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FOOD SERVICE

COMMERCIAL STEAM/CONVECTION COMBINATION OVEN

SWFS003-01

CONTENTS

MEASURE NAME

Commercial Steam/Convection Combination Oven

STATEWIDE MEASURE ID

SWFS003-01

TECHNOLOGY SUMMARY

An oven is defined as a fully enclosed and insulated chamber used to heat food. A commercial combination oven offers more options with its functionality to add steam to the oven cavity. In addition to baking and roasting, a combination oven is capable of steaming, proofing, and reheating food. Food can be cooked in a dry heat only mode, a steam-only mode, and a combination of dry heat and steam modes. The programmability of a combination oven enables food to be cooked partially in one mode at a certain temperature and in another mode and at a different temperature.

Combination ovens are available in a variety of sizes ranging from 6-pan countertop models to 40-pan roll-in models. The combination oven size is based on the capacity to accommodate 12-inch x 20-inch x 2.5-inch hotel pans. A half-size oven model can accommodate one column of hotel pans and 9-inch x 13-inch (half-size) sheet pans; a full-size oven model can accommodate two columns of hotel pans and 18-inch x 26-inch (full-size) sheet pans.

Combination oven performance is determined by applying the American Society for Testing and Materials (ASTM) Standard Test Method for the Performance of Combination Ovens in Various Modes (F2861).[1] The ASTM standard test method is the industry standard for quantifying the energy consumption, efficiency, and cooking performance of combination ovens.

MEASURE CASE DESCRIPTION

The measure case specification includes idle energy rate, cooking efficiency rate, and production capacity of a convection oven. The measure case specification values represent the average values of results of lab-based equipment performance tests (following the test procedures of ASTM F2861) conducted by the Pacific Gas & Electric (PG&E) Food Service Technology Center, the Southern California Gas Company (SoCalGas) Food Service Equipment Center, and the Southern California Edison (SCE) Food Service Technology Center. all qualified models that were tested.

[1] American Society for Testing and Materials (ASTM). 2015. ASTM F2861-15, Standard Test Method for the Performance of Combination Ovens in Different Modes. West Conshohocken (PA): ASTM International.

Measure Case Specification

Type	Capacity (pans)	Cooking Energy Efficiency		Idle Energy Rate		Production Capacity (lb/hr)		Source
		Oven Mode	Steam Mode	Oven Mode	Steam Mode	Oven Mode	Steam Mode	
Electric	< 15	70%	50%	2,000 W	5,000 W	100	120	Food Service Technology Center (FSTC). 2012. "Combination Oven Qualified Project List 2012.xls" As of April 20, 2012.
	15–28	70%	50%	2,500 W	6,000 W	125	200	
	> 28	70%	50%	4,000 W	9,000 W	325	400	
Gas	< 15	44%	38%	8,000 Btu/hr	15,000 Btu/hr	100	120	
	15–28	44%	38%	10,000 Btu/hr	18,000 Btu/hr	125	200	Food Service Technology Center (FSTC). Proprietary database.
	> 28	44%	38%	16,000 Btu/hr	28,000 Btu/hr	325	400	

BASE CASE DESCRIPTION

The Food Service Technology Center (FSTC) assessed major commercial cooking appliance technologies, including commercial ovens, the results of which were summarized and published in 2002.[2] The study revealed that standard electric oven efficiency varies from 50% to 80% and standard gas oven efficiency varies from 30% to 40%, based on oven type (convection, combination, conventional, etc.). For the standard steam mode, the cooking energy efficiency was derived from the average of gas boiler atmospheric (13%) and gas boiler pressure (27%).[3]

Insofar as the California Appliance Efficiency Regulations (Title 20) do not specify a minimum performance requirement for combination ovens, the base case specification for electric and gas combination ovens was determined as the average value of the efficiency range developed from a sample of economy-grade equipment tested by the FSTC, following the test procedures of ASTM F2861.

[2] Fisher, D. (Fisher-Nickel). 2002. Commercial Cooking Appliance Technology Assessment. Prepared for Enbridge Gas Distribution and Pacific Gas and Electric Company. FSTC Report # 5011.02.26.

[3] Fisher, D. (Fisher-Nickel). 2002. Commercial Cooking Appliance Technology Assessment. Prepared for Enbridge Gas Distribution and Pacific Gas and Electric Company. FSTC Report # 5011.02.26. Table 7-1 (p. 7-20) and Figure 8-6 (p. 8-9).

