WPSCGNRCC180705A

**Revision 00**

**Southern California Gas Company**

**Customer Programs Department**

**Commercial Underfired Broilers**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | TBD |
| **Measure Description** | Energy Efficient Commercial Underfired Broiler (with 22 kBtu/ hr./ linear foot, or less input rate while maintaining a surface temperature of 600 °F). |
| **Base Case Description** | Standard Underfired Commercial Broiler (with more than 22 kBtu/ hr./ linear foot while maintaining a surface temperature of 600 °F). |
| **Units** | (Len-ft.): length (feet)): Linear foot of broiler cooking surface. |
| **Energy Savings** | 218 Therms/year/linear foot |
| **Full Measure Cost ($/unit)** | $1,876/linear foot |
| **Incremental Measure Cost ($/unit)** | $817/linear foot |
| **Effective Useful Life** | EUL ID: Cook-UndFiredBroiler: 12 years |
| **Measure Installation Type** | New Construction (NC),  Replace on Burnout (ROB) |
| **Net-to-Gross Ratio** | 0.85 (DEER NTGR ID : ET-Default) |
| **Important Comments** | NA |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 7/5/18 | Denis Livchak (Frontier Energy) | Original Release |
|  |  |  |  |

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# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper documents the energy savings and rationale for Energy Efficient Commercial Underfired Broilers to be listed in the Commercial Food Service Catalog. Underfired broilers are abundant in institutional kitchens, high end dining and American casual eateries. These appliances are manually controlled and typically consume close to their peak energy input rate during the operating period, regardless if they are cooking or not. The high operating temperatures place a tremendous load on HVAC systems, requiring high exhaust flow rates and introducing a significant amount of heat into the surrounding kitchen space. Underfired broilers’ high-energy usage and long operating hours make them one of the most energy intense appliances in kitchens. Energy efficient broilers utilize advance burner technology to deliver equivalent heat to the cooking area, providing similar cooking characteristics while saving significant amounts of energy. Energy efficient broilers direct more heat to the cooking surface, reduce waste heat and are characterized by lower input rates while maintaining the cooking surface temperature at 600°F or more.

Table I: Base, Standard, and Measure Cases

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Energy Efficient Underfired Broilers |
| Existing Condition | Baseline Efficiency Underfired Broilers |
| Code/Standard | N/A |
| Industry Standard Practice | Baseline Efficiency Underfired Broilers |

Table II: Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE |  |
| TBD |  |  |  | Efficient Underfired Broiler |

**Eligibility requirements:**

**Measure**:

1. Replacement underfired broiler must have a tested input rate of less than or equal to (22kBtu/hr./ linear foot) while maintaining a surface temperature of 600°F or more per ASTM F1695 standard.
2. Customers must have natural gas service by a California IOU with a current, good standing account.

**Base Case:**

1. Underfired broiler must be of similar in size or larger.

**1.2 Technical Description**

Underfired broilers are composed of a heavy-duty cooking grate suspended above a radiant heat source. Below the grate gas broilers have 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's 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.

Typical underfired broilers operate at a constant input rate maintaining average cooking grate temperatures between 550 and 650°F. Constant input rate broilers do 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 advance 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 which can be closed when not cooking; controls reduce the burner input once the lid is closed thus 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 workpaper.

## 1.3 Installation Types and Delivery Mechanisms

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. An operator survey from section 1.5.5 shows that over half of the installed underfired broilers are 10 years or older and a quarter of them were over 20 years. This means that older broilers remain in restaurants for years and not replaced by the end of the EUL period. Replacement on burnout is applicable to lighter duty lower cost broilers, where broiler repair is not as cost effective as replacement. Replacement on burnout (ROB) and new construction (NC) are the applicable installation types for underfired broiler. There are currently no code requirements for broilers, therefore they will use the existing condition as the baseline.

Table III: Installation Type Descriptions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |
| New Construction (NEW/NC) | Above Code or Standard | N/A | EUL | N/A |

A delivery mechanism is a delivery method paired with an incentive method and is use by programs to obtain participation and energy savings. Most underfired broilers purchases are by independent restaurants; therefore, a down-stream 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. *Table V* shows the incentive methods for this measure.

