Work Paper SCE13CC011

**Revision 4**

**Southern California Edison**

**Commercial Convection Oven**

**Work Paper PGECOFST101**

**Commercial Convection Oven-Electric and Gas Revision # 6**

**Pacific Gas & Electric Company**

**Customer Energy Solutions**

**Commercial Convection Oven-Electric and Gas** Measure Codes F187, F188

# At a Glance Summary – Electric Convection Ovens

|  |  |  |  |
| --- | --- | --- | --- |
| **Applicable Measure Codes:** | **FS-68320** | **F187 and SCE**  **FS-59869** | **FS-78439** |
| **Measure Description:** | Commercial Half-Size Convection Oven (Electric) | Commercial Full-Size Convection Oven (Electric) | Commercial Large Full-Size Convection Oven (Electric) |
| **Energy Impact Common Units:** | Convection Oven, Each | Convection Oven, Each | Convection Oven, Each |
| **Base Case Description:** | Source: PG&E Calculations Existing Half-Size Electric Convection Oven | Source: PG&E Calculations Existing Full-Size Electric Convection Oven | Source: PG&E Calculations Existing Large Full-Size Electric Convection Oven |
| **Base Case Energy Consumption:** | Source: PG&E Calculations 9,692 kWh/yr | Source: PG&E Calculations 12,193 kWh/yr | Source: PG&E Calculations 14,527kWh/yr |
| **Measure Energy Consumption:** | Source: PG&E Calculations 7,207kWh/yr | Source: PG&E Calculations 9,406 kWh/yr | Source: PG&E Calculations 10,914kWh/yr |
| **Energy Savings (Base Case – Measure)** | Source: PG&E Calculations 2,485\*0.7=**1740** kWh/yr | Source: PG&E Calculations 2,787\*0.7=**1951** kWh/yr | Source: PG&E Calculations 3,613\*0.7=**2529** kWh/yr |
| **Costs Common Units:** | Source: PG&E Calculations  Convection Oven | Source: PG&E Calculations  Convection Oven | Source: PG&E Calculations  Convection Oven |
| **Base Case Equipment Cost ($/unit):** | Source: PG&E Calculations $3,605 | Source: PG&E Calculations $4,108 | Source: PG&E Calculations $7,300 |
| **Measure Equipment Cost ($/unit):** | Source: PG&E Calculations $4,398 | Source: PG&E Calculations $5,115 | Source: PG&E Calculations $7,949 |
| **Measure Incremental Cost ($/unit):** | Source: PG&E Calculations $793 | Source: PG&E Calculations $1,007 | Source: PG&E Calculations $649 |
| **Effective Useful Life (years):** | EULID =  Cook-ElecConvOven  12 years –  Source: 2016 DEER | EULID =  Cook-ElecConvOven  12 years –  Source: 2016 DEER | EULID =  Cook-ElecConvOven  12 years –  Source: 2016 DEER |
| **Program Type:** | Replace on Burnout (ROB), and New Construction (NC). | Replace on Burnout (ROB), and New Construction (NC). | Replace on Burnout (ROB), and New Construction (NC). |
| **Net-to-Gross Ratios:** | Source: 2016 DEER  NTGID= Com-Default>2yrs | Source: 2016 DEER NTGID= Com-Default>2yrs | Source: 2016 DEER NTGID= Com-Default>2yrs |
| **Comments:** | This measure level created for SCE |  | This measure level created for SCE |

# At a Glance Summary – Gas Convection Ovens

|  |  |  |  |
| --- | --- | --- | --- |
| **Applicable Measure Codes:** |  | **F188** |  |
| **Measure Description:** | Commercial Half-Size Convection Oven (Gas) | Commercial Full-Size Convection Oven (Gas) | Commercial Large Full-Size Convection Oven (Gas) |
| **Energy Impact Common Units:** | Convection Oven, Each | Convection Oven, Each | Convection Oven, Each |
| **Base Case Description:** | Source: PG&E Calculations Existing Half-Size Gas Convection Oven | Source: PG&E Calculations Existing Full-Size Gas Convection Oven | Source: PG&E Calculations Existing Large Full-Size Gas Convection Oven |
| **Base Case Energy Consumption:** | Source: PG&E Calculations 769 Therms/yr | Source: PG&E Calculations 1,052 Therms/yr | Source: PG&E Calculations 1,205 Therms/yr |
| **Measure Energy Consumption:** | Source: PG&E Calculations 538 Therms/yr | Source: PG&E Calculations 695 Therms/yr | Source: PG&E Calculations 749 Therms/yr |
| **Energy Savings (Base Case – Measure)** | Source: PG&E Calculations 231\*0.7=**162**  Therms/yr | Source: PG&E Calculations 357 \*0.7=**250** Therms/yr | Source: PG&E Calculations 456 \*0.7=**319** Therms/yr |
| **Costs Common Units:** | Source: PG&E Calculations Convection Oven | Source: PG&E Calculations Convection Oven | Source: PG&E Calculations Convection Oven |
| **Base Case Equipment Cost ($/unit):** | Source: PG&E Calculations $3,614 | Source: PG&E Calculations $4,349 | Source: PG&E Calculations $N/A |
| **Measure Equipment Cost ($/unit):** | Source: PG&E Calculations $4,104 | Source: PG&E Calculations $5,635 | Source: PG&E Calculations $N/A |
| **Measure Incremental Cost ($/unit):** | Source: PG&E Calculations $490 | Source: PG&E Calculations $1,286 | Source: PG&E Calculations $N/A |
| **Effective Useful Life (years):** | EULID =  Cook-GasConvOven  12 years –  Source: 2016 DEER | EULID =  Cook-GasConvOven  12 years –  Source: 2016 DEER | EULID =  Cook-GasConvOven  12 years –  Source: 2016 DEER |
| **Program Type:** | Replace on Burnout (ROB), and New Construction (NC). | Replace on Burnout (ROB), and New Construction (NC). | Replace on Burnout (ROB), and New Construction (NC). |
| **Net-to-Gross Ratios:** | Source: 2016 DEER  NTGID= Com-Default>2yrs | Source: 2016 DEER NTGID= Com-Default>2yrs | Source: 2016 DEER NTGID= Com-Default>2yrs |
| **Important Comments:** | This measure level created for SCG |  | This measure level created for SCG |

