Work Paper SCE17CC008

**Revision 0**

**Southern California Edison**

**Commercial Kitchen Exhaust Hoods Demand Controlled Ventilation**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | FS-20154, FS-17337 |
| **Measure Description** | Commercial Kitchen Exhaust Hoods Demand Controlled Ventilation |
| **Base Case Description** | Commercial kitchen hood with “on” or “off” control strategy |
| **Norm Units** | Each |
| **Energy Savings** | Refer to Excel Calculation Attachment |
| **Full Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Incremental Measure Cost ($/unit)** | Refer to Excel Calculation Attachment |
| **Effective Useful Life** | NEW: 15 years (HVAC-EMS)  REA: 5 years (Motors-fan) |
| **Measure Installation Type** | Retrofit – Add-On (REA), New Construction (NEW) |
| **Net-to-Gross Ratio** | 0.6 (Com-Default>2yrs) |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 11/28/2017 | Lake Casco (TRC) | * New calculation template for 2017 program year * This work paper is an update of SCE13CC008.2 * Added solution code FS-20154 with NEW program type for systems 5,000 CFM or less, with applicable EUL, and code considerations * Included additional eligibility requirements for REA measure based on installed dates to account for Title 24 code applicable at the time. * Updated installed costs. Measure costs are taken from SCE program data and baseline costs for NEW measure are taken from RSMeans 2017. |

# Commission Staff and Cal TF Comments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rev** | **Party** | **Submittal Date** | **Comment Date** | **Comments** | **WP Developer Response** |
|  |  |  |  |  |  |
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Cal TF website: <http://www.caltf.org/>

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper details the replacement of a manual on/off switch and magnetic relay or motor starter ventilation control for commercial kitchen exhaust hoods with a control system that varies the exhaust rate based on the energy and effluent output from the cooking appliances. The measure requires the installation of temperature sensor(s) in the hood exhaust collar or within the hood, and/or an optic sensor on the end of the hood or within the hood that senses cooking conditions and allows the system to automatically vary the rate of exhaust and make-up (ventilation) air by adjusting unit fan speeds accordingly.

**Base, Standard, and Measure Cases**

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | A control system that varies the exhaust rate based on the energy and effluent output from the cooking appliances |
| Existing Condition | Manual on/off switch and magnetic relay or motor starter for commercial kitchen hood |
| Code/Standard | NEW: 2016 Title 24, Section 140.9(b)2B (DCV Kitchen hood for systems 5,000 CFM or greater)  REA: 2013 Title 24, Section 140.9(b)2B (DCV Kitchen hood for systems 5,000 CFM or greater) if existing system installed after 7/1/2014  See Section 1.4.2 for more details. |
| Industry Standard Practice | N/A |

Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
| N/A | N/A | FS-20154 | N/A | Demand Control Ventilation Hood Control (NEW) |
| N/A | N/A | FS-17337 | N/A | Demand Control Ventilation Hood Control (REA) |

**Eligibility Requirements**

When installing a control system for their kitchen exhaust hood, customers must use a Demand Control Kitchen Ventilation System (DCKV) system and also either a temperature or optic sensor that senses cooking conditions. The DCKV system must be used in conjunction with a variable-speed drive (VSD) on the fan motor.

The incentive applies towards the purchase and installation of a new commercial kitchen exhaust hood control system installed in an existing or new dedicated commercial kitchen exhaust hood and makeup air system. See the table below for specific eligibility requirements by solution code, program type and system size.

|  |  |  |  |
| --- | --- | --- | --- |
| **Solution Code** | **Program Type** | **Total Hood Exhaust (CFM)** | **Eligibility Requirements** |
| FS-20154 | NEW | ≤5,000 | Eligible |
| >5,000 | Not Eligible |
| FS-17337 | REA | ≤5,000 | Eligible |
| >5,000 | Existing systems must have been installed before 2013 Title 24 went into effect on 7/1/2014. Please see Section 1.4.2 for more details on code requirements. |

The measures in this workpaper are eligible for all 16 Climate zones, for the building types listed below:

|  |  |
| --- | --- |
| * Education - Primary School | * Health/Medical - Nursing Home |
| * Education - Secondary School | * Lodging – Hotel |
| * Education - Relocatable Classroom | * Office – Large |
| * Education - Community College | * Office – Small |
| * Education – University | * Restaurant - Fast-Food |
| * Grocery | * Restaurant - Sit-Down |
| * Health/Medical – Hospital |  |

**Implementation Requirements**

* A Project Installation Worksheet must be submitted with the rebate application.
* Only pre-approved control systems will qualify for an incentive.
* The customer must provide verification of total exhaust CFM controlled by the new or existing kitchen hood in order to verify eligibility of the measure, based on the eligibility table above.
* For REA measures, customer must provide verification of the installation date that the existing systems kitchen hood system to verify eligibility of the measure, based on the eligibility table above.