Table IV: Delivery Method Descriptions

|  |  |
| --- | --- |
| **Delivery Method** | **Description** |
| Financial Support | The program motivates customers, through financial incentives such as rebates or low interest loans, to implement energy efficient measures or projects. |

Table V: Incentive Method Descriptions

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |
| Mid-Stream Incentive | The program gives a financial incentive to a midstream market actor, such as a retailer or contractor, to encourage the promotion of efficient measures. The incentive may or may not be passed on to the end-use customer. |
| On-bill Finance/Loan | The program offers financing for the cost an efficient measure as part of the utility bill. This can be an add-on option to an existing program or can serve as an organizing principle for its own program. |

## 1.4 Measure Parameters

### 1.4.1 DEER Data

The DEER database does not contain information on energy use or savings for energy-efficient broilers. The only reference in DEER for Commercial cooking equipment is for Estimated Useful Life.

Table VI: DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | No |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | DEER 2018, READI v2.4.7 |
| Reason for Deviation from DEER | DEER does not contain this type of measure. |
| DEER Measure IDs Used | None |

**Net-to-Gross Ratio**

DEER NTGR Values do not specifically list commercial food service appliances, an emerging technologies study was conducted on energy efficient underfired broilers (Section 1.5.1). The NTGR value for this workpaper is 0.85, the ET-Default value.

The NTGR value was obtained using the DEER READI tool. The relevant NTGR value for this measure is in the table below.

Table VII: NTGR ID

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| ET-Default | Emerging Technologies approved by ED through workpaper review | Any | Any | Any | 0.85 |

**Spillage Rate**

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

**Installation Rate**

The IR value was obtained using the DEER READI tool. The relevant IR value for this measure is in the table below.

Table VIII: GSIA ID

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

**Effective and Remaining Useful Life**

The EUL value was obtained from the DEER READI tool. The Underfired Broiler EUL is the same as other appliances in the Foodservice category. The study shown in Section 1.5.5 confirms the average age of an underfired broilers to be 11.7 years which aligns with the EUL of 12 years used in this workpaper.

Table IX: EUL ID

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| Cook-UndFiredBroiler | Underfired Broilers | Com | Foodservice | 12 | 4 |

### 1.4.2 Codes and Standards Analysis

* California Title 20 Appliance Efficiency Regulation has a category for cooking appliances, but broilers are not included.
* California Title 24 Efficiency Regulation requirements do not include broilers.
* There are no Federal energy efficiency requirements for commercial underfired charbroilers.

Table X: Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2013) | NA | NA |
| Title 20 (2014) | NA | NA |
| DOE | NA | NA |

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

Underfired charbroiler energy consumption has been measured through laboratory testing as well as field verification. Field gas sub-metering data provides broiler operating hours and operating characteristics. A broiler market assessment was conducted in both PG&E and SCG territories to determine the most popular broiler types, size, hours of operation and age.

### 1.5.1 ET13PGE1471: Emerging Technologies Underfired Broilers

The objective of this study is to determine energy and cost savings from replacing conventional broilers with best-in-class broilers. This project also characterizes the technological improvements that contribute to energy reduction in broilers across the market, monitors energy consumption, operating conditions and hours of operation.

This project was a follow-up to a previous underfired broiler study focusing on the lidded thermostatic broiler technology (ET13PGE1311).

<https://www.etcc-ca.com/reports/energy-efficient-underfired-broilers?dl=1490805543>

Table XI: Underfired Broiler Baseline and Replacement Energy Use and Hours of Operation

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Restaurant** | **Broiler width**  **(ft.)** | **Broiler operation**  **(hrs.)** | **Baseline broiler energy (Therms/day)** | **Energy efficient broiler energy (Therms/day)** | **Energy reduction (%)** | **Replacement broiler type** |
| A | 4 | 12.0 | 12.5 | 12.8 | NA | No Pilot |
| B | 4 | 12.9 | 12.0 | 11.6 | 3% | No Pilot |
| C | 3 | 12.0 | 7.5 | NA | NA | Not replaced |
| D | 3 | 5.2\*\* | 3.4 | NA | NA | Not replaced |
| E | 4\* | 15.4 | 11.6 | 7.9 | 32% | IR Burner |
| F | 2 | 18.9 | 5.3 | 4.9 | 8% | IR Plate |
| G | 4 | 11.3 | 10.4 | 6.8 | 35% | IR Plate |
| H | 3 | 12.9 | 11.0 | 6.3 | 43% | IR Plate |
| I | 3 | 8.8 | 7.0 | 4.0 | 43% | IR Plate |
| **Average** |  | **12.2** | **9.0** |  |  |  |

