KITE & LIGHTNING UNITY SYSTEM DASHBOARD AT SITE 3

A retrofit Gaylord DCV-R demand control ventilation system was installed on the existing hood—along with VFDs on the exhaust and makeup air fans. The DCV-R collects air and effluent temperatures using resistance temperature sensors installed in the hood, the duct collar, and outside of the hood in the room. The controller analyzes the sensory input and dictates the fan speed through a variable frequency drive. A DCKV control cabinet serves as the cross section for input and output signals and features a "100% Fan Button" as well as a "Exhaust Fan Start/Stop" button. EMS integration was accomplished with current sensors placed on the exhaust and makeup air fan electrical circuits and provided supervisory and alarm functionality to the DCKV system.

INSTRUMENTATION

Although much of the data collection for the project was accomplished through the EMS platforms, various separate loggers were installed by the FSTC where practical. Electrical metering used for Exhaust fans at Site 2 and Site 3 exhaust fans was a DENT Instruments ElitePro power logger. The rated accuracy is better than 1% of reading (<0.5% typical). For kitchen and dining room RTUs at Site 1, two Continental Control Systems, WattNode pulse-output watt-hour transducers were used. The resolution is 0.025 Wh/pulse/CT-rated amp and the rated accuracy is ±0.5% of reading. The pulses were counted and logged with Onset HOBO UX-90-001M pulse loggers set to record at 30-second intervals.

Accompanying current transformers (CTs) used for the electric metering were Dent Instruments CTHSC series CTs, which have a rated accuracy of <0.5%.

Metering accuracy was verified prior to field deployment with calibrated revenue-grade energy meters used for appliance energy-efficiency compliance testing in the FSTC lab.

Temperature loggers were installed in the kitchen and dining room at Site 1, and in the kitchen only at Site 2. Onset HOBO Temp Data Logger UX100-001 that have a rated accuracy of ±0.38°F were configured to record data at one-minute intervals. They were placed directly adjascent to the RTU space temperature sensors.

FIELD STUDY RESULTS

METER-LEVEL DATA ANALYSIS

The meter-level data was assessed in alignment with the Whole Building Comparison (Option C) in the International Performance Measurement & Verification Protocol. Using PG&E My Energy website to access recorded smart meter data, the energy use of the facility was assessed at the whole-building level. The baseline data set shows average energy use for the same restaurant prior to the installation of the EMS-DCKV system. This methodology does not offer a high-level of savings calculation accuracy; rather, it captures the energy and cost savings as experienced by restaurant operators through monthly billing. Using the 15-minute interval smart meter data readings, assessments of the electric use for peak, partial-peak, and off-peak energy use, as well as the overall peak energy demand were made. The billing data summary for the three sites is displayed in Table 4.

TABLE 4. ELECTRIC BILLING DATA SUMMARY BY SITE

Electric	Site 1—QSR (Burger)		Site 2—QSR (Chicken)		Site 3—Casual	
	Baseline	EMS-DCKV	Baseline	EMS-DCKV	Baseline	EMS-DCKV
Average Daily Energy (kWh/day):	1,268	1,246	1,164	1,222	863	921
Start Date:	7/1/13	7/1/14	8/1/13	8/1/14	12/18/10	12/15/12
End Date:	8/26/13	8/26/14	10/29/13	10/30/14	12/15/11	12/15/13
Average Monthly Peak Demand (kW):	82	75	113	123	N/A	N/A
Avg. Monthly Cost ($):	3,045	2,967	7,415	8,388	3,509	3,899
Avg. Outdoor Air Temp (°F):	69	71	67	68		
Percent Energy Savings (%):	1.7		-6.2		-6.7	
Percent Cost Savings (%):	2.6		-11.6%		-11.2	

**Site 1 was on a rate schedule which did not include time-of-use charges.*

Source: FNI

The energy-saving and load-shifting efficacies of EMSs at the building-level were looked for through the billing data. While Site 1 displayed marginal electrical energy savings, both the Site 2 and Site 3 experienced higher energy use. Site 1 experienced an appreciable reduction in peak demand draw, while this value increased for Site 2. Data for peak demand was not available for Site 3 because a smart meter had not yet been installed.

The gas billing data was also sourced from the PG&E My Energy website, although the Sites 1 and 2 were still in the cooling season during the study (i.e., no gas usage from the RTUs).Historical gas data for Site 1 was unavailable. The main contribution of EMS-DCKV at these sites for gas savings would be reduced space heating requirements through the RTU during colder months months with the reduced kitchen ventilation rate and the optimum economizer function.

Table 5 displays a summary of the gas use for the three test sites.

TABLE 5: GAS BILLING DATA SUMMARY BY SITE

Gas	Site 1—QSR (Burger)†		Site 2—QSR (Chicken)[C]		Site 3—Casual	
	Baseline	EMS-DCKV	Baseline	EMS-DCKV	Baseline	EMS-DCKV
Average Daily Energy (therm):	N/A	N/A	N/A	N/A	53.1	42.0
Average Monthly Cost ($):	N/A	N/A	N/A	N/A	1,619*	1,272*
Start Date:	7/1/13	7/1/14	8/2/13	8/2/14	11/18/10	11/18/12
End Date:	8/26/13	8/26/14	10/30/13	10/31/14	11/18/11	11/18/13
Average Outdoor Air Temperature (°F):	N/A	N/A	N/A	N/A	57	58
Percent Energy Savings:	N/A		N/A		21.0%	
Percent Cost Savings (%)*:	N/A		N/A		21.0%	

** Calculation based on $1.00 per therm.*
† Gas data was not available for Site 1.
[C] The monitoring period at Site 2 occurred during a period when gas use would not apply to the results of this study.

Source: FNI

The results of the building-level gas usage were limited in this study. Due to the third-party energy provider for Site 1, gas energy data was unavailable. The gas usage for Site 2 was unaffected by the installation of the EMS-DCKV due to the weather during the test period as well as the scope of the installed EMS-DCKV system. Site 3, which was examined for a full year period, showed significant reductions in gas energy usage. One explaination for this decrease was the reduced volume of outdoor air brought in during the cooler winter months. The function of the economizer, as well as the reduced air flow from the DCKV, will limit the volume of cold outdoor air which must be heated to the setpoint temperature.

There were several variances in operations and conditions which may have had a significant impact on gas and electricity use from a whole-building level. Some factors that may have contributed to the change in energy use include the following:

- Timespan of available data
- Climate variance
- Use, occupancy, and operational scheduling
- Equipment upgrades and addition of new equipment
- Building envelope modifications
- HVAC configuration and operation
- Miscellaneous energy expenditures

Based on the limited data available, variances in conditions and operations could not be normalized to provide a true representation of how much energy was saved by the EMS at a whole-building level. In addition, several of these systems were recent installations and may have required additional commissioning to achieve greater energy savings. Continuous commissioning of the EMS is a key component to realizing energy savings. However, to fully-commission an optimally tune a system, it may require several iterations and trial periods. The relatively short test period dedicated for these systems may not fully capture the energy-saving capabilities of these systems.

Ultimately, the energy-saving and load-shifting efficacy of the EMS were not able to be assessed at the building-level. In order to assess the effectiveness of the EMS, specific systems must be examined—Including HVAC, kitchen ventilation, and lighting.

DCKV Savings

The exhaust fan motor energy was monitored for each site for both the baseline and EMS-DCKV cases. For Site 1, the fan control was switched between the DCKV operating mode and the static bypass mode (considered baseline) for designated periods. Fan energy analysis for Site 2 compared pre- and post-installation data. For Site 3, because the makeup air unit was inoperative during the preliminary baseline period, a new baseline power reading was taken during a 15-minute bypass period with full-speed fan operation once the replacement makeup air unit was in operation after the DCKV system was installed. The data presented in Table 6 show the average energy us for each site.

On average, the fans used approximately half of the energy with DCKV when compared with the baseline case.