## 1.2 Technical Description

Modern commercial kitchen ventilation has advanced beyond basic heat and smoke removal at the lowest first cost, to systems that are more energy efficient and require less maintenance. In addition, there is a greater emphasis on comfort, kitchen indoor air quality, reduced noise levels and improved fire safety.

Conventional kitchen ventilation controls mainly consist of a manual on/off switch and a magnetic relay or motor starter for each fan. Exhaust and makeup air fans operate either at 100% speed or not at all. Occasionally, two-speed motor systems have been employed, which rely on cooks to manually switch from low to high-speed and vice versa, which is an improvement but not a global solution for the lack of control over kitchen exhaust. Today’s state-of-the-art commercial kitchen demand controlled kitchen ventilation (DCKV) system is essentially a demand-ventilation-based energy management system for commercial kitchen exhaust hoods that minimizes fan energy use by reducing the exhaust and makeup air fan speed and associated energy consumption when little or no cooking is occurring. Furthermore, as a function of the exhaust fan speed and associated airflow reduction, outdoor makeup air heating and cooling energy is also reduced. In addition, the kitchen ambient noise level is significantly decreased.

The DCKV system is equipped with sensors and a microprocessor-based controller used in conjunction with variable speed drives for the fan motors, automatically modulating fan speed based on cooking load and/or time of day. The minimum ventilation rate is based on the energy and effluent output from the cooking appliances (i.e., the more heat and smoke/vapor generated, the more ventilation needed). Determining this involves installing temperature sensor(s) in the hood exhaust collar or within the hood, and/or an optic sensor(s) within the hood that senses cooking conditions, allowing the control system to automatically vary the rate of exhaust to what is needed by adjusting the fan speed accordingly. Effective controller programming, performed during system commissioning, that is tailored for each equipment line and accompanying hood achieves optimal performance and savings. Cost-effectiveness for a particular facility increases proportionally with the ventilation system airflow rate, applied fan power and operating time.

## 1.3 Installation Types and Delivery Mechanisms

The delivery method is Financial Support – Down-stream Incentive – Deemed and Midstream Incentive.

The install types available for this workpaper are New Construction (NEW) and Retrofit Add-on (REA). See Section 1.1 for information on eligibility requirements for each install type.

**Installation Type Descriptions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| New Construction (NEW/NC) | Above Code or Standard | N/A | EUL | N/A |
| Retrofit Add-on (REA) | Above Customer Existing | N/A | EUL | N/A |

A delivery mechanism is a delivery method paired with an incentive method. Delivery mechanisms are used by programs to obtain program participation and energy savings.

**Delivery Method Descriptions**

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |
| Mid-Stream Programs | *See Mid-Stream Incentive in the Incentive Method Descriptions table.* |

**Incentive Method Descriptions**

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |
| Mid-Stream Incentive  Mid-Stream Buy Down | The program gives a financial incentive to a midstream market actor (distributor, vendor, or retailer) to encourage the promotion of efficient measures. Buy Down means that the incentive is required to be passed down to the end-use customer. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

The 2017 Database for Energy Efficient Resources (DEER) does not contain demand control ventilation for exhaust hood measures. The only kitchen equipment measures contained in DEER are dishwashers, freezers, refrigerators, and technologies for cooking and food-holding equipment. DEER does contain measures for reducing over-ventilation as well as adding VSDs to supply fan motors on damper-controlled VAV systems, however both of these measures pertain to space conditioning systems that do not operate in the same manner as kitchen hood exhaust systems.

DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | Yes |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | N/A |
| Reason for Deviation from DEER | DEER does not contain this type of measure |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI v.2.4.7 tool. The relevant NTG values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| Com-Default>2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for more than 2 years | Com | Any | Any | 0.6 |

The SCE Savings by Design Program offers incentives on a wide variety of energy-saving design and technologies that encourages design teams and building owners/managers to integrate a higher level of energy efficiency for their new construction and major building renovation projects. As a way to streamline incentivizing energy efficient lighting technologies, SBD offers an “express” way to participate in this opportunity using deemed equipment measures.

The process will direct the customer or their designated representative (customer) to work with an SCE New Construction Representative (NCR). The NCR will determine if the Whole Building Approach (WBA) or Deemed System Approach (DSA) will provide the most benefit to the project.

If the project qualifies for DSA Food Technology measures, the NCR will provide the customer with a coded coupon, which the customer will use when ordering construction or renovation materials for their facility. The customer will receive the rebate incentive by presenting the coupon when applying for the rebate.

The pre-inspection and post-inspection process will follow the process used by SCE’s EE program via which this product is offered. It should be noted, DSA measures apply to new construction and major renovations.

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The IR values were obtained using the DEER READI v.2.4.7 tool. The relevant IR values for the measures in this work paper are in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective and Remaining Useful Life**

The EUL and RUL values were obtained using the DEER READI v.2.4.7 tool. DEER defines the RUL as 1/3 of the EUL value. The relevant EUL and RUL values for the measures in this work paper are in the table below.

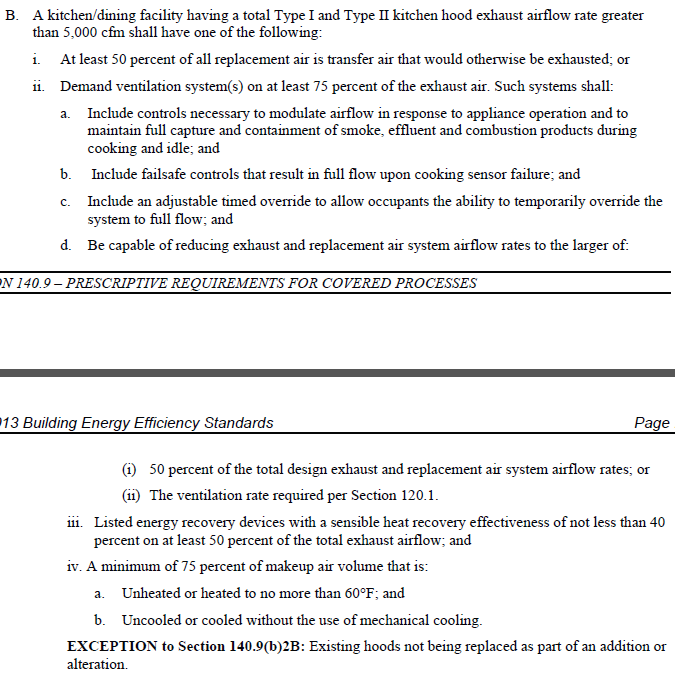
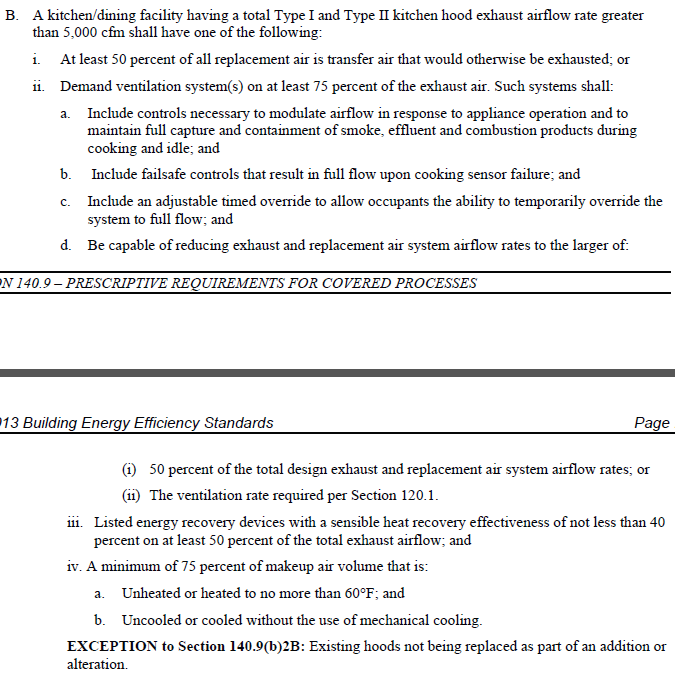
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Install Type** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| HVAC-EMS | NEW | Energy Management System | Com | HVAC | 15 | 5 |
| Motors-fan | REA | HVAC Fan Motors | Com | HVAC | 5 | N/A |

