



FOOD SERVICE
UNDERFIRED BROILER, COMMERCIAL
SWFS019-02

C O N T E N T S

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MEASURE NAME

Underfired Broiler, Commercial

STATEWIDE MEASURE ID

SWFS019-02

TECHNOLOGY SUMMARY

An underfired broiler is composed of a heavy-duty cooking grate suspended above a radiant heat source. Below the grate a gas broiler has a set of atmospheric burners spaced every four to twelve inches along the width of the broiler, covered by a protective radiant material. The radiant can be comprised of a bed of rock, ceramic briquettes, or a metal shield just above the burners. This material between the flame and the food converts some of the flame energy to radiant heat. As food cooks on an underfired broiler, drippings burn on the hot radiant surface to create the charbroiler characteristic flame and smoke. These types of broilers are mostly use for cooking meat, fish, and vegetables. Due to their high heat intensity, the common use of underfired broilers is to prepare high volumes of vegetables, meat and seafood with the characteristic smoke and flame that make them a showpiece as well as a workhorse.

A typical underfired broiler operates at a constant input rate to maintain an average cooking rate temperature between 550 °F and 650 °F. A constant input rate broiler does not differentiate between cooking and idle operation; the broiler is manually controlled and typically operates at the same rate throughout the day.

Broiler technology advancements are mostly centered around advances burners and more effective heat transfer designs, which delivers similar surface temperatures as baseline broilers with a lower input, thereby minimizing heat loss. Additionally, advance burner designs provide a more uniform heated area that can be placed closer to the food product, improving heat transfer efficiency. Advancements in controls technology allow for the use of a lid that can be closed when not cooking; controls reduce the burner input once the lid is closed, minimizing energy consumption. All these features can contribute to a lower average input rate of the broiler, however they are not required or limited to an energy efficient underfired broiler qualifying under this worksheet.

The industry standard for quantifying the energy consumption and cooking performance of an underfired broiler performance is determined by applying the American Society for Testing and Materials (ASTM) Standard Test Method for the Performance of Underfired Broilers (F1695).¹ The ASTM F1695 standard characterizes the broiler preheat, idle and cooking in terms of gas and electric energy consumption.

¹ American Society for Testing and Materials (ASTM). 2015. *ASTM F1695-03, Standard Test Method for the Performance of Underfired Broilers*. West Conshohocken (PA): ASTM International.

Most underfired broilers operate at a constant input rate that is close to the idle rate. With average hours of operation ranging between 10 and 18 hours per day,² most of the energy usage is driven by idle energy since the manual controls are seldom adjusted from the idle to cooking condition. Underfired broiling is usually done at a surface temperature between 550°F and 650°F. It is unnecessary to perform food product cooking per ASTM F1695 due to the non-thermostatic nature of the underfired broiler. For this measure, qualification can be determined through idle energy consumption test, conducted with the surface temperature adjusted to an average of 600°F per linear foot, per ASTM F1695.



ASTM F1695-03 Section 10.6 Lab Testing Broiler Temperature Measurement

Summaries of Key Studies

Underfired broiler energy consumption has been measured through laboratory testing as well as field verification. The following studies document broiler hours of operation and annual broiler energy usage for baseline units can be estimated with an acceptable level of certainty, depending on the broiler width and broiler hours of operation. Moreover, the baseline broilers analyzed in these studies have been well documented and have consistent idle and cooking input rate profiles. Three energy efficient broiler designs have been studied in a laboratory and on the field where both locations have proven to reduce energy usage compared to baseline models.

Field gas sub-metering data provides broiler operating hours and operating characteristics. A broiler market assessment was conducted in both Pacific Gas and Electric (PG&E) and Southern California Gas Company (SCG) service areas to characterize the most popular broiler types, size, hours of operation, and vintage.

² Livchack, D. (Fisher-Nickel, Inc.). 2017. *Energy Efficient Underfired Broilers*. ET Project Number ET16PGE1941. Prepared for Pacific Gas and Electric Company (PG&E). March 24.

Energy Efficient Underfired Broilers. (Fisher-Nickel for PG&E, 2017).³ The objective of this emerging technologies study (the “2017 ET study”) was to determine energy and cost savings as a result of the replacement of a conventional broiler with a “best-in-class” broiler. This project also characterized the technological improvements that contributed to energy reduction in broilers across the market, monitored energy consumption, as well as broiler operating conditions, and hours of operation. This project was a follow-up to the 2014 ET study that focusing on the lidded thermostatic broiler technology (ET13PGE1311, summarized below).

This study measured the baseline energy consumption of nine broilers, with 3-ft and 4-ft wide units being the most popular. Most of the surveyed restaurants operate during lunch and dinner with an average of 12.2 hours of operation per day.