\*4-ft broiler replaced by a 3-ft broiler \*\*Not a 7 day a week operation

This study measures the baseline energy consumption of 9 broilers, with 3 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. Average baseline energy use is as follow,

1. 2 feet in width broiler: 5.3 Therms/day
2. 3 feet in width broiler: 8.5 Therms/day
3. 4 feet in width broiler: 11.6 Therms/day.

When the data is normalized to a linear foot of broiler cooking surface in width, baseline broilers consume an average of 2.7 Therms/day/linear foot, energy efficient broilers averaged 2.3 Therms/day /linear foot.

Replacement broiler technologies evaluated in this ET 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% compare to the baseline. However, these units require semiannual maintenance of replacing the radiant plates in restaurants using marinades and high fat content proteins. The IR Burner broiler resulted in 24% savings without any additional maintenance.

Table XII: Underfired Broiler Replacement Energy Savings by Type

|  |  |  |
| --- | --- | --- |
| **Broiler type** | **Average input rate (kBtu/hr./linear) foot)** | **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% |

Figure I: Average Broiler Input Rate Based on Replacement Technology

Underfired broilers do not have thermostatic controls and the operating energy rate of each burner must be adjusted manually to achieve the desired temperature. Typically, restaurant operators turn on the broiler in the morning and operate it at a continuous input rate throughout the day, regardless of cooking demand. The graph below shows 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./ft. and energy efficient broilers have average input rates under 19 kBtu/hr./ft. while achieving similar surface temperatures.

Energy Efficient Replacement Broiler

Figure II: Underfired Broiler Energy Profile Before and After Replacement

This study also highlights the financial benefits of broiler replacement shown in the table below:

Table XIII: Underfired Broiler Replacement Energy Savings by Type

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **IR Plate** | **IR Burner** | **Radiant Reflector Pilotless** | **Lidded Thermostatic** |
| Baseline | 22.992 | 22.355 | 24.568 | 25.143 |
| Replacement | 14.859 | 16.990 | 24.916 | 18.427 |
| Percent Savings | 35% | 24% | N/A | 27% |
| Estimated Annual Energy Cost Savings\* | $818.22 | $554.88 | N/A | $634.17 |

\*Based on $1.00 per Therm

### 1.5.2 Emerging Technologies (ET) Lidded Thermostatic Infrared Broiler Field Study ET13PGE1311

This project’s objective was to determine the potential energy and cost savings, particularly during idle periods, from replacing existing un-lidded char-broilers with lidded char-broiler having thermostatic controls. The project documents energy consumption, operating conditions and hours of operation at three sites.

<https://www.etcc-ca.com/reports/lidded-thermostatic-infrared-broiler-field-study>

Table XIV: Lidded Thermostatic Broiler Baseline and Replacement Energy Use and Hours of Operation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Restaurant** | **Broiler width (ft.)** | **Broiler operation**  **(hrs.)** | **Baseline broiler energy**  **(Therms/day)** | **Energy efficient**  **broiler energy**  **(Therms/day)** | **annual operating cost savings\* (%)** |
| J | 3 | 12.5 | 9.59 | 7.51 | $757 (22%) |
| K | 3 | 11.3 | 6.56 | 3.05 | $1,278 (54%) |
| L | 3 | 14.3 | 10.67 | 8.80 | $681 (18%) |
| M | 3 | 12.8 | 10.73 | 7.98 | $1,001 (26%) |
| **Average** |  | **12.7** | **9.4** | **6.8** | **27%** |

\*Based on $1.00 per Therm

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 hr./day installed in restaurants that serve lunch and dinner. Baseline broiler consumption for the 3-ft broilers is 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./ft., compare to 24.4 kBtu/hr./ft., for baseline broilers.