Base Case Specification

Type	Capacity (pans)	Cooking Energy Efficiency		Idle Energy Rate		Production Capacity (lb/hr)		Source
		Oven Mode	Steam Mode	Oven Mode	Steam Mode	Oven Mode	Steam Mode	
Electric	< 15	65%	40%	3,000 W	10,000 W	80	100	Food Service Technology Center (FSTC). 2012. "Combination Oven Qualified Project List 2012.xls" As of April 20, 2012. Food Service Technology Center (FSTC). Proprietary database.
	15–28	65%	40%	3,750 W	12,500 W	100	150	
	> 28	65%	40%	5,250 W	18,000 W	275	350	
Gas	< 15	35%	20%	15,000 Btu/hr	45,000 Btu/hr	80	100	
	15–28	35%	20%	20,000 Btu/hr	60,000 Btu/hr	100	150	
	> 28	35%	20%	30,000 Btu/hr	80,000 Btu/hr	275	350	

CODE REQUIREMENTS

This measure is not governed by either state or federal codes and standards.

Applicable State and Federal Codes and Standards

Code	Applicable Code Reference	Effective Dates
CA Appliance Efficiency Regulations – Title 20 (2014)	None.	n/a
CA Building Energy Efficiency Standards – Title 24 (2013)	None.	n/a
Federal Standards	None.	n/a

Oven performance is determined by applying the American Society for Testing and Materials (ASTM) Standard Test Method for the Performance of Combination Ovens in Various Modes (F2861).[4] The ASTM standard test method is the industry standard for quantifying the energy consumption, efficiency, and cooking performance of combination ovens.

NORMALIZING UNIT

Each.

[4] American Society for Testing and Materials (ASTM). 2015. ASTM F2861-15, Standard Test Method for the Performance of Combination Ovens in Different Modes. West Conshohocken (PA): ASTM International.

PROGRAM REQUIREMENTS

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

Implementation Eligibility for Investor-Owned Utilities

Measure Application Type	Delivery Type	Sector
Normal replacement	NonUpStrm	Ag
Normal replacement	NonUpStrm	Ind
Normal replacement	NonUpStrm	Com
Normal replacement	PreRebDown	Ag
Normal replacement	PreRebDown	Ind
Normal replacement	PreRebDown	Com
Normal replacement	DirInstall	Ag
Normal replacement	DirInstall	Ind
Normal replacement	DirInstall	Com
Normal replacement	PreRebUp	Ag
Normal replacement	PreRebUp	Ind
Normal replacement	PreRebUp	Com
New construction	NonUpStrm	Ag
New construction	NonUpStrm	Ind
New construction	NonUpStrm	Com
New construction	PreRebDown	Ag
New construction	PreRebDown	Ind
New construction	PreRebDown	Com
New construction	DirInstall	Ag
New construction	DirInstall	Ind
New construction	DirInstall	Com
New construction	PreRebUp	Ag
New construction	PreRebUp	Ind
New construction	PreRebUp	Com

Eligible Products

This measure includes new commercial steam/convection combination ovens that meet the requirements in the Measure Case Description.

Eligible Building Types and Vintages

This measure is applicable for any building type and any vintage.

Eligible Climate Zones

This measure is applicable in any California climate zone.

PROGRAM EXCLUSIONS

Used or rebuilt equipment is not eligible.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

USE CATEGORY

Food service (FoodServ)

ELECTRIC SAVINGS (kWh)

The annual electric unit energy saving (UES) is calculated as the difference between the baseline and measure case unit energy consumption (UEC).

Annual Electric Unit Energy Consumption

The daily electric UEC (baseline or measure case) is equal to the sum of the energy required for convection cooking, steam cooking, convection idle, steam idle, and preheat modes of combination oven operation. These calculations and the inputs are provided below.

$$UEC\_DAY = convection\ cooking\ energy + steam\ cooking\ energy + convection\ idle\ energy + steam\ idle\ energy + preheat\ energy$$

Convection cooking energy is a function of the pounds of food cooked per day, the percent of time in convection cooking mode, the energy absorbed per pound of food during convection cooking mode, and the measured heavy load cooking energy efficiency in convection mode.

$$convection\ cooking\ energy = \left[\frac{LBFOOD \times (1 - PTS) \times EFOOD_{convection}}{EFFICIENCY_{convection} \times Btu/kWh}\right]$$

$LBFOOD =$ *Estimated pounds of food cooked per day (lb)*
$PTS =$ *Percent time in steam mode (%, decimal)*
$EFOOD_{convection} =$ *ASTM energy to food ratio, the energy absorbed by food during convection cooking (Btu/lb)*
$EFFICIENCY_{convection} =$ *Measured heavy load cooking efficiency, convection mode (%, decimal)*
$Btu/kWh =$ *Btu to kWh conversion factor*