TABLE 6. DCKV SAVINGS BY SITE

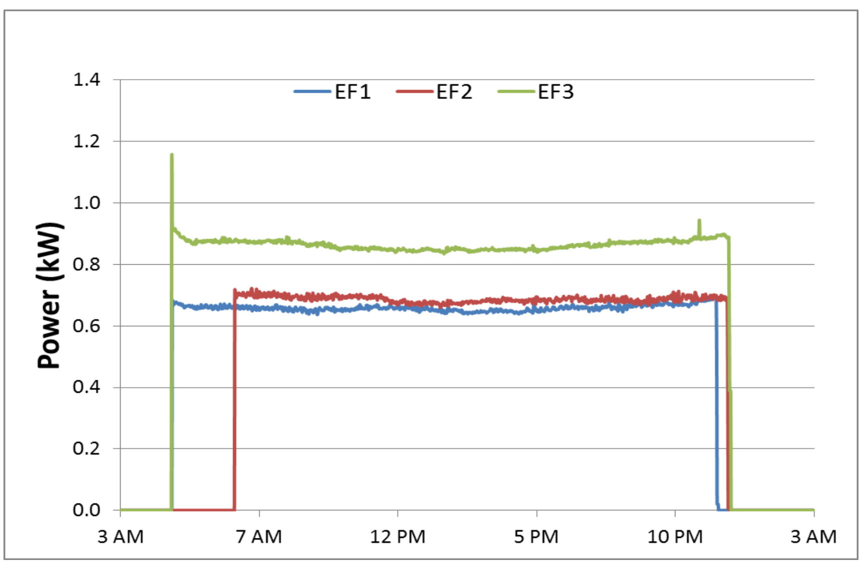
Fan Energy Savings	Site 1—QSR (Burger)	Site 2—QSR (Chicken)	Site 3—Casual	Average
Average Daily Baseline* Energy (kWh/d):	40.5	26.1	89.4	52.0
Average DCKV† Energy (kWh/d):	20.3	8.4	61.0	29.9
Reduction (kWh/d):	20.2	17.7	28.4	22.1
Percent Reduction (%):	49.9	67.9	31.8	49.9
Average Monthly Cost Savings[C] ($):	72	64	102	80

** The exhaust fans were set to maximum fan speed during normal operating hours.*
† The DCKV was active and modulating the fan speed during normal operating hours.
[C] Annual cost savings projection based on $0.12/kWh. This average cost savings was based on the data sampled between 6/3/2014 and 9/21/2014. The monthly energy was based on a 30-day period.

Source: FNI

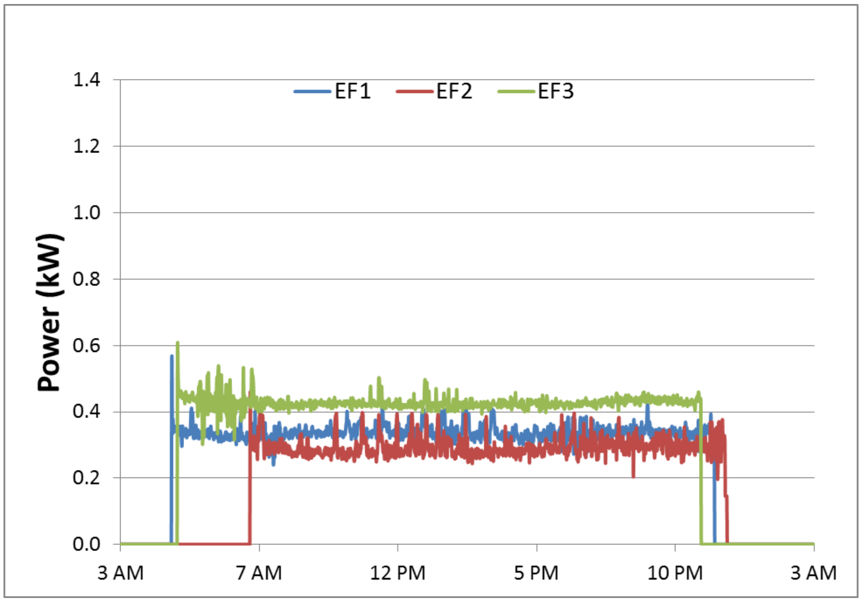
DCKV SAVINGS: SITE 1

Figures 11 and 12 show typical-day fan power profiles for the baseline case and the EMS-DCKV case respectively for Site 1. The demand-controlled fans experienced a condiderable decrease in both maximum and average power consumption and did not have a high degree of fan speed modulation.



