WPSCGNRCC171226A

**Revision 01**

**SoCalGas**

**Commercial Conveyor Broilers**

# At-a-Glance Summary

|  |  |  |  |
| --- | --- | --- | --- |
| **Measure Codes** | TBD | TBD | TBD |
| **Measure Description** | Energy Efficient Commercial Conveyor Broilers <20” wide conveyor | Energy Efficient Commercial Conveyor Broilers 20-26” wide conveyor | Energy Efficient Commercial Conveyor Broilers >26” wide conveyor |
| **Base Case Description** | Standard Commercial Conveyor Broiler of similar size or larger | Standard Commercial Conveyor Broiler of similar size or larger | Standard Commercial Conveyor Broiler of similar size or larger |
| **Units** | Broilers | Broilers | Broilers |
| **Energy Savings** | 1,145 therms/yr  7,144 kWh/yr | 1,933 therms/yr  6,403 kWh/yr | 3,161 therms/yr  23,849 kWh/yr |
| **Demand Reduction** | 1.48 kW | 0.88 kW | 3.29 kW |
| **Full Measure Cost ($/unit)** | $11,404 | $13,898 | $16,210 |
| **Incremental Measure Cost ($/unit)** | $2,523 | $3,146 | $3,659 |
| **Effective Useful Life** | 12 years (DEER EUL ID: COM, Foodservice) | | |
| **Measure Installation Type** | New Construction (NEW/NC), Replace on Burnout (ROB) or Early Retirement (ER) | | |
| **Net-to-Gross Ratio** | 0.7 (DEER NTGR ID: All-Default<=2yrs) | | |
| **Important Comments** | NA | | |

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 12/25/17 | Denis Livchak | Workpaper Creation (Frontier Energy) |
| 1 | 10/05/2018 | Carlos Pineda (SCG) | * Aligned kWh in the appropriate entry field on EAD tables * Added demand reduction * Changed measure cavity widths to belt widths * Omitted vent hood requirements and added installation requirements to cover all regulations in the installation or operation of broilers |
| 1a | 03/22/2019 | Andres Marquez | Minor correction addressing Ex-Ante Review finding.   * Added a clarification for the low electric use on Chain D in Table XI. |

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# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This work paper documents the rationale for Energy Efficient Commercial Conveyor Broilers to be listed in the Commercial Food Service Catalog. Automatic conveyor broilers are specified by numerous national restaurant chains and independent foodservice facilities requiring high production capacity and consistent results. Their high-energy usage and long operating hours make them one of the most energy intensive appliances in the kitchen. Energy efficient broilers have potential to save large amounts of energy while providing similar production capacities and reducing the heat load in the kitchen.

Table I: Base, Standard, and Measure Cases

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

Table II: Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE |  |
| TBD |  |  |  | Automatic Conveyor Broilers Belt Width <20” |
| TBD |  |  |  | Automatic Conveyor Broilers Belt Width 20-26” |
| TBD |  |  |  | Automatic Conveyor Broilers Belt Width >26” |

* **Eligibility requirements (Measure)**: Replacement automatic conveyor broiler must have a catalyst and an input rate less than 80 kBtu/h or a dual stage or modulating gas valve with a capability of throttling the input rate below 80 kBtu/h.
* **Eligibility requirements (Baseline)**: Baseline broiler must be an automatic conveyor broiler capable of maintaining a temperature above 600°F with a tested idle rate greater than:
  + 40kBtu/h for a belt narrower than 20”
  + 60kBtu/h for a belt between 20 and 26”
  + 70kBtu/h for a belt wider than 26”
* Conveyor broiler must be replaced by a conveyor broiler similar in size or smaller.
* **Implementation and installation requirements**: Installation shall comply with all policies, codes and regulations within the installation territory.

**1.2 Technical Description**

Automated conveyor broilers cook food by direct and indirect contact with gas-fired flames, giving the product a signature flame-broiled flavor and texture. These types of broilers are mostly used for cooking burgers, but can also cook a variety of other foods including grilled chicken and vegetables. Food is placed on a conveyor belt which runs through a cooking cavity. Gas burners reside above and below the belt carrying the food product. There are two types of automatic conveyor broiler configurations: larger “through” broilers where food product is fed into one side of the unit and exits on the opposite end, and “return” broilers where food product is discharged on the same side as the feed. Typical ¼-lb frozen burger patty cook times range between two and three minutes. Some units have two conveyors with independently adjustable speeds. Another type of automated broiler cooks food in batches instead of continuously; the food is then placed inside a holding cabinet prior to serving.