Average baseline energy use for each broiler width is provided in the table below.

| Broiler Width (ft) | Average Baseline Energy Consumption per Day (Therms/day) |
|--------------------|--|
| 2 | 5.3 |
| 3 | 8.5 |
| 4 | 11.6 |

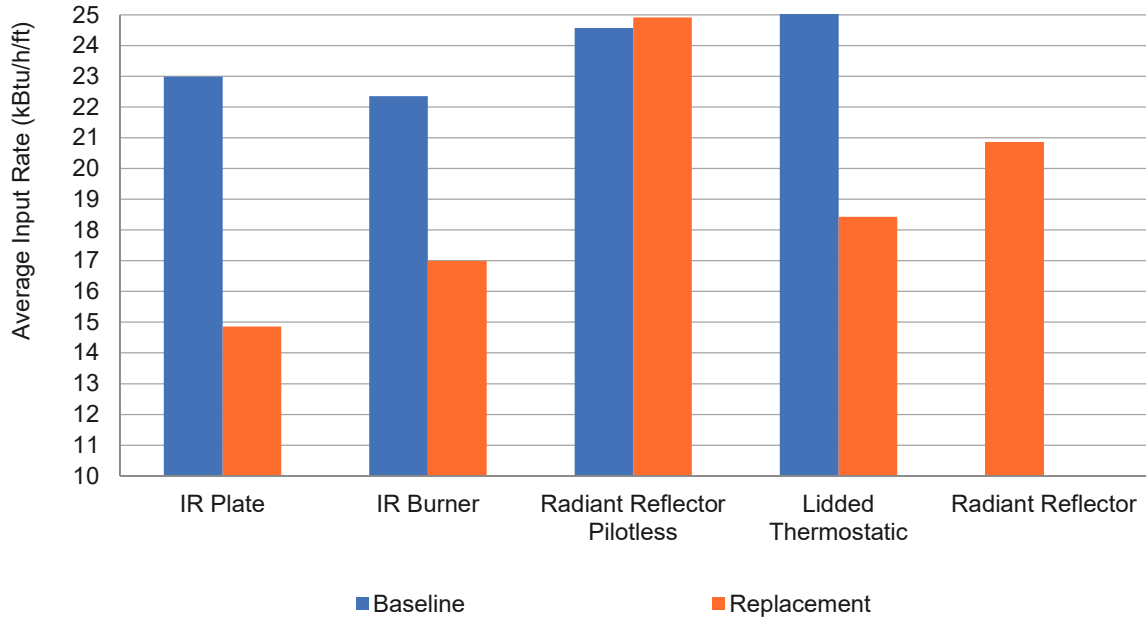
When the data is normalized to a linear foot of broiler cooking surface in width, a baseline broiler consumes an average of 2.7 Therms/day/len-ft., and an energy efficient broiler uses an average of 2.3 Therms/day /len-ft.

The replacement broiler technologies evaluated in this study include pilotless ignition, IR plate, and IR burner broilers. The pilotless ignition broiler with radiant reflectors did not yield energy savings at the installed site. IR plate burner broilers provided the highest energy savings of 35% compared to the baseline. However, IR plate burner broilers require semiannual maintenance to replace the radiant plates in restaurants that use marinades and high fat content proteins. The IR burner broiler resulted in 24% savings without any additional maintenance.

Underfired Broiler Replacement Energy Savings, by Broiler Type

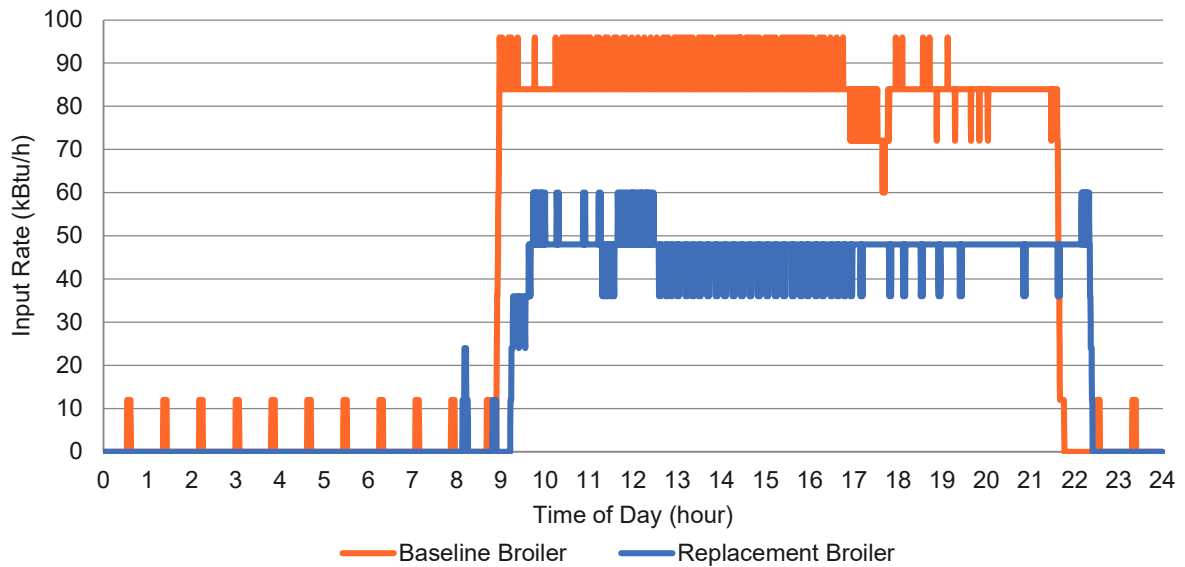
| Broiler Type | Average Input Rate (kBtu/hr./len-ft) | Average Measured Savings |
|-----------------------------|--------------------------------------|--------------------------|
| Standard Baseline | 22.8 | n/a |
| IR Plate | 14.9 | 35% |
| IR Burner | 17.0 | 24% |
| Radiant Reflector Pilotless | 24.9 | -1% |
| Lidded Thermostatic | 18.4 | 27% |

³ Livchack, D. (Fisher-Nickel, Inc.). 2017. *Energy Efficient Underfired Broilers*. ET Project Number ET16PGE1941. Prepared for Pacific Gas and Electric Company (PG&E). March 24.