Steam cooking energy is a function of the pounds of food cooked per day, the percent of time in steam cooking mode, the energy absorbed per pound of food during steam cooking mode, and the measured heavy load cooking energy efficiency in steam mode.

$$steam\ cooking\ energy = \left[\frac{LBFOOD \times PTS \times EFOOD_{steam}}{EFFICIENCY_{steam} \times Btu/kWh}\right]$$

$LBFOOD =$	*Estimated pounds of food cooked per day (lb)*
$PTS =$	*Percent time in steam mode (%, decimal)*
$EFOOD_{steam} =$	*ASTM energy to food ratio, the energy absorbed by food during convection cooking (Btu/lb)*
$EFFICIENCY_{steam} =$	*Measured heavy load cooking efficiency, convection mode (%, decimal)*
$Btu/kWh =$	*Btu to kWh conversion factor*

Preheat energy is calculated as the product of the assumed number of preheats per day and the energy required per preheat mode.

$$preheat\ energy = (nP\ x\ EP)$$

$nP =$	*Estimated number of preheats per day (#)*
$EP =$	*Measured preheat energy (kWh)*

Convection idle energy is a function of the idle energy rate in convection mode, operating hours per day, production capacity in convection mode, and the percent time in convection mode; idle energy does not include preheat time.

$$convection\ idle\ energy = \left[IDLERATE_{convection} \times \left(EHOUR - \frac{LBFOOD}{PC_{convection}} - (nP \times TP/MinHr)\right) \times (1 - PTS)\right]$$

$IDLE\ RATE_{convection} =$	*Measured idle energy rate, convection mode (kW)*
$EHOUR =$	*Estimated operating hours per day (hrs)*
$LBFOOD =$	*Estimated pounds of food cooked per day (lbs)*
$nP =$	*Estimated number of preheats per day (#)*
$PC_{convection} =$	*Measured production capacity, convection mode (lbs/hr)*
$TP =$	*Estimated preheat time (min)*
$MinHr =$	*Constant, 60 minutes per hour (min)*
$PTS =$	*Percentage time in steam mode (%, decimal)*

Steam idle energy is a function of the idle energy rate in steam mode, operating hours per day, production capacity in steam mode, and the percent time in steam mode; idle energy does not include preheat time.

$$steam\ idle\ energy = \left[IDLERATE_{steam} \times \left(EHOUR - \frac{LBFOOD}{PC_{steam}} - (nP \times TP/MinHr)\right) \times (1 - PTS)\right]$$

$IDLE\ RATE_{convection} =$	*Measured idle energy rate, steam mode (kW)*
$EHOUR =$	*Estimated operating hours per day (hrs)*
$LBFOOD =$	*Estimated pounds of food cooked per day (lbs)*
$nP =$	*Estimated number of preheats per day (#)*
$PC_{steam} =$	*Measured production capacity, steam mode (lbs/hr)*
$TP =$	*Estimated preheat time (min)*
$MinHr =$	*Constant, 60 minutes per hour (min)*
$PTS =$	*Percentage time in steam mode (%, decimal)*

The **annual UEC** is calculated as the daily UEC multiplied by the number of operating days per year.

$$UEC\_YEAR = UEC\_DAY \times EDAYS$$

UEC_DAY = *Daily unit energy consumption (kWh)*
EDAYS= *Estimated operating days per year (days)*

Annual Electric Unit Energy Savings

The **annual UES** is calculated as the difference between the baseline and measure case annual UEC.

$$UES_{YEAR} = [UEC\_YEAR_{Base} - UEC\_YEAR_{Measure}]$$

UEC_YEAR = *Annual UEC, baseline or measure (kWh/year)*
UES_YEAR= *Annual UES (kWh/year)*

Inputs and Assumptions

The inputs for the calculation of the UES of electric combination ovens for each capacity range (< 15 pans, 15-28 pans, and > 28 pans) are specified below. Inputs were derived from data obtained from lab-based equipment tests that followed the ASTM F2861 test method. Preheat time is assumed to be 15 minutes, since the industry standard preheat time is 10 to 20 minutes, based upon professional judgement of Food Service Technology Center (FSTC) staff.