Typical conveyor broilers operate at a constant input rate maintaining average cavity temperatures between 600 and 700°F. The temperature is regulated by a gas manifold pressure adjustment. Constant input rate broilers do not differentiate between cooking and idle operation – the broiler operates at the same rate throughout the day. Technology advancements in broiler technology are mostly centered around controls that either adjust the input rate of the broiler based on cooking conditions or turn the gas heating elements on/off to maintain temperature. Advanced automatic conveyor broilers utilize a dual-stage gas valve which reduces the input rate during cooking conditions to prevent flare ups. Advanced automatic batch broilers cycle gas burners on/off to maintain cooking cavity temperature. Broilers utilizing a catalyst on top of their cooking cavity reduce emissions and further insulate the cavity, resulting in lower input rates needed to maintain cooking temperatures. Advanced automatic conveyor broilers also use active airflow management techniques to recirculate hot air inside the cavity, resulting in lower gas input rates needed to maintain cooking temperatures.

## 1.3 Installation Types and Delivery Mechanisms

Conveyor broilers are often long-lasting cooking machines that can be easily repaired by a foodservice technician with replacement parts that are still manufactured. This means that older conveyor broilers are left in restaurants for years and not often replaced on burnout. Early replacement is most applicable to automatic conveyor broilers.

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 |
| Early Replacement (ER) | Above Customer Existing | Above Code or Standard | RUL | EUL-RUL |

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

The automatic conveyor broiler market is relatively small, with few restaurant chains that specify conveyor broilers as standard specification. However, the restaurant chains that use conveyor broilers are very large and have several franchisees. Broiler manufacturers usually have internal sales people that work directly with the restaurant chains and franchisees. Multi store franchisees are the best candidates for the Down-Stream Incentives. As conveyor broilers are gaining popularity, smaller individual operators may be interested in broiler savings, Mid-Stream Incentives will encourage conveyor broiler sales personnel to seek out these operators for an energy efficient replacement.

Franchisees that have several restaurants are likely to be interested with On-Bill Financing due to the high initial automatic conveyor broiler purchase cost.

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 an energy-efficient electric or gas commercial griddle measure. 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 file does not specifically list commercial food service appliances, the default used for non-residential measures is 0.7.

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

Table VII: NTGR ID

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| All-Default<=2yrs | All other EEMs with no evaluated NTGR; existing EEM in programs with same delivery mechanism for less than 2 years | Com | Any | Any | 0.7 |

**Spillage Rate**

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

**Installation Rate**

The IR values were obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are 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 and RUL values were obtained using the DEER READI tool. DEER defines the RUL as 1/3 of the EUL value. The RUL value is only applicable to the first baseline period for an ER measure with an applicable code baseline. The relevant EUL and RUL values for the measures in this work paper are in the table below. The Conveyor Broiler EUL is the same as other appliances in the Foodservice category.

Table IX: EUL ID

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| Cook-ConvBroiler | Automatic Conveyor 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 griddles.
* Air Quality Management District Rule 1138: Devices Cooking >1250lb of beef per week shall be operated with pollution control equipment which reduces PM2.5 emissions by at least 85% starting July 1, 2013. This PM reduction can be achieved through ventilation systems including HEPA filters, Wet Scrubbers, Electrostatic Precipitators or Ultraviolet Filtration. PM reduction in enclosed cavity broilers such as automatic conveyor broilers can be achieved with a catalyst. <http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1138.pdf>

Table X: Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 24 (2013) | Not Included | NA |
| Title 20 (2014) | Not Included | NA |
| DOE | Not Included | NA |

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

Automatic conveyor broilers energy consumption has been measured through laboratory testing as well as field verification. Field gas and electric sub metering data also provides broiler hours of operation and broiler operating mode. Automatic conveyor broilers are mostly installed in quick service restaurants where the units are usually turned on an hour prior to restaurant opening and turned off at restaurant’s close.