Average Broiler Input Rate Based on Replacement Technology

An underfired broiler does not have thermostatic controls and the operating energy rate of each burner must be adjusted manually to achieve the desired temperature. Typically, restaurant operators will turn the broiler ON in the morning and operate it at a continuous input rate throughout the day, regardless of cooking demand. The graph below illustrates the consistency of the input rate throughout the day and the hours of operation. The replacement IR plate broiler had a spark ignition module resulting in no energy use during restaurant OFF times. Baseline broilers operated at 23 kBtu/hr./len-ft. and energy efficient broilers have average input rates less than 19 kBtu/hr./len-ft. while achieving similar surface temperatures.



Underfired Broiler Energy Profile Before and After Replacement

Emerging Technologies (ET) Lidded Thermostatic Infrared Broiler Field Study (Fisher-Nickel for PG&E, 2014).⁴ The objective of this emerging technologies study (the “2014 ET study”) was to determine the potential energy and cost savings, particularly during idle periods, from replacing an existing un-lidded char-broilers with a lidded char-broiler with thermostatic controls. The project documents energy consumption, operating conditions, and hours of operation at four sites.

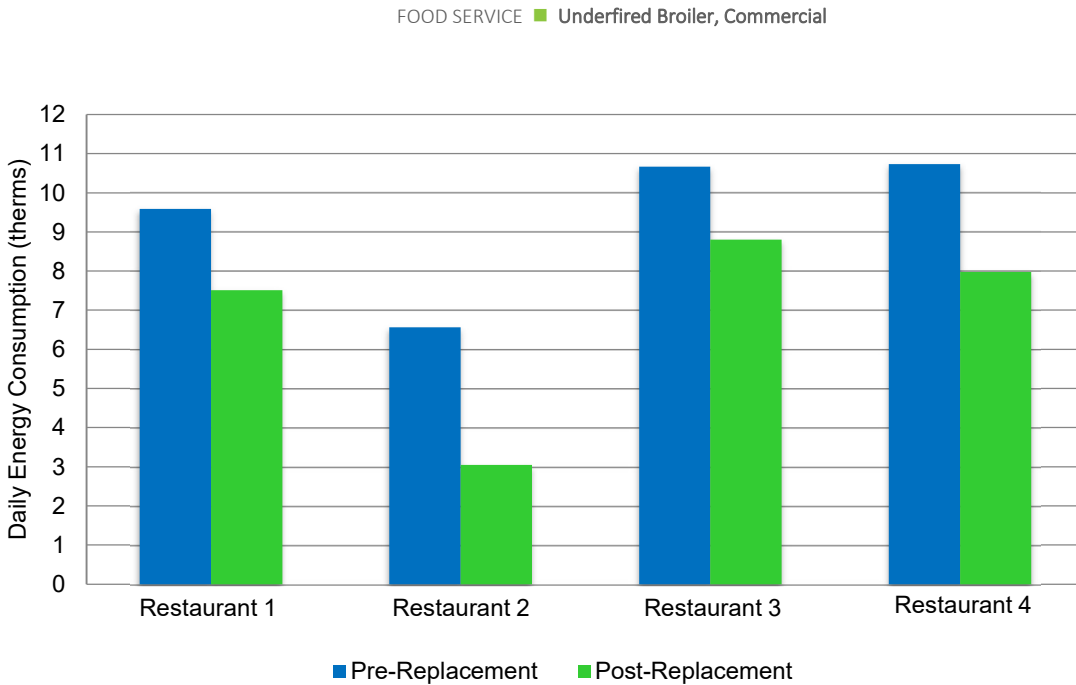
Four 3-ft wide standard underfired broilers were replaced by lidded thermostatic broilers resulting in 27% average energy savings. The average hours of operation of the underfired broilers are 12.7 hrs/day installed in restaurants that serve lunch and dinner. Baseline broiler consumption for the 3-ft broilers was 9.4 Therms/day and replacement lidded broilers consume 6.8 Therms/day. The average input rate of the thermostatic lidded broiler is 17.6 kBtu/hr./len.-ft., compare to 24.4 kBtu/hr./len.-ft., for baseline broilers.

The lidded thermostatic broiler is equipped with the same type of burners as the IR burner broiler featured in the 201y ET study, which has an average input rate of 17.0 kBtu/hr at one site. Based on this data, it is estimated that the energy savings contribution from the lid is minimal due to operators leaving the broiler lid open. Therefore, most of the savings are attributed to the efficient IR burner design.



Lidded Thermostatic Broiler

⁴ Fisher-Nickel, Inc. 2014. *Emerging Technologies (ET) Lidded Thermostatic Infrared Broiler Field Study*. ET Project Number ET13PGE1311. Prepared for Pacific Gas and Electric Company (PG&E). December 15.



Lidded Thermostatic Broiler Daily Energy Consumption Before and After Replacement

Advanced Foodservice Appliances for California Restaurants (Gas Technology Institute and Fisher-Nickel, 2014).⁵ A feasibility study conducted for the California Energy Commission estimated daily energy consumption and operating hours, among many other variables, of the lidded broiler technology. The energy consumption of broilers monitored at two restaurants revealed an average savings of 23%.