The lidded thermostatic broiler has the same burners as the IR burner broiler in the ET Underfired Broiler study (ET13PGE1471) 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.

|  |  |
| --- | --- |
| C:\Users\dlivchak\Documents\FSTC\Sites\Sideboard\New Broiler\photo 1.JPG |  |

Figure I: Lidded Thermostatic Broiler

Figure IV: Lidded Thermostatic Broiler Energy Profile Before and After Replacement

### 1.5.3 Advanced Foodservice Appliances for California Restaurants CEC-500-2014-021

This is a feasibility study for the lidded broiler technology conducted prior to the Emerging Technologies study(ET13PGE1311).

<http://www.energy.ca.gov/2014publications/CEC-500-2014-021/CEC-500-2014-021.pdf> (Chapter 6)

Table XV: Lidded Thermostatic Broiler Baseline and Replacement Energy Use and Hours of Operation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Restaurant** | **Broiler width (ft.)** | **Broiler operation**  **(hrs.)** | **Baseline broiler energy (Therms/day)** | **Replacement broiler energy (Therms/day)** | **Annual operating savings (%)** |
| N | 3 | 10.2 | 7.48 | 6.09 | 19% |
| O | 3 | 6.2 | 3.49 | 3.59 | - |
| P | 3 | 13.4 | 11.57 | 8.48 | 26% |

### 1.5.4 Characterizing the Energy Efficiency of Gas-Fired Commercial Foodservice Equipment CEC-500-2014-095

The underfired broiler market has an estimate of 40,000 units in California with 10,000 units sold annually in the US in 2010 (NAFEM Size and Shape of the industry). Broilers are heavily found in the full-service restaurant segment, with an average of one broiler per store. Hotel kitchens are likely to have several broilers, however account for only 1,300 facilities in California. Corporate cafeterias account for less than 1,000 facilities in California, but are likely to have an underfired broiler. Quick chain service restaurants account for a large facility segment, however are less likely to have underfired broilers. Most broilers are concentrated in the independent quick service restaurants segment, with 80,000 foodservice facilities in California, it is estimated that over half of them have underfired broilers.

<http://www.energy.ca.gov/2014publications/CEC-500-2014-095/CEC-500-2014-095.pdf>

Table XVI: Broiler Numbers by Market Sector 2010

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Market Sector** | **Number of stores in CA** | **Conveyor** | **Overfired** | **Salamander** | **Underfired** | **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** |

### 1.5.5 Broiler Market Assessment Conducted in 2018

This study performed a market assessment to determine the broiler type and hours of operation in different market segments over 20 sites.

Table XVII: Broiler Survey by Market Sector

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Market Sector** | **Number of stores surveyed** | **Conveyor** | **Overfired** | **Salamander** | **Underfired** | **Underfired broilers per store** |
| 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**

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 Quick Service Restaurants(QSR) independent restaurants. QSR small chain segments are less likely to have underfired broilers and QSR large chains utilized chain driven conveyor broilers which are not the scope of this workpaper. Survey results in 2018 show less underfired broilers than initially stated in the CEC survey conducted in 2010.

Table XVIII: Underfired Broilers by Cuisine Type

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Market Cuisine Type** | **QSR independent** | **QSR small chain** | **Full Service Independent** | **Full Service Small Chain** | **Total** |
| Mexican | 0 | 2 | 1 | 0 | 3 |
| Italian | 0 | 0 | 1 | 0 | 1 |
| Pub | 0 | 0 | 1 | 0 | 1 |
| **American Casual** | 2 | 2 | 3 | 1 | 8 |
| **American Fancy** | 0 | 0 | 2 | 1 | 3 |
| Asian | 1 | 1 | 0 | 0 | 2 |
| Indian | 0 | 0 | 0 | 0 | 0 |
| Mediterranean | 0 | 1 | 1 | 0 | 2 |
| South American | 1 | 0 | 0 | 0 | 1 |

Market data was analyzed by restaurant segment as well as cuisine type, underfired broilers were mostly found in American Casual and Fine Dining restaurants.

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% probable to have an underfired broiler which amounts to 33,000 units in the state.