# Document Revision History

**Revision # Date Description Author (Company)**

|  |  |  |  |
| --- | --- | --- | --- |
| Revision 0 | 12/12/2007 | Original work paper: Commercial Convection Oven PGECOFST101 R0.doc | David Zabrowski (Fisher-Nickel, Inc.) |
| |  | | --- | | Revision 1 | | |  | | --- | | 6/1/09 | | |  | | --- | | Changes to EUL, NTG language and references, costs updated | | |  | | --- | | David Zabrowski, Lauren Mills (Fisher-Nickel, inc.), Steve Blanc PG&E | |
| Revision 2 | 3/31/2010 | Updated pricing and incremental cost, Changes to align with new Energy Star specification, Update to DEER 2009-11 NTG file | David Zabrowski (Fisher-Nickel, inc.), Steve Blanc PG&E |
| Revision 3 | 7/27/2011 | Updated measure codes for 2010-12 program, included ED comments and UES reduction in savings by 30% in sections 2.3 and 2.3 | Charlene Spoor PG&E (CLCI) |
| Revision 4 | 6/5/2012  8/22/2012 | Updated NTG, EUL, IMC, and savings analysis  Updated BLD, CZ, VIN to ANY per READI tool requirements | David Zabrowski (Fisher-Nickel, inc.)  Charlene Spoor (PG&E) |
| Revision 5 | 3/14/14 | Updated T&C’s to match savings in Energy Star V 2.1, updated cost and savings data for new level. New WP template. | David Zabrowdki (Fni) Charlene Spoor (PG&E) |
| Revision 6 | 3/25/2016 | Updated Format | Denis Livchak (Fisher-Nickel) |
| Revision 6 | 8/8/2016 | The 30% UES reduction was dropped and it is incorporated in this revision. Updated calc tables to match online calculator ; updated formulas and incorporated examples | Alina Zohrabian (PG&E)  Mini Damodaran (PG&E) |

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# Section 1. General Measure & Baseline Data

## 1.1 Product Measure Description & Background

## 1.1 Measure Description & Background

This work paper documents the rationale for the Energy-Efficient Commercial Convection Oven (Electric and Gas) measures as listed in the Commercial Food Service Catalog. The Commercial Food Service Catalog is part of Pacific Gas and Electric Company’s Customer Energy Efficiency Program. PG&E offers incentives to non-residential customers for installing qualifying lighting, refrigeration, air-conditioning, food service, and agricultural equipment. All qualifying models must be listed in the California Energy Commissions Database and must meet the following minimum criteria.

***Catalog Description –***

**SCE Measure:** The half-size electric oven must meet ENERGY STAR® specifications or have a tested heavy load potato cooking energy efficiency ≥ 71% and idle rate ≤ 1.0 kW utilizing ASTM Standard F1496.[[1]](#endnote-1)

**F187**: The full-size (≤ 5 pans) electric oven must meet ENERGY STAR® specifications or have a tested heavy load potato cooking energy efficiency ≥ 71% and idle rate ≤ 1.6 kW utilizing ASTM Standard F1496.

**SCE Measure**: The large full-size (> 5 pans) electric oven must have a tested heavy load potato cooking energy efficiency ≥ 73% and idle rate ≤ 1.9 kW utilizing ASTM Standard F1496.

**SCG Measure:** The half-size gas oven must have a tested heavy load potato cooking energy efficiency ≥ 46% and idle rate ≤ 8,000 Btu/h utilizing ASTM Standard F1496.

**F188:** The full-size (≤ 5 pans) gas oven must meet ENERGY STAR® specifications or have a tested heavy load cooking energy efficiency ≥ 46% and idle rate ≤ 12,000 Btu/h utilizing ASTM Standard F1496.

**SCG Measure:** The large full-size (> 5 pans) gas oven must have a tested heavy load potato cooking energy efficiency ≥ 46% and idle rate ≤ 13,000 Btu/h utilizing ASTM Standard F1496.

**SCE1, SCE2, SCG3, SCG4:** Southern California Edison and Southern California Gas have further broken down the measure by size, separating out half size and large full size for both electric and gas technologies.

***Program Restrictions and Guidelines***

***Terms and Conditions***

F187 and F188: The rebate is **downstream** provided to the **customer** at the time of sale upon receipt of application and invoice. This is not a direct install program.

***Market Applicability***

This measure is applicable to any commercial cooking application, including (but not limited to) casual dining and quick service restaurants, hotels, motels, schools, colleges and recreational facilities. Installations across all climate zones, building types and building vintages in the PG&E Service Territory may apply.

These measures includes new commercial electric or gas convection ovens that are ENERGY STAR® qualified[[2]](#endnote-2) or meet the qualifications listed in table below. ENERGY STAR® maintains an updated list of qualifying products and specifications at www.energystar.gov. Consult with the manufacturer or manufacturer’s representative to determine if non-ENERGY STAR® qualified model meets the efficiency requirements. Used or rebuilt equipment is not eligible. Customers must provide proof that the appliance has a cooking-energy efficiency that meets the requirements.

Table-1: Energy Efficiency Requirements for Commercial Convection Ovens

|  |  |  |  |
| --- | --- | --- | --- |
| Measure Code | **Convection oven Type** | **Cooking-Energy Efficiency\*** | **Idle Energy Rate** |
|  | Electric Half-Size Convection Ovens | ≥ 71% | ≤ 1 kW |
| F187 | Electric Full-Size (≤ 5 pans) Convection Ovens | ≥ 71% | ≤ 1.6 kW |
|  | Electric Full-Size (> 5 pans) Convection Ovens | ≥ 73% | ≤ 1.9 kW |
|  | Gas Half-Size Convection Ovens | ≥ 46% | ≤ 8,000 Btu/h |
| F188 | Gas Full-Size (≤ 5 pans) Convection Ovens | ≥ 46% | ≤ 12,000 Btu/h |
|  | Gas Full-Size (> 5 pans) Convection Ovens | ≥ 46% | ≤ 13,000 Btu/h |

\*Based on the heavy-load potato test in ASTM F14961.