Characterizing the Energy Efficiency of Gas-Fired Commercial Foodservice Equipment (Fisher-Nickel, 2014).⁶ This study, conducted for the CEC, estimated 40,000 underfired broilers in use units in California in 2010, with 10,000 units sold annually in the U.S. Over half of all restaurant facilities in California are estimated to have an underfired broiler. This study revealed that broilers are primarily used in the full-service independent restaurant segment, with an average of one broiler per facility. Quick-service restaurant (QSR) segment account for a large share of the restaurant market segment, but are less likely to have underfired broilers. Most broilers in the QSR segment are used by independent QSRs.

⁵ Gas Technology Institute (GTI) and Fisher Nickel, Inc. 2013. *Advanced Foodservice Appliance for California Restaurants*. Prepared for the California Energy Commission (CEC). CEC-500-2014-021. July.

⁶ Fisher-Nickel, Inc. 2014. *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment*. Prepared for the California Energy Commission (CEC). CEC-500-2014-095. October.

Broilers by Restaurant Type, 2010

| Restaurant Type | # of Stores in CA | Conveyor | Overfired | Salamander | Underfired | Avg. # of Underfired Broilers per Store |
|--------------------------|-------------------|--------------|--------------|---------------|---------------|---|
| Hotel | 1,297 | 0 | 5,188 | 1,297 | 1,686 | 1.30 |
| Corporate Cafeteria | 809 | 0 | 0 | 0 | 566 | 0.70 |
| Grocery Store | 2,239 | 0 | 0 | 0 | 112 | 0.05 |
| QSR -independent | 12,349 | 0 | 0 | 0 | 1,993 | 0.16 |
| QSR - small chain | 6,387 | 0 | 0 | 0 | 1,045 | 0.16 |
| QSR - large chain | 20,133 | 1,375 | 0 | 0 | 689 | 0.03 |
| Full-service Independent | 27,905 | 0 | 489 | 20,425 | 27,513 | 0.99 |
| Full-service Small Chain | 4,103 | 0 | 168 | 3,266 | 4,078 | 0.99 |
| Full-service Large Chain | 2,400 | 60 | 0 | 1,399 | 2,456 | 1.02 |
| Total | 77,622 | 1,435 | 5,845 | 26,387 | 40,138 | 0.52 |

Broiler Market Assessment, 2018⁷ This market assessment identified the broiler types and hours of operation in 29 facilities across the restaurant market segment. Based on market surveys, almost half of the surveyed restaurants use underfired broilers, they were most prominent in the Independent full service, full service small chain, and QSR independent restaurants. QSR small chain restaurants are less likely to have underfired broilers and QSR large chains primarily use chain-driven conveyor broilers (not the scope of this measure). Market data was analyzed by restaurant type and cuisine type; underfired broilers were mostly found in American casual and fine dining restaurants.

The 2018 survey results indicate fewer underfired broilers than initially estimated in the CEC survey conducted in 2010.

Broilers by Restaurant Type, 2018

| Restaurant Type | Survey Sample Size | Total # of Units | | | | Avg. # of Underfired Broilers per Store |
|--------------------------|--------------------|------------------|-----------|------------|------------|---|
| | | Conveyor | Overfired | Salamander | Underfired | |
| Hotel | 3 | 0 | 0 | 0 | 2 | 0.67 |
| Corporate Cafeteria | 1 | 0 | 0 | 0 | 0 | 0.00 |
| Grocery Store | 0 | 0 | 0 | 0 | 0 | 0.00 |
| QSR independent | 3 | 0 | 0 | 1 | 2 | 0.67 |
| QSR small chain | 6 | 1 | 0 | 0 | 3 | 0.50 |
| QSR large chain | 2 | 2 | 0 | 0 | 0 | 0.00 |
| Full Service Independent | 9 | 0 | 1 | 3 | 5 | 0.56 |
| Full Service Small Chain | 2 | 0 | 1 | 0 | 1 | 0.50 |
| Full Service Large Chain | 3 | 0 | 0 | 1 | 4 | 1.33 |
| Total | 29 | 3 | 2 | 5 | 17 | 0.43 |

Based on 3-ft broiler equivalent width

⁷ Southern California Gas Company (SCG). 2018. "SWF5019-01 Commercial Underfired Broiler_2018 Market Assessment.xlsx."

The 2018 survey results from 31 restaurants were applied to the number of facilities in each segment per CEC study in 2010. The results show that California restaurant facilities are 43% likely to have an underfired broiler, which equates to 33,000 units in the State.

Broilers by Restaurant Type, 2018

| Restaurant Type | # of Stores in CA | Avg. # of Underfired Broilers per Store | Total # of Underfired Broilers in CA |
|--------------------------|-------------------|---|--------------------------------------|
| Hotel | 1,297 | 0.67 | 865 |
| Corporate Cafeteria | 809 | 0 | 0 |
| Grocery Store | 2,239 | 0 | 0 |
| QSR Independent | 12,349 | 0.67 | 8,233 |
| QSR Small chain | 6,387 | 0.5 | 3,194 |
| QSR Large chain | 20,133 | 0 | 0 |
| Full Service Independent | 27,905 | 0.56 | 15,503 |
| Full Service Small Chain | 4,103 | 0.5 | 2,052 |
| Full Service Large Chain | 2,400 | 1.33 | 3,200 |
| Total | 77,622 | 0.59 | 33,047 |

Key results of the 2018 restaurant market survey analysis are:

Average of 358 days of operation per year

Average broiler ON time of 12.6 hours per day

Average restaurant business hours are 11.9 hours day, with broiler being turned on an average of 0.7 hours prior to the restaurant open

Average broiler width of 3.15 feet and vintage of 11.7 years

Approximately 5% of restaurants use heavy marinades and 30% reported loading the broiler to its full capacity

70% of the survey respondents thought the conditions around the broiler were very hot and 38% indicated a willingness to use a lidded broiler.