### 1.5.1 50% Energy Savings for Quick-Service Restaurants, Hours of Operation

60% of quick service restaurant hours of operation are highlighted in DOE PNNL-19809 report Figure 2.7 to range between 85 and 167 with an average 128 hours per week or **18.3 hours per day**.

*Technical Support Document: 50% Energy Savings for Quick-Service Restaurants*, September 2010

<http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19809.pdf>

### 1.5.2 Energy Efficient Underfired Broilers, Energy Consumption

Conveyor broiler hours of operation and energy usage are also outlined in a ETCCRET16PGE1941 study Table 1. A small restaurant chain that does not serve breakfast had measured conveyor broiler operating hours of 14.9 hours per day and a catering facility had conveyor broiler operating hours of 20.4 hours per day. The average between the two sites was **17.7 hours per day**. Energy usage of a two-lane conveyor broiler at the catering facility was **15.7 therms per day**. The study was conducted for 91 days in Los Angeles starting January 2016 using a gas meter with 1/8 cuft resolution.

*Energy Efficient Underfired Broilers*, March 2017

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

Figure I: Conveyor Broiler Energy Profile Catering

Custom rebate incentives were calculated for automatic conveyor broilers in PG&E territory based on field measured data for a minimum of 2 weeks. Both sites were large quick service restaurants serving breakfast, lunch and dinner. One site had a baseline broiler which operated **18.2 hours per day** while consuming **16.3 therms and 77.4 kWh per day**. The other site had an energy efficient automatic batch broiler which operated **18.2 hours per day** and consumed **9.8 therms and 0.6 kWh per day**. The study was conducted in June 2017 by PG&E in Fairfield and Suisun City in California using 1 cubic feet resolution gas meters.

Figure II: Conveyor Broiler Energy Profile QSR

### 1.5.3 Unpublished field monitoring: PG&E and SCG data

Broiler hours of operation and energy usage was analyzed at 4 quick service restaurant chains. This information was collected via direct gas monitoring (chain A and B) and operator surveying for hours of operation (chain D and E). The hours of operation were supplemented with laboratory data to extrapolate daily energy use. Each chain had a specific baseline and energy efficient broiler. Electric energy usage results varied greatly based on the chain’s holding needs. The results are shown in the table below.

Table XI: Automatic Conveyor Broiler Restaurant Energy Use

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Restaurant Chain** | **A** | **B** | **D** | **E** |
| Operation Hours | 17.1 | 20.3 | 13 | 12 |
| Daily Energy Use (Therms/day) | 16.2 | 16.4 | 18.2 | 6.5 |
| Daily Energy Use (kWh/day) | 77.4 | 27.4 | 0.1 | 22.0 |

Energy data gathered by SCG for custom rebates for large restaurant chain “B” for four different locations in Southern California showed that two sites operated 24 hours on weekends and 18 hours on weekdays. One site operated 24 hours daily and another site operated 18 hours daily. The average operating hours were found to be 20.3 for that chain.

Chain operators were surveyed for the pounds of food cooked per day which mostly consisted of 1/4lb frozen burgers. Food cooked for restaurant chain A, B and D ranged between 90 and 150lb daily, but did not have a great effect on the broiler energy due to similar cooking and idle energy rates. Restaurant chain E is open for lunch and dinner only resulting in shorter hours of operation and lower gas energy usage due to a narrower conveyor belt than the other surveyed chains restaurants. Additionally, restaurant chain D utilized a broiler that did not have an electric bun grill, as opposed to the other chains, and the electric energy consumption (kWh/day) was solely a result of the conveyor motor, resulting in smaller consumption.

## 1.6 Data Quality and Future Data Needs

* Conveyor Broiler Hours of operation are well documented in the studies referenced in this document. It is possible to estimate broiler hours of operation accurately knowing the foodservice facility’s hours of operation and whether the facility serves breakfast lunch and dinner.
* Field data has been collected for two of the largest quick service restaurants utilizing conveyor broilers and laboratory energy data exists for the largest conveyor broiler manufacturer.
* Smaller quick service restaurants that utilize conveyor broilers have not yet been characterized and independent laboratory data has not been acquired for the other conveyor broiler manufacturers.
* While most conveyor broilers operate at a constant gas input rate for cooking and idle operation, different potentially energy saving control strategies have not been evaluated.
* Baseline conveyor broiler data has been well characterized and is unlikely to change, however as new conveyor broiler energy savings technologies emerge, the energy efficient broiler energy usage may come down in the future.