Source: FNI

FIGURE 11: BASELINE FAN POWER PROFILES FOR SITE 1

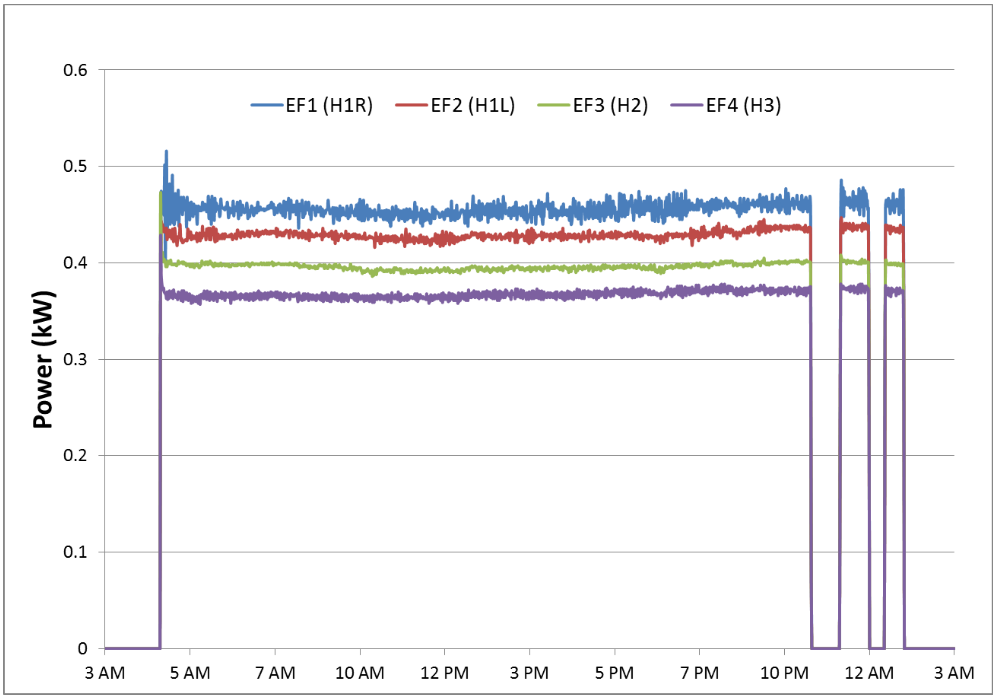


Source: FNI

FIGURE 12: DEMAND-CONTROLLED FAN POWER PROFILES FOR SITE 1

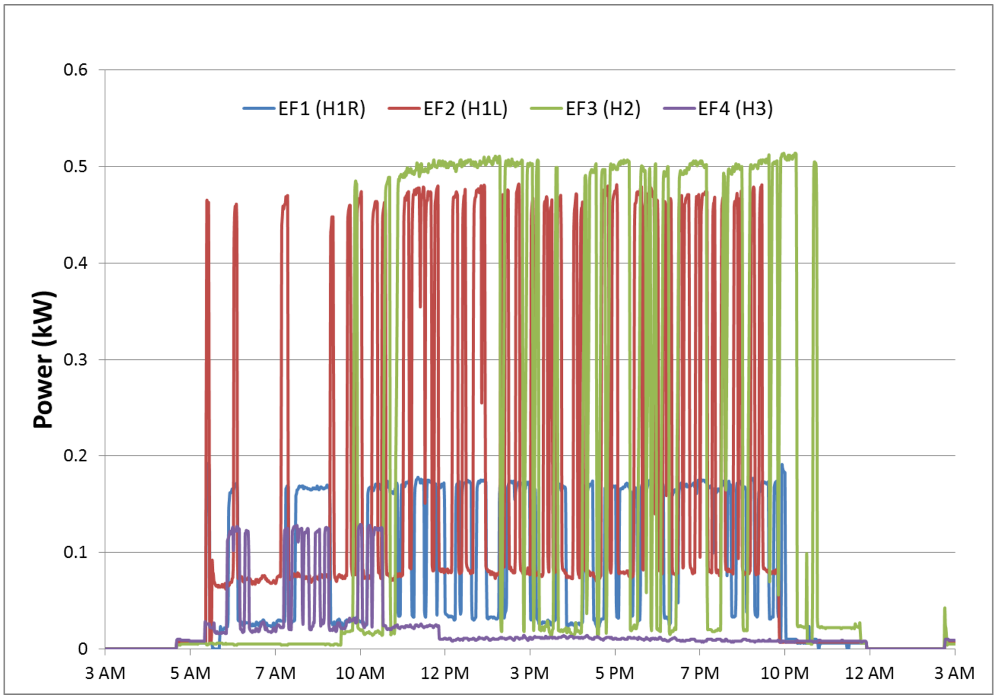
DCKV SAVINGS: SITE 2

Figures 13 and 14 show typical-day fan power profiles for the baseline case and the EMS_DCKV case respectively at Site 2. With active demand-control, all the fans experienced a high degree of fan speed modulation between cooking events and/or idle periods. Note that the maximum power on fans EF2 and EF3 slightly increased—even though they were the higher efficiency ECM fans. Because this Halton M.A.R.V.E.L system utilizes hood plenum pressure sensors to determine the actual exhaust rate and therefore can drive the fan motor to match the design value, the higher power probably indicates that the original fans were not drawing the design exhaust rate and possibly not fully capturing and containing the cooking effluent.



Source: FNI

FIGURE 13: BASELINE FAN POWER PROFILES FOR SITE 2

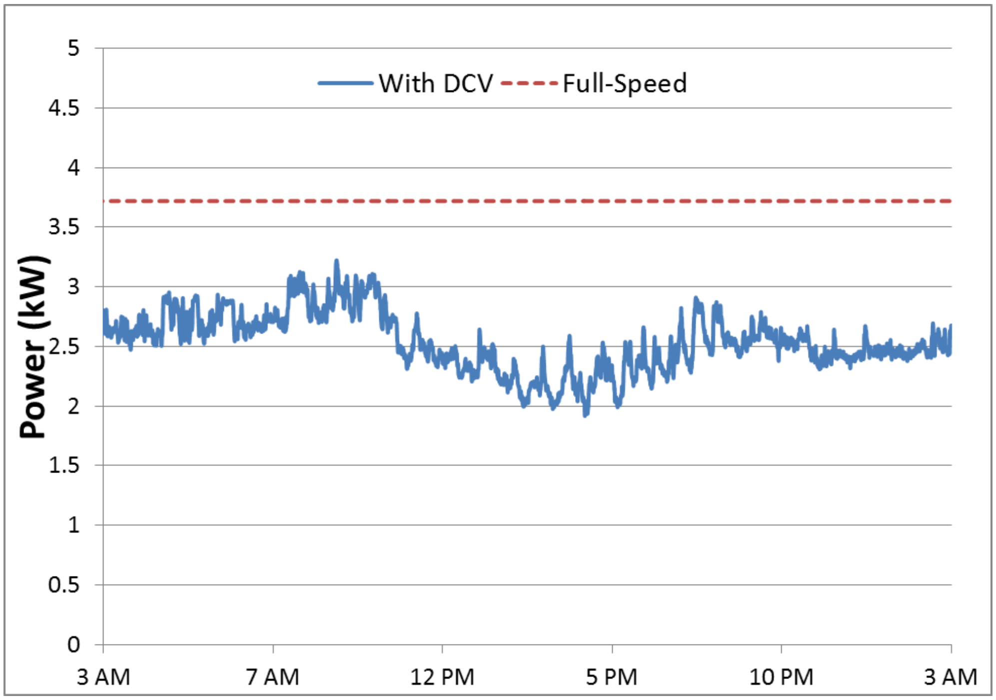


Source: FNI

FIGURE 14: DEMAND-CONTROLLED FAN POWER PROFILES FOR SITE 2

DCKV SAVINGS: SITE 3

Figure 15 shows a combined (EF1 + EF2 + MAU) typical-day demand-controlled fan power profile for Site 3 overlayed with the full-speed baseline measurement. Note that the 24-hour operation has no off periods.

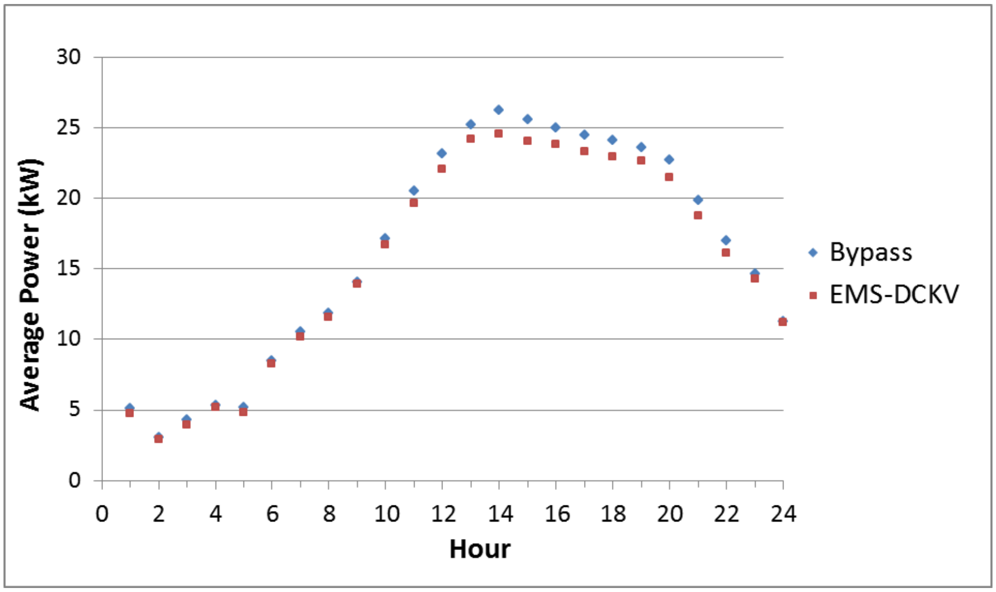


Source: FNI

FIGURE 15: DEMAND-CONTROLLED FAN POWER PROFILE FOR SITE 3

RTU ENERGY SAVINGS

The DCKV system alternated between maximum exhaust fan speed and variable frequency mode approximately every week at Site 1. The test period lasted between the months of June and September, providing a large set of data to examine the relationship between the kitchen RTU energy and the DCKV status. During this period, the economizer was limited due to high summer temperatures during hours of operation. Figure 16 displays the average power consumption of the kitchen and dining room rooftop units, averaged for each hour of the day.