Electric UEC Inputs – < 15 Pan Model

Parameter	Base Case Model	Measure Case Model	Source
Preheat time (minutes)	15	15	Professional judgement.
Number of Steam Pans (pans)	12	12	Base Case: Food Service Technology Center (FSTC). Proprietary Database. Measure Case: Food Service Technology Center (FSTC). 2012. "Combination Oven Qualified Project List 2012.xls." As of April 20, 2012.
Preheat Energy (kWh)	3.00	1.50	
Convection Idle Energy Rate (kW)	3.00	2.00	
Convection Cooking Energy Efficiency (%)	65%	70%	
Convection Production Capacity (lbs/hr)	80	100	
Steam Idle Energy Rate (kW)	10.00	5.00	
Steam Cooking Energy Efficiency (%)	40%	50%	
Steam Production Capacity (lbs/hr)	100	120	
Average Water Consumption Rate (gal/hr)	30	20	
Pounds of Food Cooked per Day	200	200	
Number of Preheats per Day	1	1	
Percent Time in Steam Mode	50%	50%	
ASTM Convection Mode Energy to Food (Btu/lb)	250	250	
ASTM Steam Mode Energy to Food (Btu/lb)	105	105	
Operating Hours/Day (hours)	12	12	

Parameter	Base Case Model	Measure Case Model	Source
Operating Days/Year (days)	365	365	Spoor, C., D. Zabrowski, and L. Mills. 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095. Appendix E Table E-4.

Electric UEC Inputs – 15-28 Pan Model

Parameter	Base Case Model	Measure Case Model	Source
Preheat time (minutes)	15	15	Professional judgement.
Number of Steam Pans (pans)	20	20	Base Case: Food Service Technology Center (FSTC). Proprietary Database. Measure Case: Food Service Technology Center (FSTC). 2012. "Combination Oven Qualified Project List 2012.xls" As of April 20, 2012.
Preheat Energy (kWh)	3.75	2.00	
Convection Idle Energy Rate (kW)	3.75	2.50	
Convection Cooking Energy Efficiency (%)	65%	70%	
Convection Production Capacity (lbs/hr)	100	125	
Steam Idle Energy Rate (kW)	12.50	6.00	
Steam Cooking Energy Efficiency (%)	40%	50%	
Steam Production Capacity (lbs/hr)	150	200	
Average Water Consumption Rate (gal/h)	40	25	
Number of Preheats per Day	1	1	
Percent Time in Steam Mode	50%	50%	
Pounds of Food Cooked per Day (lb)	250	250	
ASTM Convection Mode Energy to Food (Btu/lb)	250	250	
ASTM Steam Mode Energy to Food (Btu/lb)	105	105	
Operating Hours/Day (hours)	12	12	Spoor, C., D. Zabrowski, and L. Mills. 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095. Appendix E Table E-4.
Operating Days/Year (days)	365	365	

Electric UEC Inputs – > 28 Pan Model

Parameter	Base Case Model	Measure Case Model	Source
Preheat time (minutes)	15	15	Professional judgement.
Number of Steam Pans (pans)	40	40	Base Case: Food Service Technology Center (FSTC). Proprietary Database. Measure Case: Food Service Technology Center
Preheat Energy (kWh)	5.63	3.00	
Convection Idle Energy Rate (kW)	5.25	4.00	
Convection Cooking Energy Efficiency (%)	65%	70%	
Convection Production Capacity (lbs/hr)	275	325	

Parameter	Base Case Model	Measure Case Model	Source
Steam Idle Energy Rate (kW)	18.00	9.00	(FSTC). 2012. "Combination Oven Qualified Project List 2012.xls" As of April 20, 2012.
Steam Cooking Energy Efficiency (%)	40%	50%	
Steam Production Capacity (lbs/hr)	350	400	
Average Water Consumption Rate (gal/hr)	70	30	
Number of Preheats per Day	1	1	
Percent Time in Steam Mode	50%	50%	
Pounds of Food Cooked per Day (lb)	400	400	
ASTM Convection Mode Energy to Food (Btu/lb)	250	250	
ASTM Steam Mode Energy to Food (Btu/lb)	105	105	
Operating Hours/Day (hours)	12	12	Spoor, C., D. Zabrowski, and L. Mills. 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095. Appendix E Table E-4.
Operating Days/Year (days)	365	365	

A sample calculation of daily energy consumption (kWh) of a 40-pan base case model is provided below.