MEASURE CASE DESCRIPTION

The measure case is defined as an underfired broiler with an input rate ≤ 22 kBtu/hr/len-ft while maintaining a surface temperature of 600 °F.

As of July 2018, there are only three underfired broiler models that have been verified by in a laboratory setting to fall under the 22 kBtu/hr/len-ft threshold. The IR Burner broiler is the most universal direct replacement underfired broiler. The IR Plate broiler offers the highest potential energy savings; however, it may not be the best fit for operations that use heavy marinades or high quantities of greasy product. The lidded IR broiler lid closed energy usage is highly dependent on the operator and is expected to be operated with the lid open. An energy efficiency threshold of 22 kBtu/h/len-ft allows all three products to be incentivized, giving the customer a great choice of market available model selection.

Measures Offerings

| Statewide Measure Offering ID | Measure Offering Descriptions |
|-------------------------------|---|
| SWFS019A | Energy Efficient Commercial Underfired Broilers |

BASE CASE DESCRIPTION

The base case is defined as an underfired broiler with an input rate > 22 kBtu/hr/len-ft while maintaining a surface temperature of 600 °F.

CODE REQUIREMENTS

This measure is not governed by state or federal standards. The California Appliance Efficiency Regulations (Title 20) includes a category for cooking appliances, but broilers are not included.

Applicable State and Federal Codes and Standards

| Code | Applicable Code Reference | Effective Date |
|--|---------------------------|----------------|
| CA Appliance Efficiency Regulations – Title 20 | None. | n/a |
| CA Building Energy Efficiency Standards – Title 24 | None. | n/a |
| Federal Standards | None. | n/a |

NORMALIZING UNIT

Len-ft

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

| Measure Application Type | Delivery Type | Sector |
|--------------------------|---------------|--------|
| Normal Replacement | DnDeemed | Com |
| Normal Replacement | UpDeemed | Com |
| Normal Replacement | DnDeemDI | Com |
| Normal Replacement | DnDeemed | Ind |
| Normal Replacement | UpDeemed | Ind |
| Normal Replacement | DnDeemDI | Ind |
| Normal Replacement | DnDeemed | Ag |
| Normal Replacement | UpDeemed | Ag |
| Normal Replacement | DnDeemDI | Ag |
| New Construction | DnDeemed | Com |
| New Construction | UpDeemed | Com |
| New Construction | DnDeemDI | Com |
| New Construction | DnDeemed | Ind |
| New Construction | UpDeemed | Ind |
| New Construction | DnDeemDI | Ind |
| New Construction | DnDeemed | Ag |
| New Construction | UpDeemed | Ag |
| New Construction | DnDeemDI | Ag |

Underfired broilers are long-lasting cooking devices that can be repaired with replacement parts that are still manufactured if the integrity of the appliance frame remains intact. This means that older broilers remain in restaurants for years and not replaced by the end of the EUL period. Normal Replacement (NR) is applicable to lighter duty lower cost broilers, for which broiler repair is not as cost effective as replacement. Normal Replacement (NR) and new construction (NC) are the applicable installation types for underfired broiler.

- Most underfired broilers are purchased by independent restaurants; therefore, a downstream incentive method is the most applicable. Most restaurant supply dealers only stock baseline broilers and most energy efficient broilers must be custom-ordered from the manufacturer; mid-stream incentives can encourage restaurant dealers to increase sales of energy efficient underfired broilers.
- Franchisees that have several restaurants are likely to be interested with on-bill financing due to the higher cost of energy efficient underfired broiler models.

Eligible Products

The measure case (replacement) underfired broiler must input rate ≤ 22 kBtu/hr/len-ft while maintaining a surface temperature of 600 °F, per ASTM F1695 standard.⁸

The base case broiler must be similar size or larger than the replacement unit.

⁸ American Society for Testing and Materials (ASTM). 2015. ASTM F1695-03, Standard Test Method for the Performance of Combination Ovens in Different Modes. West Conshohocken (PA): ASTM International.

Eligible Building Types and Vintages

This measure is applicable in any commercial building of any vintage.

Eligible Climate Zones

This measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

Used or rebuilt equipment is not eligible.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined. With the advent of broiler incentives, manufacturers will develop new energy efficient models that would have to be evaluated in a laboratory setting to determine the legitimacy of their energy saving claims.

USE CATEGORY

Food Service (FoodServ)

ELECTRIC SAVINGS (kWh)

Not applicable.

PEAK ELECTRIC DEMAND REDUCTION (kW)

Not applicable.

GAS SAVINGS (Therms)

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

Annual Gas Unit Energy Consumption

Broiler annual energy consumption is a function of idle energy and operating hours per day. The daily gas UEC (baseline or measure case) is equal to energy required for idle mode of broiler operation multiplied by the annual hours of operation.⁹ These calculations and the inputs are provided below.¹⁰

$$UEC_{year} = \frac{IDLE \times EHOURS \times EDAYS}{Btu_Therm}$$

UEC_{year} = Annual unit energy consumption (Btu/year)
 $IDLE$ = Measured idle energy rate (Btu/hr)
 $EHOURS$ = Estimated operating hours per day (hr/day)
 $EDAYS$ = Estimated operating days per year (days/yr)
 Btu_Therm = Btu to therm conversion factor

An underfired broiler is not a thermostatic appliance and therefore it requires the same energy input for both cooking and idle modes; thus, the amount of food cooked per day has no effect on the energy use or demand.