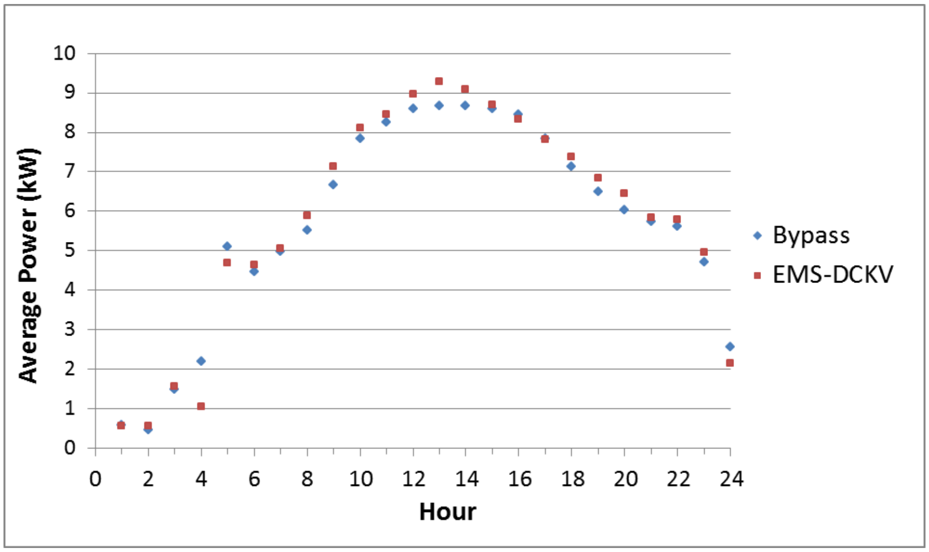
Source: FNI

FIGURE 16: KITCHEN AND DINING ROOM COMBINED RTU HOURLY POWER AT SITE 1, AVERAGED FOR 6/3/14 - 9/21/14

Figure 16 shows that the hourly energy use for both modes was commensurate for most hours of the day. It can be deduced that during these hours, the RTU was either in economizer mode or in unoccupied mode. These hours ranged from approximately 8 p.m. to 10 a.m. These results indicate that reducing the exhaust rate inside of the economizer window did not negatively affect the RTU energy. While reducing the exhaust rate during the economizer window may increase the heat load for the RTU, the results suggest that keeping the DCKV active at all hours of operation will not adversely affect normal RTU energy use.

During the hottest period of the day, approximately between 10 a.m. and 8 p.m., more energy was used in the baseline case than in the EMS-DCKV configuration. These energy savings indicate that by reducing the exhaust rate when outside conditions are not in the economizer window, less energy is required by the RTU to manage the heat load. Table 7 displays the exact amount of energy saved as well as the average daily cost savings. The annual cost savings is not reported due to the limited time the system was studied.

The EMS-DCKV system was examined at Site 2 during the fall season when the outdoor air temperatures were temperate and the economizer window marked a large portion of the day. Similar to the methodology at Site 1, the system was switched between active DCKV control and manually setting the exhaust to full-speed. The test period for this site was a total of four weeks, during which the mode of the exhaust fan control was switched daily. Figure 17 depicts the average hourly energy use for each mode throughout a 24-hour period.



Source: FNI

FIGURE 17: SITE 2'S KITCHEN RTU HOURLY POWER, AVERAGED OVER A FOUR-WEEK PERIOD

The results displayed indicate that the RTU used more energy when the DCKV was active. While these results are contrary to those found at Site 1, the larger availability of "free cooling" times during the fall may explain this outcome. When the DCKV is active, less air is being cycled through the restaurant space on average. This reduced airflow may increase the indoor heat load for the RTU during the economizer window. When the exhaust fan is set manually to maximum fan speed, additional "free" air outdoor air is cycled through the restaurant. There are more hours of free cooling in the fall, when Site 2 was examined, than in the summer, when Site 1 was examined. Maintaining maximum fan speeds is therefore believed to have maximized the intake of outdoor air and minimized the energy required by the RTU to condition the air. Granular baseline data was not available for Site 3, and therefore the energy analysis was only conducted on the whole-building level.

TABLE 7. RTU SAVINGS AS A RESULT OF EMS-DCKV INTEGRATION OUTSIDE ECONOMIZER WINDOW

	Site 1—QSR (Burger)	Site 2—QSR (Chicken)
Baseline Daily RTU Energy Use (kWh)	386.8	185.3
EMS-DCKV Daily RTU Energy Use (kWh)	371.3	186.2
Daily RTU Energy Savings (kWh)	15.5	-0.9
Percent Energy Savings (%)	4.00	0.48
Average Monthly RTU Cost Savings ($)*	56	-3

** Average monthly cost savings projection based on $0.12/kWh. This average cost savings was based on data sampled between6/3/14 and 9/21/14.*

Source: FNI

Based on the the RTU data for Site 2, it appeared that the DCKV adversely affected the energy use of the RTU. Ultimately, the measured DCKV energy increase effect for the RTU was a minimal 0.9 kWh per day. For Site 2, it should be noted that the slightly-increased RTU energy use was insiginificant compared to the 17.7 kWh per day of energy savings based on the reduced exhaust fan energy. Based on this comparison, it can be determined that the DCKV ultimately offers energy savings that are more significant than any negative energy effects for the RTU in the study sites.

COMBINED EMS-DCKV SAVINGS

Site 1 realized energy and cost savings for the exhaust fan as well as for the RTU (Table 8). The more significant savings were experienced through the reduced average exhaust fan speed with DCKV. Site 2 experienced more significant DCKV energy savings; however, no appreciable RTU energy savings were noticed. While these DCKV savings were expected to be steady throughout the year, the average savings of from the RTU will fluctuate as the temperature changes throughout the year.

The average energy savings attributable to the EMS-DCKV system for HVAC and exhaust was approximately 2% of the entire building energy loads for the sites investigated. Additional savings could be achieved through control of additional equipment in the buildings.

TABLE 8. PRE- AND POST-INSTALLATIUON HVAC AND EXHAUST ENERGY AND COST SAVINGS

	Site 1—QSR (Burger)	Site 2—QSR (Chicken)
Daily Baseline HVAC and Exhaust Energy (kWh/day)	427.3	211.4
Daily DCKV-EMS HVAC and Exhaust Energy (kWh/day)	391.6	194.6
EMS-DCKV Energy Savings (kWh/day)	35.7	16.8
Monthly Cost Savings* ($)	128.5	61
Savings as Percentage of Monthly Energy Bill (%)	2.8	**1.4**

**Average monthly cost savings projection based on $0.12/kWh. These results may only pertain to the time of year when the tests were conducted at each site.*

Source: FNI

CONCLUSIONS AND RECOMMENDATIONS

The results of the market assessment portion of this study show that there is a wide diversity among products and features offered by EMS vendors. EMSs are comprised of three primary groups: large-building EMS (or BAS) providers who seek to penetrate the foodservice market, smaller retail building EMS providers who also seek to penetrate the foodservice market, and DCKV vendors who have expanded their product capabilities to the scale of an EMS.

The core hardware capabilities of all systems observed in this study were comparable; however, the individual software-driven features offered between products varied significantly. The primary features offered with most EMSs are equipment monitoring, scheduling, controls, and alarms for HVAC and lighting systems. A small percentage of EMS providers have expanded upon these base offerings to include DCKV integration, water heater setback, smart defrost for walk-in freezers, and other advanced energy-saving options. In addition, select EMS products enable load-shifting and peak-demand management through various methods. While hardware from most EMS products can support the aforementioned features, the preprogrammed software logic and learning capabilities of most systems is relatively limited.

EMS products were found not to be "out-of-the-box" solutions for foodservice. Extensive installation and commissioning would be required for each location to fit the specific applications and equipment layout. In addition, personel are required to interpret the data generated by the EMS into actionable items to repair malfunctioning equipment, enact behavioral changes, and refine equipment schedules. EMS is as much a preventative maintenance and diagnostic tool as it is a energy-saving platform. The efficacy of these aspects is hinged upon the extent to which the data is leveraged.

The scaled installation of EMS integrated with DCKV within the scope of this ET project was considered successful; the challenges of securing, installing and commissioning the equipment and then holding to the project schedule were significant. Furthermore, meter-level energy savings were not quantified to the degree that can directly support a deemed rebate or program at this time.

It was concluded, however, that the EMS adopt DCKV as a primary "control" attribute. Similarly, the EMS should monitor and/or control the water heater setpoint, recirculation pump, refrigeration defrost, evaporator fan controls, and ice machine operating time, all where appropriate. While a deemed incentive for EMS (with or without DCKV) is not directly supported by this study, the concept of incenting EMS based on individual attributes could be considered. In other words, if the EMS controls the exhaust ventilation system, then it would be a candidate to receive the incentive currently provided for DCKV. Similarly, ice machine load-shifting and refrigeration "smart defrost" could be incentivized. This forces the "applicant" to better define the specific control features of an EMS being incentivized.