$$EDAY = 22.52 + 15.40 + 27.02 + 95.46 + 5.63 = 166.0\ kWh$$

$$convection\ cooking\ energy = \left[\frac{400 \times (1 - 0.50) \times 250 \times \frac{1}{3412.14}}{0.65}\right] = 22.52\ \text{kWh}$$

$$steam\ cooking\ energy = \left[\frac{400 \times (0.50) \times 0.0308}{0.40}\right] = 15.40\ \text{kWh}$$

$$convection\ idle\ energy = \left[5.25 \times \left(12 - \frac{400}{275} - (1 \times 15/60)\right) \times (1 - 0.50)\right] = 27.02\ \text{kWh}$$

$$steam\ idle\ energy = \left[18.00 \times \left(12 - \frac{400}{350} - (1 \times 15/60)\right) \times (0.50)\right] = 95.46\ \text{kWh}$$

$$preheat\ energy = (1 \times 5.63) = 5.63\ \text{kWh}$$

PEAK ELECTRIC DEMAND REDUCTION (kW)

The actual contribution to building 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 building peak demand is equal to the combination oven average demand.

Peak Demand Reduction Calculation

It is assumed that this measure operates within the Database of Energy Efficient Resources (DEER) peak period of 4 p.m. to 9 p.m. on weekdays[5] at a constant load throughout the day. The average and peak demand reduction calculations utilize the measured data of base case and measure case commercial combination ovens specified for Electric Savings. The average demand (baseline or measure case) is equal to the annual unit energy consumption (UEC) divided by the assumed annual hours of operation.

The average demand reduction, therefore, is the difference between the baseline and measure case average demand. The estimated peak demand reduction is calculated as the average demand reduction multiplied by the coincident demand factor (CDF).

Inputs and Assumptions

The table below provides the inputs for the calculation of peak demand reduction of a commercial combination oven.

Demand Reduction Inputs (all sizes)

Parameter	Value	Source
Coincident Demand Factor	0.90	Itron, Inc. 2005. *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study - Final Report.* Prepared for Southern California Edison. Pages 3-15 to 3-17, Table 3-14.

GAS SAVINGS (THERMS)

The annual gas unit energy saving (UES) is calculated as the difference between the baseline and measure case unit energy consumption (UEC).

Annual Gas Unit Energy Consumption

The daily gas UEC (baseline or measure case) is equal to the sum of the energy required for convection cooking, steam cooking, convection idle, steam idle, and preheat modes of combination oven operation. These calculations and the inputs are provided below.

$$UEC\_DAY = convection\ cooking\ energy + steam\ cooking\ energy + \ convection\ idle\ energy + steam\ idle\ energy \ + preheat\ energy$$

Convection cooking energy is a function of the pounds of food cooked per day, the percent of time in convection cooking mode, the energy absorbed per pound of food during convection cooking mode, and the measured heavy load cooking energy efficiency in convection mode.

$$convection\ cooking\ energy = \left[\frac{LBFOOD \times (1 - PTS) \times EFOOD_{convection}}{EFFICIENCY_{convection}}\right]$$

[5] California Public Utilities Commission (CPUC). 2018. *Resolution E-4952.* October 11. Op 1.

$LBFOOD =$ *Estimated pounds of food cooked per day (lb)*
$PTS =$ *Percent time in steam mode (%, decimal)*
$EFOOD_{convection} =$ *ASTM energy to food ratio, the energy absorbed by food during convection cooking (Btu/lb)*
$EFFICIENCY_{convection} =$ *Measured heavy load cooking efficiency, convection mode (%, decimal)*

Steam cooking energy is a function of the pounds of food cooked per day, the percent of time in steam cooking mode, the energy absorbed per pound of food during steam cooking mode, and the measured heavy load cooking energy efficiency in steam mode.

$$steam\ cooking\ energy = \left[\frac{LBFOOD \times PTS \times EFOOD_{steam}}{EFFICIENCY_{steam}}\right]$$

$LBFOOD =$ *Estimated pounds of food cooked per day (lb)*
$PTS =$ *Percent time in steam mode (%, decimal)*
$EFOOD_{steam} =$ *ASTM energy to food ratio, the energy absorbed by food during convection cooking (Btu/lb)*
$EFFICIENCY_{steam} =$ *Measured heavy load cooking efficiency, convection mode (%, decimal)*

Preheat energy is calculated as the product of the assumed number of preheats per day and the energy required per preheat mode.

$$preheat\ energy = (nP\ x\ EP)$$

$nP =$ *Estimated number of preheats per day (#)*
$EP =$ *Measured preheat energy (Btu)*

Convection idle energy is a function of the idle energy rate in convection mode, operating hours per day, production capacity in convection mode, and the percent time in convection mode; idle energy does not include preheat time.

$$convection\ idle\ energy = \left[IDLERATE_{convection} \times \left(EHOUR - \frac{LBFOOD}{PC_{convection}} - (nP \times TP/MinHr)\right) \times (1 - PTS)\right]$$