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)

The annual UES values were then normalized to per linear foot of underfired broiler cooking surface.

Inputs and Assumptions

Idle Energy Rate

Energy consumption is directly proportional to the broiler width; baseline broilers have one burner for each ½-ft of broiler width. The most common sizes of underfired broilers have a width of either two, three, or four linear feet and have a depth of two feet. Broilers wider than four feet are less common. Most energy efficient broilers with IR burners only have one burner per foot of broiler width. It is possible to normalize broiler energy usage per linear foot per hour. The lower the normalized energy use to achieve 600 °F average surface temperature, the more efficient the broiler. Broilers with high input rates mean that less energy is transfer into the food and the remainder is dissipated into the cooking space. Laboratory test data shows the average input rate of different broilers to achieve the desired surface cooking temperature in the table below.

Based on numerous restaurant site audits conducted by Fisher Nickel, it is estimated that over 90% of the baseline models on the market are standard radiant broilers. The other baseline categories in the table

⁹ American Society for Testing and Materials (ASTM). 2015. *ASTM F1695-03, Standard Test Method for the Performance of Underfired Broilers*. West Conshohocken (PA): ASTM International.

¹⁰ Southern California Gas Company (SCG). 2018. "SWFS019-01 Energy and Cost Calculations.xlsx."

below are represented by a single model. For this reason, the estimated weighted baseline average is slightly above the standard radiant idle rate of 24.5 kBtu/hr/len-ft. at 25 kBtu/hr/len-ft.

Baseline Underfired Broiler Idle Energy Rate

| Broiler Type | Lab Tested Idle Rate at 600 °F (kBtu/hr/len-ft) | Source |
|---|---|--|
| Standard Radiant (most popular) | 24.5 | Livchack, D. (Fisher-Nickel, Inc.). 2017. <i>Energy Efficient Underfired Broilers</i> . ET Project Number ET16PGE1941. Prepared for Pacific Gas and Electric Company (PG&E). March 24. Page 65, Figures 79 and 80. |
| Radiant Reflector | 25.0 | |
| Radiant Reflector Pilotless (least popular) | 29.5 | |

* Estimated weighted average 25 kBtu/hr

With the IR burner broiler serving as a direct replacement for baseline broilers and some applications being not suitable for the IR plate broiler, it is assumed that the average energy efficient broiler consumes 20 kBtu/hr/len-ft. Closing the lid of a lidded broiler depends on the operator and studies show similar average input rate of the lidded broiler as the unlidded IR burner broiler (see Technology Summary).

Measure Case Broiler Idle Energy Rate

| Broiler Type | Lab Tested Idle Rate at 600 °F (kBtu/hr/len-ft) | Source |
|--|---|--|
| IR Plate | 17.0 | Livchack, D. (Fisher-Nickel, Inc.). 2017. <i>Energy Efficient Underfired Broilers</i> . ET Project Number ET16PGE1941. Prepared for Pacific Gas and Electric Company (PG&E). March 24. Page 65, Figures 79 and 80. |
| IR Burner (most popular) | 21.0 | Livchack, D. (Fisher-Nickel, Inc.). 2017. <i>Energy Efficient Underfired Broilers</i> . ET Project Number ET16PGE1941. Prepared for Pacific Gas and Electric Company (PG&E). March 24. Page 65, Figures 79 and 80. |
| Lidded IR Burner with Lid Open | 21.0 | Fisher-Nickel, Inc. 2014. <i>Emerging Technologies (ET) Lidded Thermostatic Infrared Broiler Field Study</i> . ET Project Number ET13PGE1311. Prepared for Pacific Gas and Electric Company (PG&E). December 15. Page 10, Table 1. |
| Lidded IR Burner with Lid Closed (least popular) | 15.0 | |