# Section 2. Calculation Methodology

ASTM F2239-10 is an industry standard method for Performance of Conveyor Broilers. This laboratory test method evaluates the energy consumption and cooking performance of conveyor broilers so that the foodservice operator can use this evaluation to select a conveyor broiler and understand its energy consumption.

Broiler annual energy consumption depends on the following factors:

* Broiler hours of operation
* Broiler preheat time and energy
* Broiler idle rate
* Broiler cooking rate

The ASTM F2239-10 characterizes the broiler preheat, idle and cooking in terms of gas and electric energy consumption. These laboratory test values can be then 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 minutes before opening the broiler gets turned on and off
* Sub metered field data

Most conveyor broilers operate at a constant input rate that is close to the idle rate. Some broilers utilize a two-stage gas valve that reduces the input rate slightly during cooking so that the burger grease does not burn uncontrollably. It is estimated that the broiler is cooking under heavy load conditions for two hours per day. With average hours of operation ranging between 12 and 18 hours per day, most of the energy usage is mainly driven by idle energy. Flame broiling is usually done between 700 and 900 ͦF, however ASTM F2239-10 does not specify a broiling temperature. Idle energy usage for the calculations shall be reported with broiler cavity temperatures exceeding 600F.

Conveyor broilers can be of different sizes depending on the required production capacity and cooking product variety. Energy usage depends on the cooking cavity dimensions which are characterized by width and depth, cavity height shall not be taken into consideration (usually 1” opening for product). Cooking cavity depth often ranges between 25 and 30 inches. With a small difference in height and depth between conveyor broilers, the biggest energy driver is the width of the broiler which is characterized by the belt. Conveyor broiler belt width can accommodate between one and four ¼” 5” diameter burger patties (called lanes) depending on broiler model and should be categorized accordingly. Smaller belt width corresponds to a lower idle rate but a lower production capacity. Large quick service restaurant chains will use a 3-4 lane wide conveyor broiler.

Table XII: Energy Efficient Automatic Conveyor Broiler Size and Energy Usage

|  |  |  |  |
| --- | --- | --- | --- |
| **Model Number** | **Conveyor Width (in)** | **Burger Lane Width** | **Lab Tested Idle Rate** |
| A | 14 | 2 | 28 kBtu/h |
| B | 22 | 3 | 56 kBtu/h |
| C | 22 | 3 | 62 kBtu/h |
| D | 27 | 4 | 56 kBtu/h |
| E | 30 | 6x2 (12 burgers per batch, equivalent to 4 lanes) | 67 kBtu/h |

Table XIII: Baseline Automatic Conveyor Broiler Size and Energy Usage

|  |  |  |  |
| --- | --- | --- | --- |
| **Model Number** | **Conveyor Width (in)** | **Burger Lane Width** | **Lab Tested Idle Rate** |
| F | 19.2 | 2 | 54 kBtu/h |
| G | 25.1 | 3 | 140 kBtu/h |
| H | 29.1 | 3 | 107 kBtu/h |
| J | 28 | 4 | 90 kBtu/h |

Most popular automatic conveyor broilers fall into two categories based on their energy usage:

* 1-2 lane wide broilers with conveyor belt width less than 20 inches
* 3 lane wide broilers with conveyor belt width greater than 20-26 inches
* 4 lane wide broilers with conveyor belt width greater than 26 inches

Lane width should not be confused with individually speed controlled lanes which can hold several lanes of product. Quick service restaurants using conveyor broilers serving lunch and dinner averaged 12 hours of operation per day while restaurants that served breakfast additionally averaged 18 hours of operation. Certain restaurants were open 24 hours with an average of 23 hours of operation which included downtime for broiler cleaning. 1135 restaurants in California that use automatic conveyor broilers, the weighted average hours of operation are 18.1 hours per day. Quick service restaurants examined are open 7 days a week except for Christmas and Thanksgiving with 363 days per year operation.