## 1.2 Product Technical Description

Commercial convection ovens are the most widely used appliances in the food service industry. Many food service operations rely heavily on the versatility of ovens. Operators can cook varieties of foods in large quantities with a single appliance. An oven can be simply described as a fully enclosed, insulated chamber used to heat food. With competition rising among equipment manufacturers, new designs that incorporate timesaving features via sophisticated control packages are being introduced.

Ovens represent the largest appliance category in terms of the types of units manufactured of any of the major cooking equipment categories. This versatility and diversity mean that they can be found in almost any type of food service operation. A recent US study showed that 95% of commercial (non-institutional) operations reported using at least one type of oven; 98% of noncommercial (institutional) operations reported the same. The percentage of operations, commercial and institutional, using general bake ovens was 52% and 56%, respectively. Fifty percent of the operations in the commercial sector reported using convection ovens as compared to 83% of noncommercial operations.[[3]](#endnote-3) <http://www.energy.ca.gov/reports/2003-04-10_500-03-007F.PDF>

Convection oven performance is determined by applying the ASTM Standard Test Method for the Performance of Convection Ovens (F1496).The ASTM standard test method is considered to be the industry standard for quantifying the energy consumption, efficiency and cooking performance of convection ovens.

In 2013, ASTM F1496 was updated to accommodate a wider range of oven cavity sizes. The Energy Star v2.1 specification for commercial ovens now references the updated ASTM standard in addition to tightening the idle rate requirements for gas full-size convection ovens.

## 1.3 Measure Application Types

Table-2: Measure Application Type

|  |  |  |
| --- | --- | --- |
| **Code** | **Description** | **Comment** |
| ER | Early retirement | *measure applied while existing equipment still viable, or retrofit of existing equipment* |
| ROB | Replace on Burnout | *measure applied when existing equipment fails or maintenance requires replacement* |
| NC | New Construction | *measure applied during construction design phase as an alternative to a code-compliant standard design* |

Since there are no EM&V studies on the useful life of commercial convection ovens and it is standard practice in the commercial foodservice industry to purchase equipment only when it is needed (e.g., replacement or additional capacity), this measure is focused on ROB and NC applications only.

## 1.4 Product Base Case and Measure Case Data

### 1.4.1 DEER Base Case and Measure Case Information

The DEER database does not contain information on energy use or savings for an energy-efficient electric or gas commercial convection oven measure. The only reference in DEER for Commercial cooking equipment is for Estimated Useful Life.

**Hours of Operation**

This Work Paper assumes a 12-hour daily operating period over 365 days per year, or 5,110 hours per year. Annual hours of operation were based on market based research in collaboration with the California Energy Commission found in Appendix E Table E-4: <http://www.energy.ca.gov/2014publications/CEC-500-2014-095/CEC-500-2014-095.pdf>

12 hrs /day \* 365 day/ yr = 4380 hrs

**Base Case & Measure Case Costs**

The base case and measure case costs are calculated are found in section 4.

***Net-to-Gross Assumptions***

DEER NTGR Values file does not specifically list commercial food service appliances The default used for non-residential measures is 0.6[[4]](#endnote-4).

All applicable DEER based Net-to-Gross ratios for programs that may be used by this measure are shown below.

Table-3: DEER 2016 Net-to-Gross Ratios

|  |  |
| --- | --- |
|  |  |
| NTG-ID | NTG |
| Com-Default>2yrs | 0.6 |

**Effective Useful Lives**

DEER database shows a EUL of 12 years and an RUL of 4 years[[5]](#endnote-5) for all cooking appliance measures, including electric and gas commercial convection ovens.

Table-4: DEER Effective Useful Life

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Code** | **EUL (yrs)** | **RUL (yrs)** | **DEER Version** | **EULID** |
| F187 | 12 | N/A | DEER2016 | Cook- ElecConvOven |
| F188 | 12 | N/A | DEER2016 | Cook- GasConvOven |

**In Service Rate/ First Year Installation Rate**

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

Table-5: Installation Rate

|  |  |  |  |
| --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Com | 1 |

### 1.4.2 Codes & Standards Requirements Base Case and Measure Information

#### California Title 20

California Title 20 Appliance Efficiency Standards does require reporting the convection oven idle energy rate per ASTM F1496 for the CEC Appliance Database, but the standard contains no minimum performance requirement.[[6]](#endnote-6)

#### California Title 24

There are no State of California Title 24 Efficiency Regulation requirements for commercial convection ovens.

**Federal**

There are no Federal energy efficiency requirements for commercial convection ovens.

#### American Society for Testing and Materials (ASTM) Standards

ASTM Standards: ASTM Standard Test Method for thePerformance of Convection ovens (F1496) is applicable for estimating energy use and cooking performance. It was used to estimate the energy consumption of the base case and measure equipment.

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

There were no specific EM&V studies identified that addressed cooking measures in the commercial sector.

### 1.4.4 Assumptions and Calculations from other sources—Base and Measure Cases

This Work Paper uses ASTM Standard Test Method for thePerformance of Convection Ovens (F1496) for calculation of energy use and demand, based on testing in an approved and qualified laboratory. In the absence of mandatory regulations for testing commercial ovens, there is little incentive on the part of equipment manufacturers to have their baseline equipment tested. Therefore, the ASTM performance parameters for baseline equipment were drawn from a sample of economy grade equipment tested by the Food Service Technology Center.