$IDLE\ RATE_{convection} =$ *Measured idle energy rate, convection mode (Btu)*
$EHOUR =$ *Estimated operating hours per day (hrs)*
$LBFOOD =$ *Estimated pounds of food cooked per day (lbs)*
$nP =$ *Estimated number of preheats per day (#)*
$PC_{convection} =$ *Measured production capacity, convection mode (lbs/hr)*
$TP =$ *Estimated preheat time (min)*
$MinHr =$ *Constant, 60 minutes per hour (min)*
$PTS =$ *Percentage time in steam mode (%, decimal)*

Steam idle energy is a function of the idle energy rate in steam mode, operating hours per day, production capacity in steam mode, and the percent time in steam mode; idle energy does not include preheat time.

$$steam\ idle\ energy = \left[IDLERATE_{steam} \times \left(EHOUR - \frac{LBFOOD}{PC_{steam}} - (nP \times TP/MinHr)\right) \times (1 - PTS)\right]$$

$IDLE\ RATE_{convection} =$ *Measured idle energy rate, steam mode (Btu)*
$EHOUR =$ *Estimated operating hours per day (hrs)*
$LBFOOD =$ *Estimated pounds of food cooked per day (lbs)*

nP = *Estimated number of preheats per day (#)*
PC_{steam} = *Measured production capacity, steam mode (lbs/hr)*
TP = *Estimated preheat time (min)*
MinHr = *Constant, 60 minutes per hour (min)*
PTS= *Percentage time in steam mode (%, decimal)*

The **annual UEC** (baseline or measure) is calculated as the daily UEC multiplied by the number of operating days per year.

$$UEC\_YEAR = \frac{UEC\_DAY \times EDAYS}{BtuTherm}$$

UEC_DAY = *Calculated daily energy consumption (Btu/day)*
EDAYS= *Estimated operating days per year (days)*
BtuTherm = *Btu to therm conversion factor*

Annual Gas Unit Energy Savings

The **annual UES** is calculated as the difference between the baseline and measure case annual UEC.

$$UES_{YEAR} = [UEC\_YEAR_{Base} - UEC\_YEAR_{Measure}]$$

UEC_YEAR = *Annual UEC, baseline or measure (therms/year)*
UES_YEAR= *Annual UES (therms/year)*

Inputs and Assumptions

The inputs for the calculation of the UES of gas combination ovens for each capacity range (< 15 pans, 15-28 pans, and > 28 pans) are specified below. Inputs were derived from data obtained from lab-based equipment tests that followed the ASTM F2861 test method. Preheat time is assumed to be 15 minutes, since the industry standard preheat time is 10 to 20 minutes, based upon professional judgement of Food Service Technology Center (FSTC) staff.

Gas UEC Inputs – < 15 Pan Model

Parameter	Base Case Model	Measure Case Model	Source
Preheat Time (minutes)	15	15	Professional judgement.
Number of Steam Pans (pans)	12	12	Base Case: Food Service Technology Center (FSTC). Proprietary Database. Measure Case: Food Service Technology Center (FSTC). 2012. "Combination Oven Qualified Project List 2012.xls" As of April 20, 2012.
Preheat Energy (Btu)	18,000	13,000	
Convection Idle Energy Rate (Btu/hr)	15,000	8,000	
Convection Heavy Load Cooking Energy Efficiency (%)	35%	44%	
Convection Production Capacity (lbs/hr)	80	100	
Steam Idle Energy Rate (Btu/hr)	45,000	15,000	
Steam Cooking Energy Efficiency (%)	20%	38%	
Steam Production Capacity (lbs/hr)	100	120	
Average Water Consumption Rate (gal/hr)	42	18	
Number of Preheats per Day	1	1	
Percent Time in Steam Mode	50%	50%	

Parameter	Base Case Model	Measure Case Model	Source
Pounds of Food Cooked per Day (lb)	200	200	
ASTM Convection Mode Energy to Food (Btu/lb)	250	250	
ASTM Steam Mode Energy to Food (Btu/lb)	105	105	
Operating Hours/Day (hours)	12	12	Spoor, C., D. Zabrowski, and L. Mills. 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095. Appendix E Table E-4.
Operating Days/Year (days)	365	365	