Overall, much more work is needed to quantify the value of EMS in commercial foodservice. Within that vein, the FSTC is committed to observing the performance of the three EMS-DCKV sites over a multi-year period, working with management to utilize the platform for continuous commissioning.

The California IOUs could consider a voluntary registry of customer EMS installations that would invite meter-level interrogation by the utilities. This is something that could be promoted and the database administered by the FSTC with the support of the ETCC. Within a few years, the data could be significant, and the results conclusive with respect to the energy-saving merits of EMS in foodservice.

When this Emerging Technology field study was conceived and the work statement developed, it was anticipated that the energy savings realized by this EMS-DCKV integration, at the building-level or as a result of any individual equipment managed under EMS, would help to accelerate market adoption of EMS and DCKV (and, where applicable, integrated EMS and DCV). While the results of the meter-level analysis did not support the energy savings claims, individual equipment control features remain attractive and potentially elegible for a bundled rebate. More study on the potential for energy reductions related to EMS and DCKV integrationis needed before the California IOUs would be willing to make a firm commitment on a statewide measure involving this technology.

It should be recognized that the California climate zone is a hurdle for both EMS and DCKV savings. The heating and cooling loads for both space and outdoor air are minimal compared to other regions in the country. Thus, savings claimed by vendors of EMS and DCKV may reflect operating experiences from across the country—not California.

Independent of the field results, the authors believe that EMS products have the inherent capability of achieving energy savings and load shifting that would otherwise be unattainable. Multiple energy-saving EMS strategies were examined and vetted in the study; however, it was clear that the efficacy of these systems is hinged upon commissioning, equipment maintenance, and programming (these can be changed). The requirements to establish a highly productive EMS are specific to the project site as well as the EMS product. Unfortunately, the results of this field study along with the high variability within the product category do not translate immediately to a California utility energy efficiency program.

APPENDIX 1: MARKET ASSESSMENT SURVEY

Energy Management Market Survey

Please answer the questions about your product to the best of your ability. If the answer is unknown or not relevant, please skip.

Thank you in advance for your cooperation and support.

Food Service Technology Center

Personal and Company Information

1. **Name:**

2. **Title:**

3. **Email:**

4. **Phone Number:**

5. **Company Name:**

6. **Product Name:**
   If multiple products offered, please fill out a survey for each.

APPENDIX 1: MARKET ASSESMENT SURVEY (CONTINUED)

7.
General
Please check the following which are applicable to your product.
Check all that apply.

- [ ] Energy Information System (EIS)
- [ ] Energy Management System (EMS)
- [ ] Predictive and/or responsive load shifting/shedding based on real-time building load measurement
- [ ] Load shifting/shedding based on utility demand response
- [ ] Auto-sync with calibrated clock
- [ ] Able to "disaggregate" signals to differentiate individual loads from a multiple-load energy data

8.
Support
Check all that apply.

- [ ] Onsite commissioning
- [ ] Training offered
- [ ] 24/7 call center
- [ ] Account manager assigned to each customer
- [ ] Utility rebate services offered
- [ ] EMS savings analysis provided

9.
Duration of parts warranty (years):

10.
Duration of labor warranty (years):

Inputs / Outputs (I/O)

Please answer all that apply.

11.
Number of analog input channels:
(for temperature sensing with thermocouples)

Appendix 1: Market Assesment Survey (Continued)

12.
Number of analog output channels:

13.
Voltage range of digital input (V):

14.
Number of "pulse counter" channels:

15.
Pulse frequency range:

16.
True power/energy measurement number of channels:

17.
Does the system log data? If so, how and in what format is the data saved (ex: xls)?

Communication

18.
Which communication protocol(s) are used (i.e. ModBus)?

19.
Check all that apply.

- ☐ Wireless communication between system components
- ☐ Compliant with Nafem Data Protocol for appliance communication

Appendix 1: Market Assesment Survey (Continued)

User Interface Features

20.

Check all that apply.

- ☐ Web access available
- ☐ Mobile application
- ☐ Real-time monitoring
- ☐ Chart and graph displays
- ☐ Multi-site views available
- ☐ Alerts to cellphone and email

Lighting

21.

Check all that apply.

- ☐ Lighting control
- ☐ Multiple circuits allowable
- ☐ Light circuit dimming
- ☐ Ambient light sensor(s)

22.

Does the system feature any additional lighting features? If so, please describe.

____

____

____

____

____

HVAC System Monitoring and Control

Appendix 1: Market Assesment Survey (Continued)

23.
HVAC
Check all that apply.

- [ ] HVAC system control
- [ ] Specific thermostat required
- [ ] Variable frequency drive motor control
- [ ] Run-time data collected on compressor and fan motors
- [ ] Economizer control
- [ ] Economizer position monitoring
- [ ] HVAC scheduling control
- [ ] Thermostat setback for unoccupied mode
- [ ] Fan setback for unoccupied mode

Commercial Kitchen Ventilation (CKV)

24.
Check all that apply.

- [ ] Monitor exhaust fan speed
- [ ] Scheduling control for exhaust hood/fan
- [ ] Integrated demand controlled kitchen ventilation (DCV)
- [ ] Temperature sensing for DCV system
- [ ] IR/Optic sensors for DCV system
- [ ] Appliance communication
- [ ] Makeup air supply temperature monitoring
- [ ] Makeup air supply temperature control
- [ ] Kitchen temperature monitoring
- [ ] Auto air balance (using pressure sensors)

Kitchen Equipment Monitoring and Control

25.
Walk-in Refrigeration
Check all that apply.

- [ ] Internal (box) temperature monitoring
- [ ] Internal (box) temperature control
- [ ] Compressor run-time monitoring
- [ ] Critical temperature alerts
- [ ] On-demand (smart) defrost

Appendix 1: Market Assesment Survey (Continued)

26.
If smart defrost available, please give a brief description of this function:

....

27.
Ice Machine
Check all that apply.

- ☐ Ice machine bin level monitoring
- ☐ Ice machine run-time monitoring (duty cycle)
- ☐ Ice machine control (load shifting)

28.
Water Monitoring
Check all that apply.

- ☐ Water heater run-time (duty cycle) monitoring
- ☐ Hot water temperature monitoring
- ☐ Dishwasher consumption monitoring
- ☐ Critical water temperature monitoring

29.
Kitchen Diagnostics
Check all that apply.

- ☐ Kitchen appliance energy monitoring
- ☐ Comfort thresholds (e.g. temperature, humidity)
- ☐ Environmental quality and safety thresholds (e.g. CO, CO_2)

30.
Other
Please explain any features or services not covered in this survey:

....

....

....

....

....

Thank you!

APPENDIX 2: SURVEY RESULTS

Survey Responses Summary										
Name	Title	Email	Phone Number	Company	Product Name	EMS/EIS	Load Shifting/ Shedding Based on Building Measurement	Load Shifting/ Shedding Based on Utility DR	Auto-sync With Calibrated Clock	Able to Differentiate Individual Loads
Ifty Hasan	CTO	ifty.hasan@entouchcontrols.com		EnTouch Controls	EnTouch EMS	EMS		Yes	Yes	
Paul Needham	Business Development Manager	paul.needham@kiteandlightning.com	(503) 804-9783	Kite & Lightning	Unity	EMS/EIS	Yes		Yes	
Sean Kennedy	VP Business Development	sean.kennedy@voyantsolutions.com	(317) 507-5725	Voyant Solutions	XtraVision QSR	EMS/EIS	Yes	Yes	Yes	
Andrew Gaichuk	Manager, Customer Operations	andrew@ecobee.com	(416) 987-1060	ecobee Inc	ecobee EMSSi	EMS		Yes		
Helen Fairman	Director of Marketing	helen@powerhousedynamics.com	(617) 340-6582 ext. 215	Powerhouse Dynamics	SiteSage	EMS/EIS	Yes	Yes		
Adam Chalker	Director of Marketing	adamchalker@plotwatt.com	(919) 883-5677	PlotWatt	PlotWatt for Restaurants	EMS/EIS	Yes			Yes
Guy Wellman	VP of Sales	gwellman@profilesystems.com	(219)796-4332	Profile Systems LLC	P1900	EMS/EIS			Yes	
Paul Kuck		pkuck@ecova.com	(971) 201-4189	Ecova	NA					
Jimmy Sandusky	R&D Manager	jimmy.sandusky@halton.com	270.237.5600	Company	Halton EMS	EMS	Yes	Yes	Yes	Yes