### 1.4.2 Codes and Standards Analysis

**Current Codes**

**2016 Title 24 Code**

Current relevant requirements for commercial kitchen ventilation are contained in Title 24 2016 [496], Section 140.9(b)2B. Section 140.9(b)2B gives requirements for kitchens that have greater than 5,000 cfm total Type I and Type II kitchen hood exhaust and lists four compliance options, one of which is installing demand controlled ventilation on 75% of exhaust air. Type I Hoods are designed to remove heat, smoke, condensation, and other greasy by-products of cooking, whereas, Type II Hoods are equipped to handle heat, steam, vapor, odors and moisture from appliances that do not produce grease. The exact code language is shown below:



These requirements apply to new kitchen exhaust hood installations, while existing hoods are exempt from these requirements.

For new hoods installed in kitchens that have more than 5,000 cfm of total hood exhaust, if a DCKV system is installed and none of the other compliance options are met, the DCKV system would be considered to be required by code. This measure would therefore be at code level and would have no savings beyond code.

In addition to installing DCKV, new kitchens may also comply with code if at least 50% of replacement air is transfer air, energy recovery devices with a minimum sensible effectiveness of 40% are installed on at least 50% of the total exhaust, or at least 75% of makeup air is unheated or heated to a maximum of 60 degrees and uncooled or cooled without mechanical cooling. If one of these alternate compliance options is met, demand controlled kitchen ventilation would not be required by code. However, in these situations the DCKV system would be considered redundant and the energy savings are expected to be reduced.

**Other Current Codes**

2016 Title 20 [508] does not contain any relevant language for DCKV requirements, nor do these measures fall under Federal DOE or EPA Energy Regulations.

**Previous Code Impacts (For REA only)**

For new kitchens that have less than 5,000 cfm of total hood exhaust, the code requirements do not apply and DCKV is an applicable measure.

Existing hoods are exempt from the Title 24 2016 [496] requirements, thus DCKV measures are applicable as REA measures for existing exhaust hood systems installed under previous code requirements. 2013 Title 24 code [355] included identical requirements for DCKV as 2016 Title 24, thus existing systems installed after the implementation of 2013 Title 24 (7/1/2014) which are greater than 5,000 CFM were required to have DCKV. Title 24 versions prior to 2013 Title 24 do not require DCKV. Therefore, systems installed prior to 7/1/2014 were not required to have DCKV, so all sizes are eligible for the Retrofit Add-on (REA) measure.

To summarize, existing hoods 5,000 CFM or less which were installed after to 7/1/2014 and all sized hoods installed prior to 7/1/2014 are not required to have DCKV and are eligible for REA measures.

Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2016) | 2016 Building Energy Efficiency Standards for Residential and Nonresidential Buildings,  Section 140.9(b)2B, pg. 218-219 | January 1, 2017 |
| Title 24 (2013)  (REA only) | 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings,  Section 140.9(b)2B, pg. 218-219 | July 1, 2014 |

## 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

### 1.5.1 Non-DEER Study Review

The base case and measure case data used in this work paper were collected from field-monitored case studies conducted by the PG&E Food Service Technology Center (PG&E FSTC), Southern California Edison Foodservice Technology Center (SCE FTC) and ASHRAE (Attachment 3 and 4) at a total of eleven sites that represent a range of demand controlled ventilation installations. Table below shows the nameplate rated exhaust fan horsepower, the Base Case and Measure Case average fan power and fan energy consumption, and the estimated exhaust fan speed (airflow rate) reduction percentage (calculated using the fan affinity laws relating the fan power to the fan speed) for each facility. The daily energy savings for each site were multiplied by 360 days/year to determine the annual energy savings. The averages of these values are used in this work paper to determine the energy savings for this measure.