Table XIX: Broiler Numbers by Market Sector 2018

|  |  |  |  |
| --- | --- | --- | --- |
| **Market Sector** | **Number of stores in CA** | **Underfired broilers per store** | **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** |

The facilities surveyed have the following average values; 358-day per years operation, broiler on time of 12.6 hours per day, restaurant business hours of 11.9 with broiler being turned on 0.7 hours prior to restaurants opening their doors, width of 3.15 feet and broiler age of 11.7 years. From the surveyed restaurants, 5% use heavy marinades and 30% loaded the broiler to its full capacity, 70% of respondents thought the conditions around the broiler were very hot with 38% willing to use a lidded broiler.

## 1.6 Data Quality and Future Data Needs

* Broiler Hours of operation have been well documented in the studies referenced in this document
* Baseline broilers analyzed in these studies have been well documented and have consistent idle and cooking input rate profiles. 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.
* Three energy efficient broiler designs have been studied in a laboratory and on the field, both locations have proven to reduce energy usage over baseline models.
* 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.

# Section 2. Calculation Methodology

ASTM F1695 is an industry standard laboratory test method for the Performance of Underfired Broilers, it evaluates the energy consumption and cooking performance. A customer can use this evaluation to select an appropriate underfired broiler and understand its energy consumption. Annual broiler energy consumption depends on the following factors:

* Broiler hours of operation
* Broiler idle/cooking gas input rate at 600°F surface temperature

The ASTM F1695 standard characterizes the broiler preheat, idle and cooking in terms of gas and electric energy consumption. These laboratory test values are used to populate an energy model by applying operating hours. 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 in this workpaper)
* Sub metered field data (used in this workpaper)

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, 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 between 550 ͦF and 650 ͦF broiler surface temperature. It is unnecessary to perform food product cooking per ASTM F1695 “Cooking Energy Efficiency” Section 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.

****

Figure V: ASTM F1695-03 Section 10.6 Lab Testing Broiler Temperature Measurement

The most common sizes of underfired broilers are

1. 3-ft wide, with depth of 2-ft.
2. 2-ft wide, with depth of 2-ft.
3. 4-ft wide, with depth of 2-ft.

Broilers larger than 4-ft wide are less common. Energy use is directly proportional to the broiler width, baseline broilers have one burner for each ½-ft of broiler width. Most energy efficient broilers with IR burners only have one burner per feet 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 desire surface cooking temperature in the table below.

Table XX: Baseline Underfired Broiler Energy Usage

|  |  |
| --- | --- |
| **Type** | **Lab Tested Idle Rate at 600°F** |
| Standard Radiant (most popular) | 24.5 kBtu/h/ft |
| Radiant Reflector | 25.0 kBtu/h/ft |
| Radiant Reflector Pilotless (least popular) | 29.5 kBtu/h/ft |

**\* Estimated Weighted Average 25 kBtu/h**

Table XXI: Energy Efficient Broiler Energy Usage

|  |  |  |
| --- | --- | --- |
| **Model Number** | **Lab Tested Idle Rate at 600°F** | **Unit** |
| IR Plate | 17.0 kBtu/h/ft | Model 1 |
| IR Burner (most popular) | 21.0 kBtu/h/ft | Model 2 |
| Lidded IR Burner with Lid Open | 21.0 kBtu/h/ft | Model 3 |
| Lidded IR Burner with Lid Closed (least popular) | 15.0 kBtu/h/ft |

**\*Estimated Weighted Average 20 kBtu/h**

With standard radiant broilers being the industry standard practice based on restaurant surveys and fewer locations using radiant reflectors, it is concluded that the average baseline broiler consumes 25 kBtu/h/ft. 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/h/ft. Closing the lid of a lidded broiler depends on the operator and studies (1.5.1 and 1.5.2) show similar average input rate of the lidded broiler as the unlidded IR burner broiler.

The 13 broilers monitored during the ET studies (1.5.1 and 1.5.2) show an average of 12.3 hours of operation per day with most of them serving lunch and dinner. Broiler market survey (1.5.5) show 12.6 hours average operation at 21 sites. The full-service restaurants examined were open 7 days a week except for Christmas and Thanksgiving, amounting to 363 days per year operation. The broiler on time for savings purposes is 12 hours per day based on the studies in section 1.5.