APPENDIX 2: SURVEY RESULTS (CONTINUED)

Survey Responses Summary													
Name	Title	Email	Phone Number	Company	Product Name	Onsite Commissioning	Training Offered	24/7 Call Center	Account Manager Assigned to Customer	Utility Rebate Assistance Offered	EMS Savings Analysis Provided	Duration of Parts Warranty (Years):	Duration of Labor Warranty (Years):
Ifty Hasan	CTO	ifty.hasan@entouchcontrols.com		EnTouch Controls	EnTouch EMS	Yes	Yes	Yes	Yes		Yes		
Paul Needham	Business Development Manager	paul.needham@kiteandlightning.com	(503) 804-9783	Kite & Lightning	Unity	Yes	Yes	Yes		Yes	Yes	1	1
Sean Kennedy	VP Business Development	sean.kennedy@voyantsolutions.com	(317) 507-5725	Voyant Solutions	XtraVision QSR	Yes	Yes	Yes	Yes	Yes	Yes	2	2
Andrew Gaichuk	Manager, Customer Operations	andrew@ecobee.com	(416) 987-1060	ecobee Inc	ecobee EMSSi	Yes	Yes	Yes	Yes	Yes	Yes	3	3
Helen Fairman	Director of Marketing	helen@powerhousedynamics.com	(617) 340-6582 ext. 215	Powerhouse Dynamics	SiteSage		Yes	Yes	Yes	Yes	Yes	1	N/A
Adam Chalker	Director of Marketing	adamchalker@plotwatt.com	(919) 883-5677	PlotWatt	PlotWatt for Restaurants		Yes		Yes		Yes	2	2
Guy Wellman	VP of Sales	gwellman@profilesystems.com	(219)796-4332	Profile Systems LLC	P1900	Yes	Yes	Yes	Yes	Yes	Yes	1	1
Paul Kuck		pkuck@ecova.com	(971) 201-4189	Ecova	NA		Yes	Yes	Yes	Yes	Yes		
Jimmy Sandusky	R&D Manager	jimmy.sandusky@halton.com	270.237.5600	Halton Company	Halton EMS	Yes				Yes		1	0

APPENDIX 2: SURVEY RESULTS (CONTINUED)

Survey Responses Summary													
Name	Title	Email	Phone Number	Company	Product Name	Number of Analog Input Channels:	Number of Analog Output Channels:	Voltage Range of Digital Input (V):	Number of Pulse Counter Channels:	Pulse Frequency Range:	Energy Measurement Number of Channels:	Does the system Log Data? If so, How is it saved?
Adam Chalker	Director of Marketing	adamchalker@plotwatt.com	(919) 883-5677	PlotWatt	PlotWatt for Restaurants	N/A	N/A	N/A	N/A	N/A	Unlimited	Yes. One second readings to the cloud.
Guy Wellman	VP of Sales	gwellman@profilesystems.com	(219)796-4332	Profile Systems LLC	P1900	Unlimited	0	0 - 5 V	Unlimited		Unlimited	Yes, back to day one of install. Network Operation Center collects & stores all info; can then be exported into .xls or any desired format
Paul Kuck		pkuck@ecova.com	(971) 201-4189	Ecova	N/A							
Jimmy Sandusky	R&D Manager	jimmy.sandusky@halton.com	270.237.5600	Halton Company	Halton EMS	8 per PLC	2 per PLC	0 - 30V	4		unlimited	

APPENDIX 2: SURVEY RESULTS (CONTINUED)

Survey Responses Summary														
Name	Title	Email	Phone Number	Company	Product Name	Communication Protocol Used	Wireless Communication Between Components	Compliant w/NAFEM Protocol	Web Access	Mobile App	Real-time Monitoring	Chart & Graph Displays	Multi-site Views	Alerts to Cell/ E-mail
Ifty Hasan	CTO	ifty.hasan@entouchcontrols.com		EnTouch Controls	EnTouch EMS	Zigbee	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Paul Needham	Business Development Manager	paul.needham@kiteandlightning.com	(503) 804-9783	Kite & Lightning	Unity	Zigbee	Yes		Yes		Yes	Yes		Yes
Sean Kennedy	VP Business Development	sean.kennedy@voyantsolutions.com	(317) 507-5725	Voyant Solutions	XtraVision QSR	BACnet, ModBus, EnOcean, ZigBee, oBix	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Andrew Gaichuk	Manager, Customer Operations	andrew@ecobee.com	(416) 987-1060	ecobee Inc	ecobee EMSSi	Standard 24V AC			Yes	Yes	Yes	Yes	Yes	Yes
Helen Fairman	Director of Marketing	helen@powerhousedynamics.com	(617) 340-6582 ext. 215	Powerhouse Dynamics	SiteSage	WiFi, Zigbee, Z-Wave, Ethernet, Modbus	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Adam Chalker	Director of Marketing	adamchalker@plotwatt.com	(919) 883-5677	PlotWatt	PlotWatt for Restaurants	Cat5, wireless	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Guy Wellman	VP of Sales	gwellman@profilesystems.com	(219)796-4332	Profile Systems LLC	P1900	Modbus	Yes		Yes	Yes	Yes	Yes	Yes	Yes
Paul Kuck		pkuck@ecova.com	(971) 201-4189	Ecova	N/A						Yes	Yes	Yes	Yes
Jimmy Sandusky	R&D Manager	jimmy.sandusky@halton.com	270.237.5600	Halton Company	Halton EMS	Modbus, Bacnet, or LonWorks	Yes		Yes		Yes	Yes	Yes	Yes

APPENDIX 2: SURVEY RESULTS (CONTINUED)

Survey Responses Summary										
Name	**Title**	**Email**	**Phone Number**	**Company**	**Product Name**	**Lighting Control**	**Multiple Circuits Allowable**	**Light Circuit Dimming**	**Ambient Light Sensor(s)**	**Additional Features:**
Ifty Hasan	CTO	ifty.hasan@entouchcontrols.com		EnTouch Controls	EnTouch EMS	Yes	Yes			Astronomic schedule and outside light condition (cloud based)
Paul Needham	Business Development Manager	paul.needham@kiteandlightning.com	(503) 804-9783	Kite & Lightning	Unity	Yes	Yes	Yes	Yes	Can be interfaced with most industry-standard systems. Can use any combination of schedule, threshold and dimming management
Sean Kennedy	VP Business Development	sean.kennedy@voyantsolutions.com	(317) 507-5725	Voyant Solutions	XtraVision QSR	Yes	Yes	Yes	Yes	XtraVision QSR utilizes a photocell for lighting enable/ disable, allowing QSR to control outdoor lights and signage at different light level setpoints.
Andrew Gaichuk	Manager, Customer Operations	andrew@ecobee.com	(416) 987-1060	ecobee Inc	ecobee EMSSi					
Helen Fairman	Director of Marketing	helen@powerhousedynamics.com	(617) 340-6582 ext. 215	Powerhouse Dynamics	SiteSage	Yes	Yes		Yes	Lighting can be programmed in absolute time, relative to sunrise/sunset, or relative to open/close (or any combination of the above).
Adam Chalker	Director of Marketing	adamchalker@plotwatt.com	(919) 883-5677	PlotWatt	PlotWatt for Restaurants					Lighting analysis and waste detection.
Guy Wellman	VP of Sales	gwellman@profilesystems.com	(219)796-4332	Profile Systems LLC	P1900	Yes	Yes		Yes	Profile Master can handle up to 4 zones of lighting, but can add as many as needed with little additional cost. Each zone controlled separately from one another and can use lumen sensor to allow each zone to have its own sensitivity level for when lights come on. Lighting has 7-day programmability with holiday and event schedules. Knows exactly where on the earth it sits and automatically changes every day for new dusk and dawn times, along with DLST.
Paul Kuck		pkuck@ecova.com	(971) 201-4189	Ecova	N/A					
Jimmy Sandusky	R&D Manager	jimmy.sandusky@halton.com	270.237.5600	Halton Company	Halton EMS	Yes	Yes	Yes	Yes	