**Summary of Demand Controlled Ventilation Case Studies**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Institutional Cafeteria** | **Casual Dining Restaurant** | **Hotel Main Kitchen** | **Supermarket** | **University Dining** | **University Dining** | **Hotel Main Kitchen** | **Hotel Main Kitchen** | **Quick Service Restaurant** | **Quick Service Restaurant** | **Quick Service Restaurant** | **Average** |
| Rated Exhaust Fan Horsepower (HP) | 6 | 3 | 15 | NA | 8 | 20 | 21 | 14 | 3 | 4 | 2.5 | **9.65** |
| Base Case Total Fan Power (kW) | 7.3 | 3.9 | 14.0 | 8.49 | 12.7 | 12.0 | 27.9 | 12.1 | 4.7 | 5.2 | 2.9 | **10.11** |
| Measure Case Total Fan Power (kW) | 1.9 | 2.1 | 5.3 | 2.33 | 5.8 | 6.6 | 10.7 | 5.2 | 2.9 | 2.0 | 1.4 | **4.20** |
| **Fan Power Reduction (kW)** | **5.4** | **1.8** | **8.7** | **6.16** | **6.9** | **5.4** | **17.2** | **6.9** | **1.8** | **3.2** | **1.5** | **5.91** |
| Estimate Exhaust Fan Speed Reduction (%) | 36 | 19 | 28 | 35 | 23 | 18 | 27 | 25 | 15 | 27 | 22 | **25** |
| Base Case Daily Fan Energy Consumption (kWh/day) | 137.90 | 58.90 | 336.00 | 117.90 | 216.60 | 168.00 | 670.00 | 291.00 | 72.00 | 67.00 | 44.00 | **198.12** |
| Measure Case Daily Fan Energy Consumption (kWh/day) | 34.80 | 31.60 | 127.00 | 30.70 | 97.90 | 77.00 | 257.00 | 125.00 | 45.00 | 26.00 | 23.00 | **79.55** |
| Base Case Annual Fan Energy Consumption (kWh/yr) | 49,644 | 21,204 | 120,960 | 42,444 | 77,976 | 60,480 | 241,200 | 104,760 | 25,920 | 24,120 | 15,840 | **71,323** |
| Measure Case Annual Fan Energy Consumption (kWh/yr) | 12,528 | 11,376 | 45,720 | 11,052 | 35,244 | 27,720 | 92,520 | 45,000 | 16,200 | 9,360 | 8,280 | **28,636** |
| **Annual Fan Energy Savings (kWh/yr)** | **37,116** | **9,828** | **75,240** | **31,392** | **42,732** | **32,760** | **148,680** | **59,760** | **9,720** | **14,760** | **7,560** | **42,686** |

To better characterize the commercial kitchen exhaust hood market, SCE FTC, PG&E FSTC, and Honeywell/Melink (a manufacturer of kitchen hood DCKV systems) gathered data from a number of additional commercial kitchen sites with exhaust hood DCKV systems. Exhaust fan horsepower, exhaust cfm, operating hours, and DCKV system cost were documented for a total of 72 sites. This data is summarized in Attachment 5. The averages of these values are used in this work paper to determine the gas savings and cost for this measure.

The total data set used for this workpaper includes the eleven case study sites (Attachment 3 and 4) at which energy consumption was measured for the base and measure cases, and the 72 field sites (Attachment 5) for which DCKV system specifications were documented. Data from both sets was used to inform the savings calculations.

**Support of Savings from 2014 PG&E ET Study**

A more recent study completed in late 2014 by PG&E’s Emerging Technologies Program detailed savings from Energy Management Systems (EMS) and DCKV systems in casual and quick service restaurants (Attachment 4, g - PGE ET13PGE8151 Study). The findings for the DCKV study were compared with the savings approved with this workpaper for like sites. The findings from the study show that the reduction in energy (kWh) and therms support the saving included in this workpaper.

## 1.6 Data Quality and Future Data Needs

N/A

# Section 2. Calculation Methodology

**2.1 Electric Energy Savings Calculation**

The electric energy savings for this measure were based on the eleven case studies conducted by PG&E FSTC and SCE FST (Attachments 3 and 4). The sites were power-meter-monitored with and without the Demand-Controlled Kitchen Ventilation System enabled to obtain Base Case and Measure Case data. The results from the eleven case studies were averaged to obtain the average power reduction values (and estimated average fan speed reduction values to be used later for gas saving calculations). The energy reduction values were divided by the respective rated exhaust fan horsepower values from each site and then averaged to yield a single normalized and unitized savings estimate for incentive simplicity.