The qualifying threshold for energy efficient underfired broilers qualifying for this measure is equal to or less than **22 kBtu/hr./ft.** idle input rate while maintaining a cooking surface temperature of 600°F or greater. Based on numerous site audits, it is estimated that over 90% of the baseline models on the market are standard radiant broilers. The other baseline categories in table XX 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./ft. at 25 kBtu/hr./ft.

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/h/ft. threshold shown in the Table XXI.

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 22kBtu/h/ft. allows all three products to be incentivized, giving the customer a great choice of market available model selection.

Table XXII: Underfired 2-ft wide Broiler Cost Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Base Model** | **Energy Efficient Model** |
| Broiler Width (ft) | 2 | |
| Preheat Time (min) | 15 | 15 |
| Idle and Cooking Energy Rate (Btu/hr/ft) | 25,000 | 20,000 |
| Idle and Cooking Energy Rate (Btu/hr) | 50,000 | 40,000 |
| Operating Hours/Day | 12 | |
| Operating Days/Year | 363 | |
| Daily Total Gas Energy Consumption (Btu) | 600,000 | 480,000 |
| Annual Energy Consumption (therms)a | 2,178 | 1,742 |
| Estimated Energy Savings (therms/yr) | - | **436** |
| Incremental Measure Costb | - | $1,635 |
| Estimated Useful Life (EUL)c | 12 years | |

a 1 therm = 100,000 Btu.

b Incremental measure cost was determined through comparison of an average of published pricing listed in APPENDIX B.

c The estimated useful life is based on the 2017 DEER EUL estimates of commercial cooking equipment.

Table XXIII: Underfired 3-ft wide Broiler Cost Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Base Model** | **Energy Efficient Model** |
| Broiler Width (ft) | 3 | |
| Preheat Time (min) | 15 | 15 |
| Idle and Cooking Energy Rate (Btu/hr/ft) | 25,000 | 20,000 |
| Idle and Cooking Energy Rate (Btu/hr) | 75,000 | 60,000 |
| Operating Hours/Day | 12 | |
| Operating Days/Year | 363 | |
| Daily Total Gas Energy Consumption (Btu) | 900,000 | 720,000 |
| Annual Energy Consumption (therms)a | 3,267 | 2,614 |
| Estimated Energy Savings (therms/yr) | - | **653** |
| Incremental Measure Costb | - | $ 2,452 |
| Estimated Useful Life (EUL)c | 12 years | |

a 1 therm = 100,000 Btu.

b Incremental measure cost was determined through comparison of an average of published pricing listed in APPENDIX B.

c The estimated useful life is based on the 2017 DEER EUL estimates of commercial cooking equipment.

Table XXIV: Underfired 4-ft wide Broiler Cost Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Base Model** | **Energy Efficient Model** |
| Broiler Width (ft) | 4 | |
| Preheat Time (min) | 15 | 15 |
| Idle and Cooking Energy Rate (Btu/hr/ft) | 25,000 | 20,000 |
| Idle and Cooking Energy Rate (Btu/hr) | 100,000 | 80,000 |
| Operating Hours/Day | 12 | |
| Operating Days/Year | 363 | |
| Daily Total Gas Energy Consumption (Btu) | 1,200,000 | 960,000 |
| Annual Energy Consumption (therms)a | 4,356 | 3,485 |
| Estimated Energy Savings (therms/yr) | - | **871** |
| Incremental Measure Costb | - | $3,270 |
| Estimated Useful Life (EUL)c | 12 years | |

a 1 therm = 100,000 Btu.

b Incremental measure cost was determined through comparison of an average of published pricing listed in APPENDIX B.

c The estimated useful life is based on the 2017 DEER EUL estimates of commercial cooking equipment.

The annual energy savings were Normalized to 218 Therms/linear foot of underfired broiler cooking surface. The following shows the normalization.

1. 2ft broiler = 436 Therms/year saved = 436/2 = 218 Therms/ft./year
2. 3ft broiler = 653 Therms/year saved = 653/3 = 218 Therms/ft./year
3. 4ft broiler = 871 Therms/year saved = 871/4 = 218 Therms/ft./year

Underfired broilers are not a thermostatic appliance therefore they have the same energy input for cooking and idle modes, thus the amount of food cooked per day has no effect on the energy demand.