APPENDIX 2: SURVEY RESULTS (CONTINUED)

Survey Responses Summary

Name	Title	Email	Phone Number	Company	Product Name	HVAC System Control	Specific Thermostat Required	VFD Motor Control	Runtime Data on Motors	Economizer Control	Economizer Position Monitoring	HVAC Scheduling	Thermostat Setback	Fan Setback
Ifty Hasan	CTO	ifty.hasan@entouchcontrols.com		EnTouch Controls	EnTouch EMS	Yes		Yes	Yes	Yes		Yes	Yes	Yes
Paul Needham	Business Development Manager	paul.needham@kiteandlightning.com	(503) 804-9783	Kite & Lightning	Unity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sean Kennedy	VP Business Development	sean.kennedy@voyantsolutions.com	(317) 507-5725	Voyant Solutions	XtraVision QSR	Yes	Yes	Yes	Yes			Yes	Yes	Yes
Andrew Gaichuk	Manager, Customer Operations	andrew@ecobee.com	(416) 987-1060	ecobee Inc	ecobee EMSSi	Yes	Yes		Yes			Yes	Yes	Yes
Helen Fairman	Director of Marketing	helen@powerhousedynamics.com	(617) 340-6582 ext. 215	Powerhouse Dynamics	SiteSage	Yes			Yes			Yes	Yes	Yes
Adam Chalker	Director of Marketing	adamchalker@plotwatt.com	(919) 883-5677	PlotWatt	PlotWatt for Restaurants							Yes	Yes	
Guy Wellman	VP of Sales	gwellman@profilesystems.com	(219)796-4332	Profile Systems LLC	P1900	Yes	Yes		Yes			Yes	Yes	Yes
Paul Kuck		pkuck@ecova.com	(971) 201-4189	Ecova	N/A	Yes			Yes		Yes	Yes	Yes	Yes
Jimmy Sandusky	R&D Manager	jimmy.sandusky@halton.com	270.237.5600	Halton Company	Halton EMS	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes

APPENDIX 2: SURVEY RESULTS (CONTINUED)

Survey Responses Summary

Name	Title	Email	Phone Number	Company	Product Name	Monitor Exhaust Fan Speed	Scheduled Control for Hood	Integrated DCKV	Temp Sensing for DCV	IR/ Optic Sensors for DCV System	Appliance Communication	MUA Supply Temp Monitoring	MUA Supply Temp Control	Kitchen Temp Monitoring	Auto Air Balance (Using Pressure Sensors)
Ifty Hasan	CTO	ifty.hasan@entouchcontrols.com		EnTouch Controls	EnTouch EMS		Yes							Yes	
Paul Needham	Business Development Manager	paul.needham@kiteandlightning.com	(503) 804-9783	Kite & Lightning	Unity	Yes	Yes					Yes	Yes	Yes	Yes
Sean Kennedy	VP Business Development	sean.kennedy@voyantsolutions.com	(317) 507-5725	Voyant Solutions	XtraVision QSR	Yes	Yes				Yes	Yes	Yes	Yes	Yes
Andrew Gaichuk	Manager, Customer Operations	andrew@ecobee.com	(416) 987-1060	ecobee Inc	ecobee EMSSi							Yes	Yes	Yes	
Helen Fairman	Director of Marketing	helen@powerhousedynamics.com	(617) 340-6582 ext. 215	Powerhouse Dynamics	SiteSage		Yes		Yes		Yes	Yes		Yes	
Adam Chalker	Director of Marketing	adamchalker@plotwatt.com	(919) 883-5677	PlotWatt	PlotWatt for Restaurants										
Guy Wellman	VP of Sales	gwellman@profilesystems.com	(219)796-4332	Profile Systems LLC	P1900	Yes	Yes					Yes	Yes	Yes	
Paul Kuck		pkuck@ecova.com	(971) 201-4189	Ecova	N/A										
Jimmy Sandusky	R&D Manager	jimmy.sandusky@halton.com	270.237.5600	Halton Company	Halton EMS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	

APPENDIX 2: SURVEY RESULTS (CONTINUED)

Survey Responses Summary

Name	Title	Email	Phone Number	Company	Product Name	Ice Machine Control (Load-shifting)	Water Heater Runtime Monitoring	Hot Water Temp Monitoring	Dishwasher Consumption Monitoring	Critical Water Temp Monitoring	Kitchen Appliance Energy Monitoring	Comfort Thresholds (Temp, Humidity)	Safety Thresholds (CO, CO_2)
Ifty Hasan	CTO	ifty.hasan@entouchcontrols.com		EnTouch Controls	EnTouch EMS								
Paul Needham	Business Development Manager	paul.needham@kiteandlightning.com	(503) 804-9783	Kite & Lightning	Unity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sean Kennedy	VP Business Development	sean.kennedy@voyantsolutions.com	(317) 507-5725	Voyant Solutions	XtraVision QSR								
Andrew Gaichuk	Manager, Customer Operations	andrew@ecobee.com	(416) 987-1060	ecobee Inc	ecobee EMSSi								
Helen Fairman	Director of Marketing	helen@powerhousedynamics.com	(617) 340-6582 ext. 215	Powerhouse Dynamics	SiteSage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adam Chalker	Director of Marketing	adamchalker@plotwatt.com	(919) 883-5677	PlotWatt	PlotWatt for Restaurants		Yes				Yes		
Guy Wellman	VP of Sales	gwellman@profilesystems.com	(219)796-4332	Profile Systems LLC	P1900	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Paul Kuck		pkuck@ecova.com	(971) 201-4189	Ecova	N/A							Yes	Yes
Jimmy Sandusky	R&D Manager	jimmy.sandusky@halton.com	270.237.5600	Halton Company	Halton EMS	Yes	Yes	Yes		Yes	Yes	Yes	Yes

APPENDIX 2: SURVEY RESULTS (CONTINUED)

Survey Responses Summary														
Name	Title	Email	Phone Number	Company	Product Name	Box Temp Monitoring	Box Temp Control	Compressor Runtime Monitroing	Critical Temp Alerts	On-demand (Smart) Defrost	Describe Smart Defrost (If Available)	Ice Machine Bin Level Monitoring	Ice Machine Runtime Monitoring
Ifty Hasan	CTO	ifty.hasan@entouchcontrols.com		EnTouch Controls	EnTouch EMS	Yes							
Paul Needham	Business Development Manager	paul.needham@kiteandlightning.com	(503) 804-9783	Kite & Lightning	Unity	Yes		Yes	Yes				Yes
Sean Kennedy	VP Business Development	sean.kennedy@voyantsolutions.com	(317) 507-5725	Voyant Solutions	XtraVision QSR	Yes			Yes				
Andrew Gaichuk	Manager, Customer Operations	andrew@ecobee.com	(416) 987-1060	ecobee Inc	ecobee EMSSi	Yes	Yes	Yes	Yes				
Helen Fairman	Director of Marketing	helen@powerhousedynamics.com	(617) 340-6582 ext. 215	Powerhouse Dynamics	SiteSage	Yes		Yes	Yes				Yes
Adam Chalker	Director of Marketing	adamchalker@plotwatt.com	(919) 883-5677	PlotWatt	PlotWatt for Restaurants			Yes	Yes				Yes
Guy Wellman	VP of Sales	gwellman@profilesystems.com	(219)796-4332	Profile Systems LLC	P1900	Yes	Yes	Yes	Yes			Yes	Yes
Paul Kuck		pkuck@ecova.com	(971) 201-4189	Ecova	N/A	Yes	Yes	Yes	Yes				
Jimmy Sandusky	R&D Manager	jimmy.sandusky@halton.com	270.237.5600	Halton Company	Halton EMS	Yes	Yes	Yes	Yes				Yes