Table XIV: Automatic Conveyor Broiler Hours of Operation

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Restaurant Chain** | **A** | **B standard** | **C**  **24h operation** | **D** | **E** | **Total** |
| Number of Stores in California | 268 | 497 | 213 | 71 | 86 | 1135 |
| Operation Hours | 18 | 18 | 23 | 12 | 12 | **18.1** |
| Total | 4824 | 8946 | 4899 | 852 | 1032 | 20553 |

Daily and annual energy consumption of conveyor broilers can be estimated based on ASTM test results.

Table XV: Automatic Conveyor Broiler 2 lane width (<20”) Cost Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Base Model** | **Energy Efficient Model** |
| Preheat Time (min) | 10 | 29 |
| Idle Energy Rate (Btu/hr) | 54,500 | 28,000 |
| Cooking Energy Rate (Btu/hr) | 55,000 | 28,500 |
| Electrical Idle Energy Rate (kW) | 1.84 | 0.20 |
| Production Capacity (lb/hr) | 29 | 21 |
| Operating Hours/Day | 12 | 12 |
| Operating Days/Year | 363 | 363 |
| Pounds of Food Cooked per Day | 75 | 75 |
| Preheat Energy (Btu) | 11,500 | 13,500 |
| Daily Cooking Energy (Btu) | 142,241 | 101,786 |
| Daily Idle Energy (Btu) | 513,052 | 236,000 |
| Daily Total Gas Energy Consumption (Btu) | 666,793 | 351,286 |
| Daily Total Electric Energy Consumption (kWh) | 22.1 | 2.4 |
| Annual Energy Consumption (therms)a | 2,420 | 1,275 |
| Annual Energy Consumption (kWh) | 8,015 | 871 |
| Demand Reduction(kW) |  | 1.64 |
| Actual Demand Reduction with CDF of 0.9 (kW) |  | 1.48 |
| Estimated Energy Savings (therms/yr) | - | **1,145** |
| Estimated Energy Savings (kWh/yr) | - | **7,144** |
| Incremental Measure Costb | - | $ 2,523 |
| Estimated Useful Life (EUL)c | 12 years | 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 XVI: Automatic Conveyor Broiler 3 lane width (20-26”) Cost Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Base Model** | **Energy Efficient Model** |
| Preheat Time (min) | 8.42 | 16.25 |
| Idle Energy Rate (Btu/hr) | 78,120 | 47,960 |
| Cooking Energy Rate (Btu/hr) | 78,240 | 50,938 |
| Electrical Idle Energy Rate (kW) | 1.35 | 0.37 |
| Production Capacity (lb/hr) | 47.6 | 41.7 |
| Operating Hours/Day | 18 | 18 |
| Operating Days/Year | 363 | 363 |
| Pounds of Food Cooked per Day | 150 | 150 |
| Preheat Energy (Btu) | 14,130 | 14,214 |
| Daily Cooking Energy (Btu) | 246,555 | 183,230 |
| Daily Idle Energy (Btu) | 1,159,984 | 690,762 |
| Daily Total Gas Energy Consumption (Btu) | 1,420,668 | 888,206 |
| Daily Total Electric Energy Consumption (kWh) | 24.3 | 6.7 |
| Annual Energy Consumption (therms)a | 5,157 | 3,224 |
| Annual Energy Consumption (kWh) | 8,821 | 2,418 |
| Demand Reduction(kW) |  | 0.98 |
| Actual Demand Reduction with CDF of 0.9 (kW) |  | 0.88 |
| Estimated Energy Savings (therms/yr) | - | **1,933** |
| Estimated Energy Savings (kWh/yr) | - | **6,403** |
| Incremental Measure Costb | - | $ 3,146 |
| Estimated Useful Life (EUL)c | 12 years | 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 XVII: Automatic Conveyor Broiler 4 lane width (>26”) Cost Effectiveness Example