The rated exhaust fan horsepower was selected as the single, standard unit of measure because of the larger degree of variance in makeup air system size, type and complexity (e.g., some facilities do not have dedicated make up air units, some have a high percentage of transfer air from rooftop equipment serving areas outside the kitchen, some DCKV systems are installed as exhaust-only controls, etc.) It is important to note that although the energy savings have been normalized to the rated exhaust fan horsepower, the estimated energy savings include both the exhaust fan and the makeup air fan energy of the average system. Note that the electric savings do not account for any coincidental cooling savings due to reduced makeup airflow in the Measure Case.

Fan energy consumption for each case was calculated according to Equation 1.

**Equation 1 Annual Energy Consumption**

*Annual Energy Consumption (kWh/yr) = Power (kW) × Daily Operating Hours × Days Per Year*

Energy consumption was calculated for each of the 11 case study sites assuming 360 days per year. The individual and average savings results for the case studies are listed in section 1.5.1.

The normalized fan energy savings estimate is 4,423 kWh/yr/Exh HP, and the normalized fan energy cost savings estimate is $575/yr/Exh HP. The prescriptive normalized energy reduction and energy cost reduction are summarized in table shown below. See Attachments 3 and 4 for more details.

**Summary of Demand Controlled Kitchen Ventilation Fan Energy Savings\***

|  |  |
| --- | --- |
| **Average Rated Exhaust Fan Power (HP)** | **9.65** |
| Average Base Case Total Fan Power (kW) | 10.11 |
| Average Measure Case Total Fan Power (kW) | 4.20 |
| Average Base Case Annual Fan Energy Consumption (kWh/yr) | 71,323 |
| Average Measure Case Annual Fan Energy Consumption (kWh/yr) | 28,636 |
| Average Annual Fan Energy Savings (kWh/yr) | 42,686 |
| Normalized Base Case Fan Energy Consumption (kWh/yr/Exh HP) | 7,391 |
| Normalized Measure Case Fan Energy Consumption (kWh/yr/Exh HP) | 2,968 |
| Normalized Fan Energy Savings (kWh/yr/Exh HP) | **4,423** |
| Applied Electric Rate ($/kWh) | $0.13 |
| Average Base Case Annual Fan Energy Cost ($/yr) | $9,272 |
| Average Measure Case Annual Fan Energy Cost ($/yr) | $3,723 |
| Average Annual Fan Energy Cost Savings ($/yr) | $5,549 |
| Normalized Fan Energy Cost Savings ($/yr/Exh HP) | **$575** |

\*Based on the average results from eleven case studies

**2.2 Demand Reduction Calculation**

The demand reduction estimation is based on Base Case and Measure Case monitored power data from the eleven PG&E FSTC and SCE FST (Attachments 3 and 4) case study sites. The normalized demand (kW/Exh HP) is based on the average rated exhaust fan horsepower of the eleven case study sites. It is important to note that although the demand reduction has been normalized per rated exhaust fan horsepower, the total system demand reduction reflects the total fan power reduction of the exhaust and makeup air fans of an average system. The normalized demand reduction for the eleven sites was 0.612 kW per rated exhaust fan horsepower. Applying a Coincidence Factor of 0.9 per the DEER methodology [26] yields a Coincident Demand Reduction of 0.551 kW. Table below shows the Base Case and Measure Case demand, and average and normalized demand reduction. See Attachments 3 and 4 for more details.

**Summary of Demand Controlled Kitchen Ventilation Fan Demand Savings\***

|  |  |
| --- | --- |
| **Average Rated Exhaust Fan Power (HP)** | **9.65** |
| Average Base Case Total Fan Power (kW) | 10.11 |
| Average Measure Case Total Fan Power (kW) | 4.20 |
| Average Demand Reduction (kW) | 5.91 |
| Normalized Demand Reduction (kW/Exh HP) | 0.612 |
| Coincident Demand Reduction (kWh/Exh HP) | **0.551** |

\*Based on the average results from eleven case studies

**2.3 Gas Energy Savings Calculation**

Gas energy savings were determined using data from both the eleven case study sites (Attachments 3 and 4) and the 72 field sites (Attachment 5).