Gas UEC Inputs – 15-28 Pan Model

Parameter	Base Case Model	Measure Case Model	Source
Preheat Time (minutes)	15	15	Professional judgement.
Number of Steam Pans (pans)	20	20	Base Case: Food Service Technology Center (FSTC). Proprietary Database. Measure Case: Food Service Technology Center (FSTC). 2012. "Combination Oven Qualified Project List 2012.xls" As of April 20, 2012.
Preheat Energy (Btu)	22,000	16,000	
Convection Idle Energy Rate (Btu/h)	20,000	10,000	
Convection Heavy Load Cooking Energy Efficiency (%)	35%	44%	
Convection Production Capacity (lbs/hr)	100	125	
Steam Idle Energy Rate (Btu/h)	60,000	18,000	
Steam Cooking Energy Efficiency (%)	20%	38%	
Steam Production Capacity (lbs/hr)	150	200	
Average Water Consumption Rate (gal/h)	70	30	
Number of Preheats per Day	1	1	
Percentage Time in Steam Mode	50%	50%	
Pounds of Food Cooked per Day (lb)	250	250	
ASTM Convection Mode Energy to Food (Btu/lb)	250	250	
ASTM Steam Mode Energy to Food (Btu/lb)	105	105	
Operating Hours/Day (hours)	12	12	Spoor, C., D. Zabrowski, and L. Mills. 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095. Appendix E Table E-4.
Operating Days/Year (days)	365	365	

Gas UEC Inputs – > 28 Pan Model

Parameter	Base Case Model	Measure Case Model	Source
Preheat Time (minutes)	15	15	Professional judgement.
Number of Steam Pans (pans)	40	40	
Preheat Energy (Btu)	32,000	24,000	

Parameter	Base Case Model	Measure Case Model	Source
Convection Idle Energy Rate (Btu/h)	30,000	16,000	Base Case: Food Service Technology Center (FSTC). Proprietary Database. Measure Case: Food Service Technology Center (FSTC). 2012. "Combination Oven Qualified Project List 2012.xls" As of April 20, 2012.
Convection Heavy Load Cooking Energy Efficiency (%)	35%	44%	
Convection Production Capacity (lbs/hr)	275	325	
Steam Idle Energy Rate (Btu/h)	80,000	28,000	
Steam Cooking Energy Efficiency (%)	20%	38%	
Steam Production Capacity (lbs/hr)	350	400	
Average Water Consumption Rate (gal/h)	140	60	
Number of Preheats per Day	1	1	
Percentage Time in Steam Mode	50%	50%	
Pounds of Food Cooked per Day (lb)	400	400	
ASTM Convection Mode Energy to Food (Btu/lb)	250	250	
ASTM Steam Mode Energy to Food (Btu/lb)	105	105	
Operating Hours/Day (hours)	12	12	Spoor, C., D. Zabrowski, and L. Mills. 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Food Service Equipment.* Prepared for the California Energy Commission. CEC-500-2014-095. Appendix E Table E-4.
Operating Days/Year (days)	365	365	

A sample calculation of daily gas energy consumption is provided below.

$$UEC\_DAY = 142{,}857 + 105{,}000 + 154{,}432 + 424{,}286 + 32{,}000 = 858{,}575\ Btu/day$$

$$convection\ cooking\ energy = \left[\frac{400 \times \left(1 - \frac{50}{100}\right) \times 250}{\frac{35}{100}}\right] = 142{,}857\ Btu/day$$

$$steam\ cooking\ energy = \left[\frac{400 \times \left(\frac{50}{100}\right) \times 105}{\frac{20}{100}}\right] = 105{,}000\ Btu/day$$

$$convection\ idle\ energy = \left[30{,}000 \times \left(12 - \frac{400}{275} - (1 \times 15/60)\right) \times \left(1 - \frac{50}{100}\right)\right] = 154{,}432\ Btu/day$$

$$steam\ idle\ energy = \left[80{,}000 \times \left(12 - \frac{400}{350} - (1 \times 15/60)\right) \times \left(\frac{50}{100}\right)\right] = 424{,}286\ Btu/day$$

$$preheat\ energy = (1 \times 32{,}000) = 32{,}000\ Btu/day$$

LIFE CYCLE

Effective Useful Life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining Useful Life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

The EUL and RUL specified for the commercial combination oven are specified below. Note that RUL is only applicable for add-on and accelerated replacement measures and not applicable for this measure.

Effective Useful Life and Remaining Useful Life

Parameter	Value	Source
EUL (yrs)	12	Robert Mowris & Associates. 2005. *Ninth Year Retention Study of the 1995 Southern California Gas Company Commercial New Construction Program*. Prepared for Southern California Gas Company. Study ID Number 718A. California Public Utilities Commission (CPUC), Energy Division. 2003. *Energy Efficiency Policy Manual v 2.0.* Page 18 Table 4.1.
RUL (yrs)	n/a	n/a

BASE CASE MATERIAL COST ($/UNIT)

The base case material cost for equipment *delivered via direct install* is equal to $0.