*Estimated weighted average 20 kBtu/hr

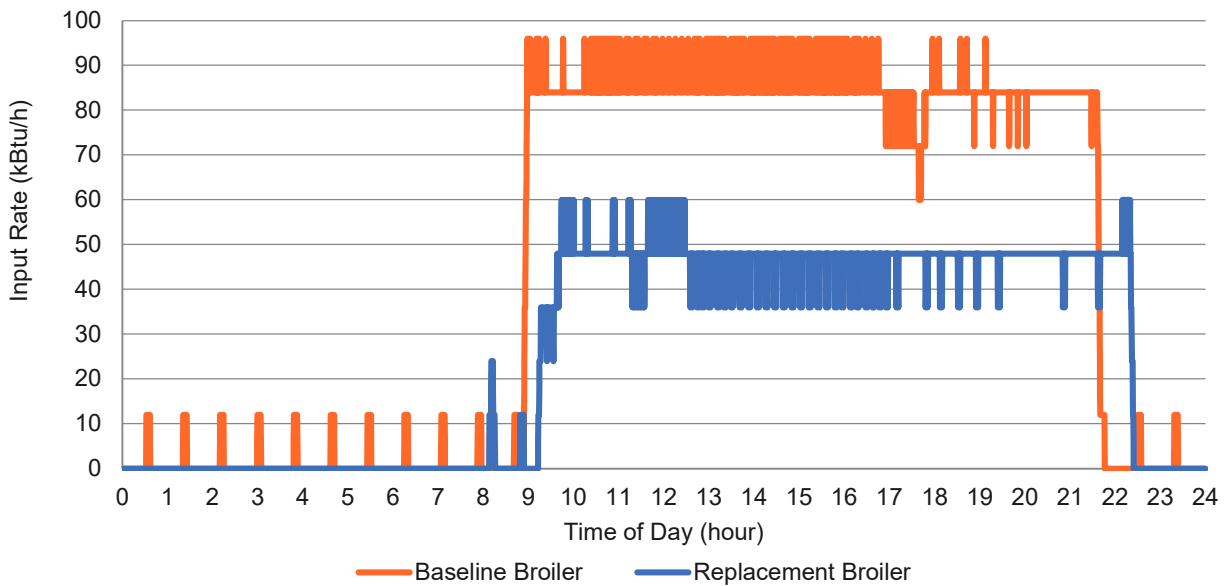
Hours of Operation per Day

Broiler operating hours can be determined by:

- Restaurant open hours
- Operation surveys stating how many hours before or after opening the broiler gets turned ON and OFF (used for this measure analysis)
- Sub metered field data (used for this measure analysis)

The broiler ON time for this analysis is assumed to be 12 hours per day based on the studies described in the Technology Summary.

Underfired broilers have almost constant gas input rates in their load shapes and do not consume electric energy. Units equipped with electronic ignition may have a 120 Volt connection. However, their energy consumption is low, less than 5 Watts per hour.



Baseline and Replacement Broiler Hourly Operation

Energy efficient replacement underfired broilers have a lower average input but have the same load shape. Pilotless broilers with electronic ignition do not consume energy outside their hours of operation. Most baseline broilers have a single pilot for each burner, hence a 3-ft broiler with six burners will have six pilot lights operating around 0.3 kBtu/hr per pilot light (for a total of 1.8 kBtu/hr).

Days of Operation per Year

The 13 broilers monitored for the 2014 and 2017 ET studies reveal an average of 12.3 hours of operation per day;¹¹ most sites served both lunch and dinner. Broiler market survey indicates an average 12.6 hours of operation at 21 sites.¹² The full-service restaurants examined were open seven days per week, except for Christmas and Thanksgiving, which equates to 363 days per year operation.

UEC Calculation Inputs – Constants

| Variable | Value | Source |
|-------------------------|-------|--|
| Preheat Time (min) | 15 | Livchack, D. (Fisher-Nickel, Inc.). 2017. <i>Energy Efficient Underfired Broilers</i> . ET Project Number ET16PGE1941. Prepared for Pacific Gas and Electric Company (PG&E). March 24. Page 65, Figures 79 and 80. |
| Operating Hours per Day | 12 | |
| Operating Days per Year | 363 | |

¹¹ Livchack, D. (Fisher-Nickel, Inc.). 2017. *Energy Efficient Underfired Broilers*. ET Project Number ET16PGE1941. Prepared for Pacific Gas and Electric Company (PG&E). March 24

¹² Southern California Gas Company (SCG). 2018. "SWFS019-01 Commercial Underfired Broiler_2018 Market Assessment.xlsx."

UEC Calculation Inputs - Underfired 2-ft wide Broiler

| Performance | Base Model | Measure Case Model | Source |
|--|------------|--------------------|--|
| Broiler Width (ft) | 2 | | Fisher-Nickel, Inc. 2014. <i>Emerging Technologies (ET) Lidded Thermostatic Infrared Broiler Field Study</i> . ET Project Number ET13PGE1311. Prepared for Pacific Gas and Electric Company (PG&E). December 15. |
| Idle and Cooking Energy Rate (Btu/hr/ft) | 25,000 | 20,000 | |
| Idle and Cooking Energy Rate (Btu/hr) | 50,000 | 40,000 | |

UEC Calculation Inputs - Underfired 3-ft wide Broiler

| Performance | Base Model | Measure Case Model | Source |
|--|------------|--------------------|--|
| Broiler Width (ft) | 3 | | Fisher-Nickel, Inc. 2014. <i>Emerging Technologies (ET) Lidded Thermostatic Infrared Broiler Field Study</i> . ET Project Number ET13PGE1311. Prepared for Pacific Gas and Electric Company (PG&E). December 15. |
| Idle and Cooking Energy Rate (Btu/hr/ft) | 25,000 | 20,000 | |
| Idle and Cooking Energy Rate (Btu/hr) | 75,000 | 60,000 | |

UEC Calculation Inputs - Underfired 4-ft wide Broiler

| Performance | Base Model | Measure Case Model | Source |
|--|------------|--------------------|--|
| Broiler Width (ft) | 4 | | Fisher-Nickel, Inc. 2014. <i>Emerging Technologies (ET) Lidded Thermostatic Infrared Broiler Field Study</i> . ET Project Number ET13PGE1311. Prepared for Pacific Gas and Electric Company (PG&E). December 15. |
| Idle and Cooking Energy Rate (Btu/hr/ft) | 25,000 | 20,000 | |
| Idle and Cooking Energy Rate (Btu/hr) | 100,000 | 80,000 | |

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 methodology to calculate the RUL conforms with Version 5 of the Energy Efficiency Policy Manual, which recommends “one-third of the effective useful life in DEER as the remaining useful life until further study results are available to establish more accurate values”.¹³ This approach provides a reasonable RUL estimate without the requiring any a priori knowledge about the age of the equipment being replaced.¹⁴ Further, as per Resolution E-4807, the California Public Utilities Commission (CPUC) revised

¹³ California Public Utilities Commission (CPUC), Energy Division. 2013. *Energy Efficiency Policy Manual Version 5*. Page 32.