Table-6: Baseline ASTM Test Results for Commercial Convection Ovens

|  |  |  |  |
| --- | --- | --- | --- |
| **Convection Oven Type** | **Idle Energy Rate** | **Cooking-Energy Efficiency\*** | **Production Capacity\*** |
| Electric Half-Size | 1,500 W | 65% | 45 lb/h |
| Electric Full-Size | 2,000 W | 65% | 70 lb/h |
| Electric Large Full-Size | 2,500 W | 65% | 100 lb/h |
| Gas Half-Size | 12,000 Btu/h | 30% | 45 lb/h |
| Gas Full-Size | 18,000 Btu/h | 30% | 70 lb/h |
| Gas Large Full-Size | 21,000 Btu/h | 30% | 100 lb/h |

\*Based on the Heavy-load potato test in ASTM F14961.

The measure case data was drawn from the list of commercial convection ovens that have been tested by The PG&E Food Service Technology Center in San Ramon, the Southern California Gas Company Foodservice Equipment Center in Downey and the Southern California Edison Foodservice Technology Center in Irwindale.

Table-7: Measure Case ASTM Test Results for Commercial Convection Ovens

|  |  |  |  |
| --- | --- | --- | --- |
| **Convection Oven Type** | **Idle Energy Rate** | **Cooking-Energy Efficiency\*** | **Production Capacity\*** |
| Electric Half-Size | 830 W | 73% | 52 lb/h |
| Electric Full-Size | 1,380 W | 74% | 85 lb/h |
| Electric Large Full-Size | 1,730 W | 76% | 137 lb/h |
| Gas Half-Size | 8,500 Btu/h | 53% | 47 lb/h |
| Gas Full-Size | 10,339 Btu/h | 49% | 88 lb/h |
| Gas Large Full-Size | <13,000Btu/h | 46% | 100 lb/h |

\*Based on the Heavy-load potato test in ASTM F1496.1

The Food Service Technology Center conducted an assessment of major commercial cooking appliance technologies in 2002, which included a chapter on ovens.[[7]](#endnote-7) The study showed that oven efficiency varies from 10% to 80%, based on primary fuel source and oven type (convection, combination, conventional, etc.). A further Food Service Technology Center study included convection oven performance data, which suggests a baseline efficiency of 65% for electric convection ovens and 30% gas convection ovens, respectively.[[8]](#endnote-8)

Since the current Title 20 regulations do not include a minimum performance requirement for convection ovens, the base case for existing models of electric convection ovens was determined from Table 3-2 in the Food Service Technology Center study.3

#### Hours of Operation

This measure would follow the hours of operation for quick serve and full serve restaurants as noted in the ASTM standards. For this measure annual hours of operation are considered 4380. Annual hours of operation were based on market based research in collaboration with the California Energy Commission found in Appendix E: <http://www.energy.ca.gov/2014publications/CEC-500-2014-095/CEC-500-2014-095.pdf> .

12 hrs /day \* 365 day/ yr = 4380 hrs

Effective Useful Life: EUL values were downloaded and used directly from DEER

DEER2016 database shows a EUL of 12 years and an RUL of 4 years6 for all cooking appliance measures, including electric and gas convection ovens.

Net-to-Gross Assumption: NTG values were downloaded and used directly from DEER.

In-service rate/first year installation rate: ISR is assumed to be 1 based on engineering expertise.

### 1.4.5 Time of use Adjustment Factor

The TOU adjustment factor for all non A/C measures is 0.

# Section 2. Calculation Methods

**The UES (Unit Energy Savings) savings are adjusted based on Decision 11-07-030, and comments in Attachment A, which stated “Energy Division believes that operating hours, food production rates and baseline efficiencies contribute to overly optimistic UES calculations and recommend a 30% reduction in UES values”. Therefore the final claimable UES numbers are adjusted down 30% and shown in table below.**

Table 8: Final claimable savings

|  |  |  |
| --- | --- | --- |
| **Performance** | **Estimated savings** | **Claimable savings after 30% reduction** |
| Commercial Half-Size Convection Oven (Electric) - Annual kWh savings | **2,485** | **2,485\*0.7=1740** |
| Commercial Full-Size Convection Oven (Electric) - Annual kWh savings | **2,787** | **2,787\*0.7=1951** |
| Commercial Large Full-Size Convection Oven (Electric) - Annual kWh savings | **3,613** | **3,613\*0.7=2529** |
| Commercial Half-Size Convection Oven (Electric) - Peak kW savings | **0.54** | **0.54\*0.7=0.378** |
| Commercial Full-Size Convection Oven (Electric) - Peak kW savings | **0.63** | **0.63\*0.7=0.441** |
| Commercial Large Full-Size Convection Oven (Electric) - Peak kW savings | **0.747** | **0.747\*0.7=0.553** |
| Commercial Half-Size Convection Oven (Gas) - Annual therm savings | **231** | **231\*0.7=162** |
| Commercial Full-Size Convection Oven (Gas)- Annual therm savings | **357** | **357\*0.7=250** |
| Commercial Large Full-Size Convection Oven (Gas)- Annual therm savings | **456** | **456\*0.7=319** |

## 

## 

## 2.1 Electric Energy Savings Estimation Methodologies

The industry standard for energy use and cooking performance of convection ovens is ASTM Standard Test Method for thePerformance of Convection ovens (F1496). Tables 9 - 11 show examples of the calculation results for electric convection ovens based on ASTM F1496 test results. To simplify the calculation the preheat time is assumed to be 15 min, since the industry standard preheat time is from 10-20min.