The average base case outdoor air load thermal requirements determined by using the Food Service Technology Center (FSTC) Outdoor Airload Calculator (OAC) for the 16 climate zones in California and inputting the average airflow rate and operating time values from the 72 field sites documented by PG&E FSTC, SCE FTC and Honeywell/Melink (Attachment 5). The average values used from the field data included a 14,000 cfm exhaust airflow rate and 17 hours of operation (input time: 7:00 AM to 12 midnight). The outdoor makeup airflow rate was taken to be 11,200 cfm or 80% of the exhaust airflow rate (specification typical rule of thumb). The inputs also assumed a heating setpoint of 65°F, no dehumidification and no lock-out months. The output is summarized in Attachment 6.

The gas energy savings were based on an assumed heating system efficiency of 80%, and a 25% average reduction in fan speed (and thus airflow rate) as determined from the eleven SCE FTC and PG&E FSTC (Attachments 3 and 4) case study sites.

**Equation 2 Annual Gas Savings**

The normalized natural gas savings are based on savings per rated exhaust fan horsepower (correlating average airflow rate cfm to average rated exhaust fan horsepower). The 72-site average was 14.3 rated exhaust fan horsepower. For incentive simplicity, the facility types and the climate zones were averaged to generate a single normalized gas savings value. The normalized natural gas savings for 16 climate zones averaged 101 therms per rated exhaust fan horsepower and ranged between a minimum of 38 and a maximum of 219 therms per rated exhaust fan horsepower. The normalized gas savings summary is shown in Table below. See Attachments 3 and 4 for more details.

**Summary of Gas Savings by Climate Zone**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Climate Zone** | **OAC Output (kBtu/yr)** | **Base Case Heating Energy (kBtu/yr)** | **Measure Case Heating energy (kBtu/yr)** | **Natural Gas Savings (therms/yr)** | **Natural Gas Savings (therms/yr/Exh HP)** |
| 1 | 777,247 | 971,559 | 728,669 | 2,429 | 170 |
| 2 | 609,224 | 761,530 | 571,148 | 1,904 | 133 |
| 3 | 510,934 | 638,668 | 479,001 | 1,597 | 112 |
| 4 | 466,873 | 583,591 | 437,693 | 1,459 | 102 |
| 5 | 486,129 | 607,661 | 455,746 | 1,519 | 106 |
| 6 | 296,319 | 370,399 | 277,799 | 926 | 65 |
| 7 | 245,283 | 306,604 | 229,953 | 767 | 54 |
| 8 | 291,176 | 363,970 | 272,978 | 910 | 64 |
| 9 | 260,834 | 326,043 | 244,532 | 815 | 57 |
| 10 | 312,989 | 391,236 | 293,427 | 978 | 68 |
| 11 | 533,354 | 666,693 | 500,019 | 1,667 | 117 |
| 12 | 539,166 | 673,958 | 505,468 | 1,685 | 118 |
| 13 | 427,560 | 534,450 | 400,838 | 1,336 | 93 |
| 14 | 505,617 | 632,021 | 474,016 | 1,580 | 110 |
| 15 | 165,481 | 206,851 | 155,138 | 517 | 36 |
| 16 | 964,179 | 1,205,224 | 903,918 | 3,013 | 211 |
| **Average** | **462,023** | **577,529** | **433,146** | **1,444** | **101** |

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below.

Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| Education - Primary School | Economy\_cycle-Ret | Small\_Office |
| Education - Secondary School | Economy\_cycle-Ret | Small\_Office |
| Education - Relocatable Classroom | Economy\_cycle-Ret | Small\_Office |
| Education - Community College | Economy\_cycle-Ret | College\_University |
| Education – University | Economy\_cycle-Ret | College\_University |
| Grocery | Economy\_cycle-Ret | Small\_Office |
| Health/Medical – Hospital | Economy\_cycle-Ret | Small\_Office |
| Health/Medical - Nursing Home | Economy\_cycle-Ret | Small\_Office |
| Lodging – Hotel | Economy\_cycle-Ret | Small\_Office |
| Office – Large | Economy\_cycle-Ret | Large\_Office |
| Office – Small | Economy\_cycle-Ret | Small\_Office |
| Restaurant - Fast-Food | Economy\_cycle-Ret | Restaurant |
| Restaurant - Sit-Down | Economy\_cycle-Ret | Restaurant |