¹⁴ KEMA, Inc. 2008. "Summary of EUL-RUL Analysis for the April 2008 Update to DEER." Memorandum submitted to Itron, Inc.

add-on measures so that the EUL of the measure is equal to the lower of the RUL of the modified system or equipment or the EUL of the add-on component.¹⁵

The EUL for the underfired broiler measure 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. <i>Ninth Year Retention Study of the 1995 Southern California Gas Company Commercial New Construction Program</i> . Prepared for Southern California Gas Company. Study ID Number 718A. California Public Utilities Commission (CPUC), Energy Division. 2003. <i>Energy Efficiency Policy Manual v 2.0</i> . Page 18 Table 4.1. |
| RUL (yrs.) | n/a | - |

BASE CASE MATERIAL COST (\$/UNIT)

The base case material cost was calculated as the average cost of five standard radiant broiler models obtained from the online equipment price list of two foodservice equipment dealers in 2018. The average unit cost was then normalized per linear foot.¹⁶

Baseline Underfired Broiler Material Costs

| Model | Cost |
|-------------------------------------|-----------------|
| Model A | \$ 2,212 |
| Model B | \$ 2,536 |
| Model C | \$ 3,628 |
| Model D | \$ 3,650 |
| Model E | \$ 3,855 |
| Average Cost 3-ft Broiler | \$ 3,176 |
| Average Cost per Linear Foot | \$ 1,059 |

MEASURE CASE MATERIAL COST (\$/UNIT)

The measure case material cost was calculated as the average cost IR plate and IR burner broilers that have a lab tested idle rate of ≤ 22 kBtu/hr/len-ft while maintaining surface temperatures of 600 °F: Cost data was obtained for three broiler models from the online price list of two foodservice equipment vendors in 2018. The average unit cost was then normalized per linear foot.¹⁷

¹⁵ California Public Utilities Commission (CPUC). 2016. Resolution E-4807. December 16. Page 13.

¹⁶ Southern California Gas Company (SCG). 2018. "SWFS019-01 Energy and Cost Calculations.xlsx."

¹⁷ Southern California Gas Company (SCG). 2018. "SWFS019-01 Energy and Cost Calculations.xlsx."

Measure Case Underfired Broiler Costs

| Model | Broiler Type | Cost |
|-------------------------------------|-----------------------------------|-----------------|
| Model F | IR Plate | \$ 4,715 |
| Model G | IR Burner | \$ 5,410 |
| Model H | IR Burner with Lid and Thermostat | \$ 6,760 |
| Average Cost 3-ft Broiler | | \$ 5,628 |
| Average Cost per Linear Foot | | \$ 1,876 |

BASE CASE LABOR COST (\$/UNIT)

The installation costs are the same for the baseline and energy efficient underfired broilers. It is estimated that the underfired broiler delivery and installation costs are \$300 for a 3-ft broiler, normalized per linear foot, or \$100 per linear foot.

MEASURE CASE LABOR COST (\$/UNIT)

Measure labor costs are the costs to install the underfired broiler and are the same for both the baseline and energy efficient underfired broilers. See Base Case Labor Cost.

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 | Value | Source |
|--------------------|-------|---|
| NTG – Commercial | 0.60 | Itron, Inc. 2011. <i>DEER Database 2011 Update Documentation</i> . Prepared for the California Public Utilities Commission. Page 15-4 Table 15-3. |
| NTG – Industrial | 0.60 | |
| NTG – Agricultural | 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

| Parameter | GSIA | Source |
|----------------|------|---|
| GSIA – Default | 1.00 | California Public Utilities Commission (CPUC), Energy Division. 2013. <i>Energy Efficiency Policy Manual Version 5</i> . Page 31. |

NON-ENERGY IMPACTS

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

DEER DIFFERENCES ANALYSIS

This section provides a summary of inputs and methods based upon the Database of Energy Efficient Resources (DEER), and the rationale for inputs and methods that are not DEER-based.

DEER Difference Summary

| DEER Item | Comment |
|--------------------------------|---|
| 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 does not contain Energy Efficient Underfired Broilers. |
| DEER Measure IDs Used | None |
| NTG | Source: DEER. The NTG of 0.60 is associated with NTG ID: <i>Com-Default>2yrs, Agric-Default>2yrs, Ind-Default>2yrs</i> |
| GSIA | The GSIA of 1.0 is associated with GSIA ID: <i>Def-GSIA</i> |
| EUL/RUL | Source: DEER. The value of 12 years is associated with EUL ID: <i>Cook-ConvBroiler</i> |

REVISION HISTORY

Measure Characterization Revision History

| Revision Number | Revision Complete Date | Primary Author, Title, Organization | Revision Summary and Rationale for Revision |
|-----------------|------------------------|--|--|
| 01 | 10/17/2018 | Jaime Lopez, SoCalGas RMS Energy Consulting, LLC | Draft of consolidated text for this statewide measure is based upon: WPSCGNRCC180705A_R0 |
| 02 | 04/13/2021 | Anders Danryd, SoCalGas | Updated NTG Ratio from ET-Default to Com-Default>2yrs, formatting changes, made calculations and sources easier to follow and more clearly labeled |