Table-9: Commercial Electric Half-Size Convection Oven Cost-Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Baseline Model** | **Energy Efficient Model** |
| Preheat Energy (kWh) | 1.00 | 0.90 |
| Idle Energy Rate (kW) | 1.5 | 0.88 |
| Heavy Load Cooking Energy Efficiency (%) | 65 | 72 |
| Production Capacity (lbs/hr) | 45 | 53 |
| Operating Hours/Day | 12 | 12 |
| Operating Days/Year | 365 | 365 |
| Number of Preheats per Day | 1 | 1 |
| Pounds of Food Cooked per Day | 100 | 100 |
| ASTM Energy to Food (kWh/lb)a | 0.0732 | 0.0732 |
| Daily Energy Consumption (kWh) | 26.6 | 19.7 |
| Average Demand (kW) | 2.2 | 1.6 |
| Estimated Demand Reduction (kW) | - | 0.6 |
| Actual Demand Reduction with CDF of 0.9 (kW) | - | **0.54** |
| Annual Energy Consumption (kWh) | 9,692 | 7,207 |
| Estimated Energy Savings (kWh/yr) | - | **2,485** |
| Estimated Useful Life (EUL)b | 12 years | 12 years |

a  This is the average value calculated by FSTC through ASTM F1496 test through weight and temperature measurement of test product cooked in convection ovens (250 Btu/lb for russet potato); 250/3412=0.0732 kWh/lb) [http://www.fishnick.com/publications/appliancereports/convectionovens/](https://urldefense.proofpoint.com/v2/url?u=http-3A__www.fishnick.com_publications_appliancereports_convectionovens_&d=CwMFAg&c=hLS_V_MyRCwXDjNCFvC1XhVzdhW2dOtrP9xQj43rEYI&r=TlrXy5TrK8nTfd5c4pv-ow&m=xiQt0BJefxi1OOdFkKZw68uwF1ADiFrzRTcIJvZNzVQ&s=k--GDCdnQ_T7bin0pEeeBnubYisig4zpIhizmi6w_b0&e=)

b  The estimated useful life is based on DEER EUL estimates.

Table-10: Commercial Electric Full-Size Convection Oven Cost-Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Baseline Model** | **Energy Efficient Model** |
| Preheat Energy (kWh) | 1.50 | 1.00 |
| Idle Energy Rate (kW) | 2.00 | 1.40 |
| Heavy Load Cooking Energy Efficiency (%) | 65 | 73 |
| Production Capacity (lbs/hr) | 70 | 82 |
| Operating Hours/Day | 12 | 12 |
| Operating Days/Year | 365 | 365 |
| Number of Preheats per Day | 1 | 1 |
| Pounds of Food Cooked per Day | 100 | 100 |
| ASTM Energy to Food (kWh/lb)a | 0.0732 | 0.0732 |
| Daily Energy Consumption (kWh) | 33.4 | 25.8 |
| Average Demand (kW) | 2.8 | 2.1 |
| Estimated Demand Reduction (kW) | - | 0.7 |
| Actual Demand Reduction with CDF of 0.9 (kW) | - | **0.63** |
| Annual Energy Consumption (kWh) | 12,193 | 9,406 |
| Estimated Energy Savings (kWh/yr) | - | **2,787** |
| Estimated Useful Life (EUL)b | 12 years | 12 years |

a  This is the average value calculated by FSTC through ASTM F1496 test through weight and temperature measurement of test product cooked in convection ovens (250 Btu/lb for russet potato); 250/3412=0.0732 kWh/lb) [http://www.fishnick.com/publications/appliancereports/convectionovens/](https://urldefense.proofpoint.com/v2/url?u=http-3A__www.fishnick.com_publications_appliancereports_convectionovens_&d=CwMFAg&c=hLS_V_MyRCwXDjNCFvC1XhVzdhW2dOtrP9xQj43rEYI&r=TlrXy5TrK8nTfd5c4pv-ow&m=xiQt0BJefxi1OOdFkKZw68uwF1ADiFrzRTcIJvZNzVQ&s=k--GDCdnQ_T7bin0pEeeBnubYisig4zpIhizmi6w_b0&e=)

b  The estimated useful life is based on DEER EUL estimates.

Table-11: Commercial Electric Large Full-Size Convection Oven Cost-Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Baseline Model** | **Energy Efficient Model** |
| Preheat Energy (kWh) | 1.70 | 1.20 |
| Idle Energy Rate (kW) | 2.50 | 1.73 |
| Heavy Load Cooking Energy Efficiency (%) | 65% | 76% |
| Production Capacity (lbs/hr) | 100 | 137 |
| Operating Hours/Day | 12 | 12 |
| Operating Days/Year | 365 | 365 |
| Number of Preheats per Day | 1 | 1 |
| Pounds of Food Cooked per Day | 100 | 100 |
| ASTM Energy to Food (kWh/lb)a | 0.0732 | 0.0732 |
| Daily Energy Consumption (kWh) | 39.8 | 29.9 |
| Average Demand (kW) | 3.3 | 2.5 |
| Estimated Demand Reduction (kW) | - | 0.83 |
| Actual Demand Reduction with CDF of 0.9 (kW) | - | **0.747** |
| Annual Energy Consumption (kWh) | 14,527 | 10,914 |
| Estimated Energy Savings (kWh/yr) | - | **3,613** |
| Estimated Useful Life (EUL)b | 12 years | 12 years |

a  This is the average value calculated by FSTC through ASTM F1496 test through weight and temperature measurement of test product cooked in convection ovens (250 Btu/lb for russet potato); 250/3412=0.0732 kWh/lb) [http://www.fishnick.com/publications/appliancereports/convectionovens/](https://urldefense.proofpoint.com/v2/url?u=http-3A__www.fishnick.com_publications_appliancereports_convectionovens_&d=CwMFAg&c=hLS_V_MyRCwXDjNCFvC1XhVzdhW2dOtrP9xQj43rEYI&r=TlrXy5TrK8nTfd5c4pv-ow&m=xiQt0BJefxi1OOdFkKZw68uwF1ADiFrzRTcIJvZNzVQ&s=k--GDCdnQ_T7bin0pEeeBnubYisig4zpIhizmi6w_b0&e=)

b  The estimated useful life is based on DEER EUL estimates..