|  |  |  |
| --- | --- | --- |
| **Performance** | **Base Model** | **Energy Efficient Model** |
| Preheat Time (min) | 22 | 12 |
| Idle Energy Rate (Btu/hr) | 104,000 | 57,000 |
| Cooking Energy Rate (Btu/hr) | 111,210 | 67,117 |
| Electrical Idle Energy Rate (kW) | 4.8 | 1.15 |
| Production Capacity (lb/hr) | 90 | 86 |
| Operating Hours/Day | 18 | 18 |
| Operating Days/Year | 363 | 363 |
| Pounds of Food Cooked per Day | 110 | 110 |
| Preheat Energy (Btu) | 42,500 | 13,500 |
| Daily Cooking Energy (Btu) | 135,923 | 85,847 |
| Daily Idle Energy (Btu) | 1,744,889 | 953,093 |
| Daily Total Gas Energy Consumption (Btu) | 1,923,312 | 1,052,440 |
| Daily Total Electric Energy Consumption (kWh) | 86.4 | 20.7 |
| Demand Reduction (kW) |  | 3.65 |
| Actual Demand Reduction with CDF of 0.9 (kW) |  | 3.29 |
| Annual Energy Consumption (therms)a | 6,982 | 3,820 |
| Annual Energy Consumption (kWh) | 31,363 | 7,514 |
| Estimated Energy Savings (therms/yr) | - | **3,161** |
| Estimated Energy Savings (kWh/yr) | - | **23,849** |
| Incremental Measure Costb | - | $ 3,659 |
| Estimated Useful Life (EUL)c | 12 years | 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.

Daily Energy Consumption Calculation and Definitions

EDAY = (LBFOOD x EFOOD) ÷ EFFICIENCY + [IDLERATE x (TON - LBFOOD/PC – nP x TP/60)] + nP x EP

Where:

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

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 XVIII: 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 |

# 

## 2.1 Demand Reduction

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

The demand reduction estimation is based on measured data for standard efficiency conveyor broilers and for high-efficiency conveyor broilers. The measured data are derived from tests conducted under ASTM Standard Test Method “Standard Test Method for Performance of Conveyor Broilers” (ASTMF2239). Conveyors consume energy for both gas and electric constantly at max input rate. Due to this the energy is not averaged during different modes of operation and the power demand is used to estimate demand reduction.

ASTM F2239 provides standard conditions under which conveyor broiler energy use is measured. The estimated demand reduction of 1640 Watts for conveyor broiler of less than 20 inches in width, 980 Watts for conveyor broilers of 20 inches and up to 26 inches in width and 3650 watts for conveyor broilers greater than 26 inches in width. Applying a Coincidence Factor of 0.9 for food service establishments using the professional judgement of the Food Service Technology Center, yields the

demand savings of 1476 Watts for conveyor broiler of less than 20 inches in width, 882 Watts for conveyor broilers of 20 inches and up to 26 inches in width and 3285 watts for conveyor broilers greater than 26 inches in width.

# Section 3. Load Shapes

Conveyor broilers have almost constant gas input rates in their load shapes. Quick service restaurants utilizing conveyor broilers may be 24h operation every day or 24-hour operation on weekends only. The following gas load shapes show the differences in operation profile for baseline broilers:

Figure III: Baseline Broiler Hourly Operation

Figure IV: Weekend Hourly Operation Baseline Broiler

Energy efficient replacement broilers have a lower average input; however they have a dual stage valve that allow the unit to have a higher input rate during preheat and shutdown.

Figure V: Measure Broiler Hourly Operation

Figure VI: Weekend Hourly Operation Measure Broiler

Some gas conveyor broilers are equipped with heating and warming elements. These resistance heating elements are on at a constant rate to keep the product warm as it exits the conveyor belt. The profile below shows 18-hour broiler electrical profile.

Figure VII: Hourly Baseline Broiler Electric Profile

Figure VIII: Hourly Measure Broiler Electric Profile

The profile shown is for the largest 4 lane conveyor broiler with warming elements, with the baseline broiler operating at 4 kW constant rate, the energy efficient broiler consumed 1.2 kW which resulted in a 3.8 kW demand reduction. Not all broilers are equipped with warming elements and the input rate of the conveyor belt motors and controls is less than 100W. In all monitored applications, the broiler was on and using electricity during a demand window between noon an 6pm.