Daily Energy Consumption Calculation and Definitions

Eday = IDLEcookingrate x Ton

Where:

Eday = Calculated Daily Energy Consumption (Btu/day)

IDLEcookingrate =Measured Idle Energy Rate (Btu/h)

Ton = Estimated Operating (Hours/Day)

Demand reduction estimates must consider the DEER peak demand period, which is 2:00 PM to 5:00 PM during specific weekday periods and varies by climate zone:

Table XXV: DEER Demand Peak Period

|  |  |
| --- | --- |
| **Climate Zone** | **3-Weekday Period** |
| 1 | Sep 16 – Sep 18 |
| 2 | July 8 – July 10 |
| 3 | July 8 – July 10 |
| 4 | Sep 1 – Sep 3 |
| 5 | Sep 8 – Sep 10 |
| 6 | Sep 1 – Sep 3 |
| 7 | Sep 1 – Sep 3 |
| 8 | Sep 1 – Sep 3 |
| 9 | Sep 1 – Sep 3 |
| 10 | Sep 1 – Sep 3 |
| 11 | July 8 – July 10 |
| 12 | July 8 – July 10 |
| 13 | July 8 – July 10 |
| 14 | Aug 26 – Aug 28 |
| 15 | Aug 25 – Aug 27 |
| 16 | July 8 – July 10 |

# Section 3. Load Shapes

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 very low at less than 5 Watt per hour.

Figure VI: 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 3ft broiler with 6 burners will have 6 pilot lights operating around 0.3 kBtu/h per pilot light (for a total of 1.8kBtu/h).

Table XXVI: Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| PGE: COMMERCIAL:5 = Commercial Food Service | COMMERCIAL | 5 = Commercial Food Service |

# Section 4. Costs

Cost data was obtained from online retailers and broiler manufacturers for the most popular baseline and energy efficient models for 3-ft wide broilers.

## 4.1 Base Case Cost

Baseline cost data was obtained for standard radiant broilers. The models listed below are some of the most popular 3-ft (36″) wide broilers:

Table XXVII: Baseline Underfired Broiler Pricing

|  |  |
| --- | --- |
| **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** | **$ 3,176** |
| **Average Cost per Linear Foot** | **$ 1,059** |

## 4.2 Measure Case Cost

Energy efficient cost data was obtained for IR plate and IR burner broilers that have a lab tested idle rate of less than 22kBtu/hr./linear foot while maintaining surface temperatures of 600°F:

Table XXVIII: Energy Efficient Underfired Broiler Pricing

|  |  |  |
| --- | --- | --- |
| **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** | | **$ 5,628** |
| **Average Cost per Linear Foot** | | **$ 1,876** |

## 4.3 Full and Incremental Measure Cost

Table XXIX: Full and Incremental Measure Cost Equations

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

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

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

The incremental measure costs were calculated by comparing the cost premium of an energy efficient underfired broiler over a baseline broiler in per linear foot:

Table XXX: IMC Cost

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost Per Linear Foot of Broiler** | **Full Measure Cost Per Linear Foot of Broiler** | |
| **1st**  **Baseline** | **2nd Baseline** |
| ROB, NC | ($1,876 +$100)-  ($1,059 +$100) = $817 | ($1,876 +$100) -  ($1,059 +$100) = $817 | N/A |

Measure labor costs are the costs to install the underfired broiler. 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 ($100 install cost per linear foot), this cost will be used for both the measure and base case labor cost.

# Attachments

1. WPSCGNRCC180705A\_Rev00\_Underfired Broilers Energy Model and Cost Model
2. WPSCGNRCC180705A\_Rev00\_ Market assessment CEC
3. WPSCGNRCC180705A\_Rev00\_ET13PGE1311\_LIDDED\_BROILER\_FINAL
4. WPSCGNRCC180705A\_Rev00\_ET16PGE1941\_ENERGY\_EFFICIENT\_BROILERS
5. WPSCGNRCC180705A\_Rev00\_2018 Market Assessment

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