**Daily Energy Consumption Calculation and Definitions**

Where:

|  |  |
| --- | --- |
| EDAY = | Calculated Daily Energy Consumption (kWh/day) |
| LBFOOD = | Estimated Pounds of Food Cooked per Day |
| EFOOD = | ASTM Energy to Food (kWh/lb) = kWh/pound of energy absorbed by food product during cooking based on ASTM F1496 |
| EFFICIENCY = | Measured Heavy Load Cooking Energy Efficiency % |
| IDLE RATE = | Measured Idle Energy Rate (kW) |
| EHOU = | Estimated Operating Hours/Day |
| PC = | Measured Production Capacity (lbs/hr) |
| TP = | Estimated Preheat Time (min) |
| nP = | Estimated Number of preheats/Day |
| EP = | Measured Preheat Energy (kWh) |

**Daily Energy Consumption Example:**

Hand calculation may generate slightly different number due to rounding to significant digits.

## 2.2. Demand Reduction Estimation Methodologies

An oven’s actual contribution to a building’s peak demand may vary significantly depending on its usage pattern in relation to that of other electric equipment in the facility (operating schedule, appliance on time, etc.). The probability of an appliance drawing its average rate during the period that the building peak is set is significantly higher than for any other input rate for that appliance. Therefore, it has been assumed that the probable contribution to the building’s peak demand is equal to the appliance’s average demand.

The demand reduction estimation is based on measured data for standard efficiency electric convection ovens and for high-efficiency convection ovens. The measured data are derived from tests conducted under ASTM Standard Test Method for thePerformance of Convection ovens (F1496).

ASTM F1496 provides standard conditions under which convection oven energy use is measured. The estimated demand reduction of 600 Watts for a Half-Size oven, 700 Watts for a Full-Size oven and 830 Watts for a Large Full-Size oven is based on data from tests of standard efficiency and high efficiency convection ovens. Applying a Coincidence Factor of 0.9 for food service establishments using the professional judgement of the Food Service Technology Center, yields a Demand Savings of 540 Watts for a Half-Size oven, 630 Watts for a Full-Size oven and 747 Watts for a Large Full-Size oven.

## 2.3. Gas Energy Savings Estimation Methodologies

The industry standard for energy use and cooking performance of convection ovens is ASTM Standard Test Method for thePerformance of Convection ovens (F1496). Tables 12 - 14 show examples of the calculation results under ASTM F1496. To simplify the calculation the preheat time is assumed to be 15 min, since the industry standard preheat time is from 10-20min.

Table-12: Commercial Gas Half-Size Convection Oven Cost Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Base Model** | **Energy Efficient Model** |
| Preheat Energy (Btu) | 13,000 | 7,500 |
| Idle Energy Rate (Btu/hr) | 12,000 | 8,500 |
| Cooking-Energy Efficiency (%) | 30 | 45 |
| Production Capacity (lb/hr) | 45 | 55 |
| Operating Hours/Day | 12 | 12 |
| Operating Days/Year | 365 | 365 |
| Number of Preheats per Day | 1 | 1 |
| Pounds of Food Cooked per Day | 100 | 100 |
| ASTM Energy to Food (Btu/lb)a | 250 | 250 |
| Daily Energy Consumption (Btu) | 210,672 | 147,~~4~~80 |
| Annual Energy Consumption (therms)b | 769 | 538 |
| Estimated Energy Savings (therms/yr) | - | **231** |
| Estimated Useful Life (EUL)c | 12 years | 12 years |

a This is the average value calculated by FSTC through ASTM F1496 test through weight and temperature measurement of test product cooked in convection ovens (250 Btu/lb for russet potato)

[http://www.fishnick.com/publications/appliancereports/convectionovens/](https://urldefense.proofpoint.com/v2/url?u=http-3A__www.fishnick.com_publications_appliancereports_convectionovens_&d=CwMFAg&c=hLS_V_MyRCwXDjNCFvC1XhVzdhW2dOtrP9xQj43rEYI&r=TlrXy5TrK8nTfd5c4pv-ow&m=xiQt0BJefxi1OOdFkKZw68uwF1ADiFrzRTcIJvZNzVQ&s=k--GDCdnQ_T7bin0pEeeBnubYisig4zpIhizmi6w_b0&e=)

b 1 therm = 100,000 Btu..

C The estimated useful life is based DEER EUL estimates.

Table-13: Commercial Gas Full-Size Convection Oven Cost Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Base Model** | **Energy Efficient Model** |
| Preheat Energy (Btu) | 19,000 | 11,000 |
| Idle Energy Rate (Btu/hr) | 18,000 | 11,758 |
| Cooking-Energy Efficiency (%) | 30 | 45 |
| Production Capacity (lb/hr) | 70 | 83 |
| Operating Hours/Day | 12 | 12 |
| Operating Days/Year | 365 | 365 |
| Number of Preheats per Day | 1 | 1 |
| Pounds of Food Cooked per Day | 100 | 100 |
| ASTM Energy to Food (Btu/lb)a | 250 | 250 |
| Daily Energy Consumption (Btu) | 288,120 | 190,548 |
| Annual Energy Consumption (therms)b | 1,052 | 695 |
| Estimated Energy Savings (therms/yr) | - | **357** |
| Estimated Useful Life (EUL)c | 12 years | 12 years |

a This is the average value calculated by FSTC through ASTM F1496 test through weight and temperature measurement of test product cooked in convection ovens (250 Btu/lb for russet potato)

[http://www.fishnick.com/publications/appliancereports/convectionovens/](https://urldefense.proofpoint.com/v2/url?u=http-3A__www.fishnick.com_publications_appliancereports_convectionovens_&d=CwMFAg&c=hLS_V_MyRCwXDjNCFvC1XhVzdhW2dOtrP9xQj43rEYI&r=TlrXy5TrK8nTfd5c4pv-ow&m=xiQt0BJefxi1OOdFkKZw68uwF1ADiFrzRTcIJvZNzVQ&s=k--GDCdnQ_T7bin0pEeeBnubYisig4zpIhizmi6w_b0&e=)

b 1 therm = 100,000 Btu..

C The estimated useful life is based on DEER EUL estimates.