APPENDIX 2: SURVEY RESULTS (CONTINUED)

Survey Responses Summary

Name	Title	Email	Phone Number	Company	Product Name	Other:
Ifty Hasan	CTO	ifty.hasan@entouchcontrols.com		EnTouch Controls	EnTouch EMS	
Paul Needham	Business Development Manager	paul.needham@kiteandlightning.com	(503) 804-9783	Kite & Lightning	Unity	The Unity Energy Management System consists of software running on, and interfaced with, industry-standard third-party hardware. This makes it able to be configured to handle a wide range of requirements that are specific to food service operations. Kite and Lightning also offers professional services to our clients based on over 25 years providing energy management systems to the food service industry.
Sean Kennedy	VP Business Development	sean.kennedy@voyantsolutions.com	(317) 507-5725	Voyant Solutions	XtraVision QSR	"XtraVision QSR has a complete integrated work order (ticket) system for closed loop monitoring of all building alarms and repairs. When an out of normal condition is indicated the system generates an alarm and a work order is created by the system. This work order is acknowledged by the customer or our service center and assigned. If the repair is not made in a given period the alarm is created again. This allows all customers to have a closed loop system to manage and ensure system repairs, which are critical to energy savings, are completed. "XtraVision QSR has a complete continuous commissioning and analytics package integrated into our hosted cloud service. This allows us to created Key Performance Indicators (KPI's) to track system performance and find low saving stores. It also has agents continuously running in the background looking for system anomalies and outliers. "XtraVision QSR utilizes a motion sensor in the dining room as a scheduling override. For example, if it is a unscheduled holiday the system will start as it should on a normal day. But if after 15 minutes no motion has been detected the system will go back into set-back mode. "XtraVision QSR has a number of next level features many of our competitors don't provide. This includes advanced HVAC algorithms including RTU Synchronization to ensure units do not fight each other and advanced real time demand control. All RTU's have both a return and supply temp sensor for trouble shooting. All units have actual status feedback (CT's) on all compressors, fans and heating elements. "Finally XtraVision QSR provides a 24/7 call center for system monitoring, alarm triage and support."
Andrew Gaichuk	Manager, Customer Operations	andrew@ecobee.com	(416) 987-1060	ecobee Inc	ecobee EMSSi	
Helen Fairman	Director of Marketing	helen@powerhousedynamics.com	(617) 340-6582 ext. 215	Powerhouse Dynamics	SiteSage	With the SiteSage Controller, we enable remote control and programming of any piece of equipment that has a dedicated electrical circuit.
Adam Chalker	Director of Marketing	adamchalker@plotwatt.com	(919) 883-5677	PlotWatt	PlotWatt for Restaurants	Real-time monitoring of all major kitchen appliances at fraction of the cost of other energy management systems. Failure detection on major equipment. PlotWatt analyzes the data for you and provides alerts and notifications with specific action steps to reduce costs.

APPENDIX 2: SURVEY RESULTS (CONTINUED)

Guy Wellman	VP of Sales	gwellman@profilesystems.com	(219)796-4332	Profile Systems LLC	P1900	Profile Systems LLC can monitor or control anything the end user would want. What we try and tell our Partners (customers) is that we are trying to give them the quickest payback possible (under two years). For this reason we try and concentrate on lighting and HVAC but the good thing about Profile is that we are a Modular system and can be added to at anytime down the line. We are able to flash our units wirelessly with the newest firmware/ software upgrades free of charge, preventing your unit from ever becoming obsolete. At our core, we are a wireless solution (using cellular to communicate to and from the site but can use direct connect or WiFi) and we are wireless on site utilizing Zigbee Technology. We have a system that has an ROI of under two years but when you add in the intangible benefits you have a system that pays you back year after year.
Paul Kuck		pkuck@ecova.com	(971) 201-4189	Ecova	N/A	Hi - Ross Landcaster sent me this survey via Elan Frantz. Ecova doesn't provide an EMS though we have partnered with a couple companies providing different levels of EMS offerings. Varisae, Lucid and Powerhouse Dynamics. What Ecova offers is continuous monitoring of other vendors EMS, but not the equipment itself, generally. So, big box store installs Company ABCs EMS/BMS at their stores and our 24/7 "operations control center" (OCC) monitors and manages the system - receiving and escalating alerts, which could include rolling a truck, dealing with hot/cold compaints, adjusting thermostats or time clocks for changes in store schedules, benchmarking refrigeration equipment, etc. The brands and types of systems we monitor go beyond the three companies listed above. Any info I included in the survey was based on that service of monitoring. Happy to answer questions or put you in contact with people at our OCC based in Atlanta.

APPENDIX 2: SURVEY RESULTS (CONTINUED)

Jimmy Sandusky	R&D Manager	jimmy.sandusky@halton.com	270.237.5600	Halton Company	Halton EMS	Air balancing for the site can be configured in different ways. In the simplest form, start/stop and current/voltage references can be sent to modulate in response to exhaust demand. Options are available to measure zone supply and exhaust volumes at all times and modulate accordingly. Pressure based systems can be configured as necessary. Control algorithms are developed per job based on user requirements. The PLC accommodates a range of sensor types: **Digital Inputs** Quantity: 4 Dry Contact Rating: 12 mA, 30 V Current Leak: Not more than 0.05 mA Isolation: Optical **Analog Inputs** Quantity: 8 Configuration: Jumpers Available Configurations: Voltage: 0 - 2.4 VDC, 0 -10 VDC Current: 4 - 20 mA Dry Contact Rating: 5 mA, 10 V Thermistor: 3 Kohm, 10 Kohm R/TC/RTD: 50 ohm, 100 ohm, 500 ohm, 1000 ohm **Digital Outputs** Quantity: 8 Type: Triacs Voltage Rating: 24 VAC Current Rating: 0.015 A to 0.5 A Maximum Voltage: 48 VAC Voltage Drop: < 2 VAC Galvanically Isolated **Analog Outputs** Quantity: 2 Configuration: Jumpers Available Configurations: 0 – 10 VDC with load > 2 Kohm 0 – 5 mA with load < 2 Kohm 0 – 20 mA with load < 500 ohm

APPENDIX 3: SITE 1SURVEY REPORT FROM ALAN GREER,FRANKE SYSTEMS

Kitchen & Dining RTUs need to have their economizers returned to working condition. Both need new economizer modules and likely need new damper actuators. Economizers run about $75 each and damper actuators are around $200 each and are available on the internet. Actual parts and Installation prices may vary based on your HVAC guy, but this will give you an idea of internet parts pricing. He will also need to check the temperature sensors to make sure they are working as they are part of the economizer package.

Both economizer modules (Honeywell W7459 A 1019) had heavy terminal corrosion and need to be replaced as some terminals are missing. Damper actuator motor (Honeywell M7415A1006) may also need to be replaced. Damper kits appear to be free (not stuck). The service tech should give the system a good check out.

The condenser coils on both units are in medium-to-poor shape, but could probably last another season or two. Between the corrosive salt air and the use of a pressure washer on them, the airflow is not the best. You should have your HVAC guy check system pressures to ensure the coils are working well enough and consider replacing them if they are not.

The store also needs an air balance, which is listed as a requirement in the test agreement letter. I think that will run around $2500. The store is currently running very negative air pressure. Primarily because the fresh air dampers are barely open. Additionally, the exhaust fans also need adjusting, but that will also be done as part of the air balance. Grill hood is pulling about 25% more air than needed, Filet Fryer hood is pulling about 35% more air than needed, and Fry Fryer hood is only pulling about 75% of its rated flow. All of this will be addressed with the air balance performed by Melink, which I will coordinate.

From an Energy Management System perspective, I think we are OK. No real surprises, except that your old lighting control panel timer is not working and the staff is merely turning everything on / off with the a breaker that controls the contactor coils. Our system will return automation to the store lighting.

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