# Section 4. Costs

## 4.1 Base Case Cost

The Base Case is a standard commercial kitchen ventilation system with single speed exhaust and makeup air fans, and a simple on/off control. Since the commercial kitchen ventilation system is required for both standard systems and demand controlled ventilation systems, the Base Case cost for the REA measure is zero. For the NEW measure the baseline costs were estimated using RSMeans online (2017) using the cost breakdown as found below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Component** | **Material Cost ($)** | **Labor Cost ($)** | **Total Cost ($)** |
| Fans, Roof Mounted Kitchen Exhaust\* | $1,126.28 | $185.00 | $1,311.28 |
| Kitchen Exhaust Hood | $4,950.00 | $168.00 | $5,118.00 |
| Controller | $248.00 | $221.00 | $469.00 |
| Wiring | $348.00 | $442.00 | $790.00 |
| **Total Cost ($)** | **$6,672.28** | **$1,016.00** | **$7,688.28** |
| **Normalized Cost ($/HP)** | **$5,337.82** | **$812.80** | **$6,150.62** |

\*Since the NEW measure is only applicable to systems 5,000 CFM and under, costs for five kitchen exhaust fans under 5,000 CFM found in RSMeans online (2017) were used to create a linear fit line for both labor and material costs based on horsepower. The linear best fit line (R2=0.9382) was used to extrapolate the labor and material costs based on the average horsepower of 1.25 HP, found from the SCE program data for measure costs of measures under 1.5 HP. Please see Attachment 2, “Base Cost” tab for more details.

No costs were included in the base case for the makeup air units due the variability found in the system type, size and existence.

The total base costs for this measure are found in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Solution Code** | **Install type** | **Base Material Cost ($/HP)** | **Base Labor Cost ($/HP)** | **Total Base Cost ($/HP)** | **Cost ID** |
| FS-20154 | NEW | $5,337.82 | $812.80 | $6,150.62 | SCE17CC008\_00\_B001 |
| FS-17337 | REA | $0.00 | $0.00 | $0.00 | SCE17CC008\_00\_B002 |

## 4.2 Measure Case Cost

The measure costs were obtained using SCE program data for (33) previous installations of the REA measures of exhaust kitchen hood DCV systems from years 2013 to 2017. Based on the data the normalized cost for the DCV kitchen hood controls addition was found to be $3,311.43 per HP (Attachment 2, “SCE Program Data” tab)

For the REA measure, the full measure costs include only the new controls costs for the DCV kitchen hood system. For the new construction measure (NEW), the full measure costs were assumed to include both the installation of the entire kitchen hood system used in the base case costs, and the incremental costs of adding the DCV system. The total measure case cost for both measures can be found below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Solution Code** | **Install type** | **Normalized Measure Cost ($/HP)** | **Total Hood Cost ($/HP)** | **Total Project Cost ($/HP)** | **Cost ID** |
| FS-20154 | NEW | $3,311.43 | $6,150.62 | $9,462.05 | SCE17CC008\_00\_M001 |
| FS-17337 | REA | $3,311.43 | $0.00 | $3,311.43 | SCE17CC008\_00\_M002 |

Please see Attachment 2, “Measure Cost” and “SCE Program Data” tabs for more details.

## Measure costs are adjusted for each climate zone using 2008 DEER cost adjustments for HVAC measures (HVAC50) in Attachment 1.

## 4.3 Full and Incremental Measure Cost

## The FMC includes both materials and labor. See section 4.2 for the calculated FMC.

**Full and Incremental Measure Cost Equations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| NEW | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |
| REA | MEC + MLC | MEC + MLC | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

**Full and Incremental Costs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure** | **Installation Type** | **Incremental Measure Cost ($/HP)** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| FS-20154 | NEW | $3,311.43 | $3,311.43 | N/A |
| FS-17337 | REA | $3,311.43 | $3,311.43 | N/A |

# Attachments

1. SCE17CC008.0 A1 Calculation Templates
2. SCE17CC008.0 A2 Cost Calculations
3. SCE17CC008.0 A3 Savings Studies
4. SCE17CC008.0 A4 Savings Summaries and Calculations
5. SCE17CC008.0 A5 Field System Data
6. SCE17CC008.0 A6 OLC Results

# References

*References\_11152017\_131456*

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