Table-14: Commercial Gas Large Full-Size Convection Oven Cost Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Base Model** | **Energy Efficient Model** |
| Preheat Energy (Btu) | 21,000 | 11,000 |
| Idle Energy Rate (Btu/hr) | 21,000 | 13,000 |
| Cooking-Energy Efficiency (%) | 30% | 46% |
| Production Capacity (lb/hr) | 100 | 100 |
| Operating Hours/Day | 12 | 12 |
| Operating Days/Year | 365 | 365 |
| Number of Preheats per Day | 1 | 1 |
| Pounds of Food Cooked per Day | 100 | 100 |
| ASTM Energy to Food (Btu/lb)a | 250 | 250 |
| Daily Energy Consumption (Btu) | 330,083 | 205,098 |
| Annual Energy Consumption (therms)b | 1,205 | 749 |
| Estimated Energy Savings (therms/yr) | - | **456** |
| Estimated Useful Life (EUL)c | 12 years | 12 years |

a This is the average value calculated by FSTC through ASTM F1496 test through weight and temperature

measurement of test product cooked in convection ovens (250 Btu/lb for russet potato)

[http://www.fishnick.com/publications/appliancereports/convectionovens/](https://urldefense.proofpoint.com/v2/url?u=http-3A__www.fishnick.com_publications_appliancereports_convectionovens_&d=CwMFAg&c=hLS_V_MyRCwXDjNCFvC1XhVzdhW2dOtrP9xQj43rEYI&r=TlrXy5TrK8nTfd5c4pv-ow&m=xiQt0BJefxi1OOdFkKZw68uwF1ADiFrzRTcIJvZNzVQ&s=k--GDCdnQ_T7bin0pEeeBnubYisig4zpIhizmi6w_b0&e=)

b 1 therm = 100,000 Btu..

C The estimated useful life is based on DEER EUL estimates.

**Daily Energy Consumption Calculation and Definitions**

Where:

EDAY = Calculated Daily Energy Consumption (Btu/day)

LBFOOD = Estimated Pounds of Food Cooked per Day

EFOOD = ASTM Energy to Food (Btu/lb) = Btu/pound of energy absorbed by food product during cooking

EFFICIENCY= Measured Heavy Load Cooking Energy Efficiency %

IDLE RATE= Measured Idle Energy Rate (Btu/h)

EHOU= Estimated Operating Hours/Day

PC = Measured Production Capacity (lbs/hr)

TP = Estimated Preheat Time (min)

nP = Estimated Number of preheats/Day

EP = Measured Preheat Energy (Btu)

**Daily Energy Consumption Example:**

Hand calculation may generate slightly different number due to rounding to significant digits.

# Section 3. Load Shapes

Load Shapes are an important part of the life-cycle cost analysis of any energy efficiency program portfolio. The net benefits associated with a measure are based on the amount of energy saved and the avoided cost per unit of energy saved. For electricity, the avoided cost varies hourly over an entire year. Thus, the net benefits calculation for a measure requires both the total annual energy savings (kWh) of the measure and the distribution of that savings over the year. The distribution of savings over the year is represented by the measure’s load shape. The measure’s load shape indicates what fraction of annual energy savings occurs in each time period of the year. An hourly load shape indicates what fraction of annual savings occurs for each hour of the year. A Time-of-Use (TOU) load shape indicates what fraction occurs within five or six broad time-of-use periods, typically defined by a specific utility rate tariff. Formally, a load shape is a set of fractions summing to unity, one fraction for each hour or for each TOU period. Multiplying the measure load shape with the hourly avoided cost stream determines the average avoided cost per kWh for use in the life cycle cost analysis that determines a measure’s Total Resource Cost (TRC) benefit.

## 3.1 Base Case Load Shapes

The base case load shape would be expected to follow a typical non-residential foodservice end use load shape.

Commercial convection oven load shapes differ among food service facilities (quick service, casual dining, hotels, college, schools, hospitals, etc.) depending on daily menu variations, hours of operation, serving periods, day-of-week, and facility location (city downtown, suburban mall, access to interstate highways, etc.). Consequently, applicable average TOU and hourly load shapes for commercial convection ovens are unavailable. The ASTM Standard Test Method used to generate energy use data is based on hours of use and operating state (preheat, idle, and heavy-load cooking). Generally, commercial convection ovens are used to prepare food within a few days to a few hours before it is served, so loads tend to not necessarily be coincident with regular meal periods (breakfast, lunch, and dinner). Between meal periods commercial convection ovens may be used to prepare ingredients for either the next meal period or for menu items to be served the next several days (in which case the ingredients are refrigerated immediately after cooking).

## 

## 3.2 Measure Load Shapes

For purposes of the net benefits estimates in the E3 calculator, what is required is the load shape that ideally represents the *difference* between the base equipment and the installed energy efficiency measure. This *difference* load profile is what is called the Measure Load Shape and would be the preferred load shape for use in the net benefits calculations.

The measure load shape for this measure is determined by the E3 calculator based on the applicable non-residential market sector and the foodservice end-use.

The electric demand profile for the high-efficiency electric commercial convection oven is expected to be the same as the Base Case. The profile will vary as explained in Section 3.1. The Measure Load Shape for the high-efficiency commercial convection ovens will use less energy and have a lower demand profile.

The gas load profile for the high efficiency gas commercial convection ovens is expected to be the same as the Base Case. The profile will vary as explained in Section 3.1. The Measure Load Shape for the high efficiency commercial convection ovens will use less energy.

# Section 4. Base Case & Measure Costs

High efficiency convection ovens typically list for more than standard efficiency convection ovens. However, high efficiency designs are often bundled with other features such as all stainless steel construction and high quality components and controls. In addition to lower operating costs, high efficiency convection ovens exhibit higher production rates than Baseline model convection ovens.

Equipment prices for these work papers were compiled from a number of sources including, Autoquotes, equipment sales reps and manufacturer sources[[9]](#endnote-9). Since equipment pricing in food service is closely held information and prices vary widely according to buying volume and other factors, we cannot list the sources for prices specifically.