For *all other delivery types*, the base case material cost was derived as the average of the manufacturer list prices for electric and gas combination ovens retrieved from the AutoQuotes online catalog for food service equipment and supplies.[6]

MEASURE CASE MATERIAL COST ($/UNIT)

The measure case material cost for *all delivery types* was derived as the average of the manufacturer list prices for energy efficient electric and gas convection ovens retrieved from the AutoQuotes online catalog for food service equipment and supplies.[7]

BASE CASE LABOR COST ($/UNIT)

The base case labor cost for equipment *delivered via direct install* is equal to $0.

For *all other delivery types*, the base case and measure case model installation costs are expected to be the same for the customer and thus were not estimated for the incremental cost analysis.

MEASURE CASE LABOR COST ($/UNIT)

The measure case labor cost for equipment *delivered via direct install* will be derived as the average installation cost submitted by one or more implementation contractors. The actual installation cost can vary by contractor, the date when the work occurred, and by the volume of each specific contractor's business. Contractor costs are confidential information and are based upon contractually agreed upon pricing as established in their purchase order with the program administrator. Therefore, the program administrator program tracking systems are the only source for the labor installation cost data. The

[6] Food Service Technology Center (FSTC). 2016. "Combi 2016 Prices Updated.xlsx"

[7] Food Service Technology Center (FSTC). 2016. "Combi 2016 Prices Updated.xlsx"

program administrator will utilize the actual program cost to evaluate the cost-effectiveness of the measure.

For *all other delivery types*, a high efficiency model does not require additional installation labor compared to a base case model. Since this measure is applicable for normal replacement and new construction installations, the base case and measure case model installation costs are expected to be the same for the customer and thus were not estimated for the incremental cost analysis.

NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. These NTG values are based upon the average of all NTG ratios for all evaluated 2006 – 2008 commercial, industrial, and agriculture programs, as documented in the 2011 DEER Update Study conducted by Itron, Inc. These sector average NTGs ("default NTGs") are applicable to all energy efficiency measures that have been offered through commercial, industrial, and agriculture sector programs for more than two years and for which impact evaluation results are not available.

Net-to-Gross Ratios

Parameter	Combination Oven – Electric	Combination Oven – Gas	Source
NTG – Commercial	0.60	0.60	Itron, Inc. 2011. *DEER Database 2011 Update Documentation.* Prepared for the California Public Utilities Commission. Page ES-8 Table ES-9 and Page 15-4 Table 15-3.
NTG – Industrial	0.60	0.60	
NTG - Agriculture	0.60	0.60	

GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method. This GSIA rate is the current "default" rate specified for measures for which an alternative GSIA has not been estimated and approved.

Gross Savings Installation Adjustment Rate

Parameter	Value	Source
GSIA	1.0	California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 31.

NON-ENERGY IMPACTS

Non-energy impacts for this measure have not been quantified.

DEER DIFFERENCES ANALYSIS

The table below summarizes the inputs and methods that are and are not based upon the Database for Energy Efficient Resources (DEER).

DEER Difference Summary

DEER Item	Comment / Used for Workpapers
Modified DEER methodology	No
Scaled DEER measure	No
DEER Base Case	No
DEER Measure Case	No
DEER Building Types	No
DEER Operating Hours	No
DEER eQUEST Prototypes	No
DEER Version	n/a
Reason for Deviation from DEER	DEER 2014 does not contain these measures.
DEER Measure IDs Used	n/a
NTG	Source: DEER2016. NTG of 0.60 is associated with NTG ID: *Com-Default>2yrs*, *Ag-Default>2yrs*, *Ind-Default>2yrs*
GSIA	The GSIA of 1.0 is associated with ID: *Def-GSIA*
EUL/RUL	Source: DEER 2016. EUL of 12 years is associated with EUL IDs: *Cook-ElecCombOven* and *Cook-GasCombOven*

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Revision Complete Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	07/31/2018	Jennifer Holmes Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: PGECOFST100, Revision #6 (August 2016) SCE13CC006, Revision 2 (January 19, 2016) WPSDGENRCC0005, Revision 3.1 (June 26, 2014) Consensus reached among Cal TF members.
	10/9/2018 10/30/2018	Jennifer Holmes Cal TF Staff	Completed final revisions for submittal of version 1.