## 4.1 Base Cases Costs

The Base Case costs include only the equipment. High efficiency convection ovens require no additional labor or maintenance compared to base case convection ovens. Since this measure is applicable for ROB and NC installations, the installation and maintenance costs are expected to be the same for the customer. The estimated equipment cost is based on recent list cost data for electric and gas convection ovens and applying an industry-standard 50% discount to the manufacturer published list prices.

## 4.2 Measure Costs

The Measure costs include only the equipment, as explained in Section 4.1. The estimated equipment cost is based on recent list cost data (see Appendix A).

## 4.3 Incremental & Full Measure Costs

Incremental measure costs are used in the analysis.

Table-15: Equipment Incremental Cost Data for Energy Efficient Commercial Convection Ovens

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Convection Oven Type** | **PG&E Measure Code** | **Baseline Unit Price** | **Energy Efficient Unit Price** | **Incremental Price Difference** | **Baseline Unit Cost** | **Energy Efficient Unit Cost** | **Incremental Measure Cost (IMC)** |
| Electric Half-Size |  | $7,209 | $8,795 | $1,586 | $3,605 | $4,398 | $793 |
| Electric Full-Size | F187 | $8,216 | $10,229 | $2,014 | $4,108 | $5,115 | $1,007 |
| Electric Large Full-Size |  | $14,600 | $15,899 | $1,299 | $7,300 | $7,949 | $649 |
| Gas Half-Size |  | $7,228 | $8,208 | $980 | $3,614 | $4,104 | $490 |
| Gas Full-Size | F188 | $8,697 | $11,270 | $2,573 | $4,349 | $5,635 | $1,286 |
| Gas Large Full-Size |  | N/A | N/A | N/A | N/A | N/A | N/A |

\*Estimated purchase price and Incremental Measure Cost (IMC) were based on list prices from AutoQuotes catalog in 2012

**Appendix A**

**Equipment Cost Data for Electric Convection Ovens Updated 2012**

| Designation | Group | Size | List Price ($) | Cost ($)\* |
| --- | --- | --- | --- | --- |
| B1 | Baseline | Full-Size | $5,354 | $2,677 |
| B2 | Baseline | Large Full-Size | $14,600 | $7,300 |
| B3 | Baseline | Half-Size | $6,826 | $3,413 |
| B4 | Baseline | Full-Size | $9,404 | $4,702 |
| B5 | Baseline | Full-Size | $6,818 | $3,409 |
| B6 | Baseline | Half-Size | $8,710 | $4,355 |
| B7 | Baseline | Full-Size | $6,499 | $3,250 |
| B8 | Baseline | Half-Size | $8,240 | $4,120 |
| B9 | Baseline | Full-Size | $7,956 | $3,978 |
| B10 | Baseline | Full-Size | $8,788 | $4,394 |
| B11 | Baseline | Half-Size | $3,900 | $1,950 |
| B12 | Baseline | Full-Size | $10,696 | $5,348 |
| B13 | Baseline | Half-Size | $8,370 | $4,185 |
| B14 | Baseline | Full-Size | $10,210 | $5,105 |
| EE1 | Energy Efficient | Full-Size | $10,864 | $5,432 |
| EE2 | Energy Efficient | Half-Size | $8,470 | $4,235 |
| EE3 | Energy Efficient | Full-Size | $12,775 | $6,388 |
| EE4 | Energy Efficient | Half-Size | $9,120 | $4,560 |
| EE5 | Energy Efficient | Full-Size | $9,405 | $4,703 |
| EE6 | Energy Efficient | Full-Size | $11,915 | $5,958 |
| EE7 | Energy Efficient | Large Full-Size | $11,915 | $5,958 |
| EE8 | Energy Efficient | Large Full-Size | $19,882 | $9,941 |
| EE9 | Energy Efficient | Full-Size | $6,188 | $3,094 |

\*Estimated purchase price and Incremental Measure Cost (IMC) were based on list prices from AutoQuotes catalog in 2012

**Equipment Cost Data for Gas Commercial Convection Ovens Updated 2012**

| Designation | Group | Size | List Price ($) | Cost ($)\* |
| --- | --- | --- | --- | --- |
| B1 | Baseline | Half-Size | $10,155 | $5,078 |
| B2 | Baseline | Full-Size | $6,818 | $3,409 |
| B3 | Baseline | Half-Size | $5,492 | $2,746 |
| B4 | Baseline | Full-Size | $8,640 | $4,320 |
| B5 | Baseline | Full-Size | $8,414 | $4,207 |
| B6 | Baseline | Full-Size | $9,707 | $4,854 |
| B7 | Baseline | Full-Size | $12,566 | $6,283 |
| B8 | Baseline | Full-Size | $10,488 | $5,244 |
| B9 | Baseline | Full-Size | $5,378 | $2,689 |
| B10 | Baseline | Half-Size | $6,037 | $3,019 |
| EE1 | Energy Efficient | Full-Size | $7,567 | $3,784 |
| EE2 | Energy Efficient | Full-Size | $14,015 | $7,008 |
| EE3 | Energy Efficient | Full-Size | $11,340 | $5,670 |
| EE4 | Energy Efficient | Full-Size | $12,718 | $6,359 |
| EE5 | Energy Efficient | Full-Size | $10,582 | $5,291 |
| EE6 | Energy Efficient | Half-Size | $5,786 | $2,893 |
| EE7 | Energy Efficient | Full-Size | $8,546 | $4,273 |
| EE8 | Energy Efficient | Half-Size | $10,630 | $5,315 |
| EE9 | Energy Efficient | Full-Size | $13,050 | $6,525 |
| EE10 | Energy Efficient | Full-Size | $10,210 | $5,105 |
| EE11 | Energy Efficient | Full-Size | $9,700 | $4,850 |

\*Estimated purchase price and Incremental Measure Cost (IMC) were based on list prices from AutoQuotes catalog in 2012

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9. AutoQuotes electronic catalog for foodservice equipment and supplies <http://www.aqnet.com/> [↑](#endnote-ref-9)