Table XIX: 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 broiler manufacturers for the most popular energy efficient models. Models vary in size dictated by the conveyor width and accessories including burger holding warming elements and individually controlled conveyor belt speeds for multiple products. Pricing depends on the size of the order, with larger chain restaurants purchasing in bulk receiving lower pricing. The cost data is shown below:

Table XX: Energy Efficient Automatic Conveyor Broiler Pricing

|  |  |  |  |
| --- | --- | --- | --- |
| **Model** | **Conveyor Width (in)** | **Burger Lane Width** | **Retail Price** |
| A | 14 | 2 | $14,915 |
| B | 22 | 3 | $17,356 |
| C | 22 | 3 | $12,120 |
| D | 27 | 4 | $13,539 |
| E |  | 6x2 (12 burgers per batch, equivalent to 4 lanes) | NA |

Most popular automatic conveyor broilers fall into categories based on their energy usage:

* 1-2 lane wide broilers with conveyor belt width less than 20 inches
* 3 lane wide broilers with conveyor belt width greater than 20-26 inches
* 4 lane wide broilers with conveyor belt width greater than 26 inches

Lane width should not be confused with individually speed controlled lanes which can hold several lanes of product. Two individually controlled lanes resulted in higher retail prices for models’ A and B broilers than the standard models.

## 4.1 Base Case Cost

Cost data was available for the 4-burger wide broiler in both energy efficient and baseline configurations. With baseline costs unavailable for other sizes, the same percentage cost premium over the energy efficient broiler for the 4-burger wide model was carried out for the smaller 2 and 3 burger width models.

Table XXI: Base Case Cost

|  |  |  |
| --- | --- | --- |
| **Burger Width** | **Conveyor Width (in)** | **Retail Price** |
| 2 | 14 | $ 8,881 |
| 3 | 22 | $ 10,752 |
| 4 | 27 | $ 12,552 |

## 4.2 Measure Case Cost

Measure case cost data was gathered for energy efficient broilers from their manufacturers shown in section 4. Broilers were distributed into the three belt width categories. Models that fell in the same category were averaged together. With not all model size options available with both single and dual belt controls, the cost for both models was extrapolated based on the cost premium of the dual belt model over the single belt option. Then the pricing was averaged for both models to achieve the measure costs.

Table XXII: Measure Case Cost

|  |  |  |
| --- | --- | --- |
| **Burger Width** | **Conveyor Width (in)** | **Retail Price** |
| 2 | 14 | $11,404 |
| 3 | 22 | $13,898 |
| 4 | 27 | $16,210 |

## 4.3 Full and Incremental Measure Cost

Table XXIII: 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 |
| NEW/NC |
| ER | (MEC + MLC) – (BEC + BLC) | MEC + MLC | (MEC + MLC) – (BEC + BLC) |
| REF | (MEC + MLC) – (BEC + BLC) | MEC + MLC | N/A |
| REA | MEC + MLC | MEC + MLC | N/A |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

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

The incremental measure costs were calculated by comparing the cost premium of an energy efficient automatic conveyor broiler over a baseline broiler in each size category:

Table XXIV: IMC Cost

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Installation Type** | **Burger Width** | **Conveyor**  **Width (in)** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st**  **Baseline** | **2nd Baseline** |
| ROB, NC, NEW | 2 | 14(< 20”) | ($10,404+$1000)-  ($7,881+$1,000) = $2,523 | ($10,404+$1000) -  ($7,881+$1,000) = $2,523 | N/A |
| 3 | 22(20-26”) | ($12,898+$1000) -  (9,752+$1000) = $3,146 | ($12,898+$1000) -  (9,752+$1000) = $3,146 | N/A |
| 4 | 27(> 26”) | ($15,210 + $1000) -  ($11,552+$1000) = $3,659 | ($15,210 + $1000) -  ($11,552+$1000) = $3,659 | N/A |
| ER | 2 | 14(< 20”) | ($10,404+$1000) -  ($7,881+$1,000) = $2,523 | ($10,404 + $1000) = $11,404 | ($10,404+$1000) -  ($7,881+$1,000) = $2,523 |
| 3 | 22(20-26”) | ($12,898+$1000)-  (9,752+$1000) = $3,146 | ($12,898+$1000) = $13,898 | ($12,898+$1000)-  (9,752+$1000) = $3,146 |
| 4 | 27(> 26”) | ($15,210 + $1000)-  ($11,552+$1000) = $3,659 | ($15,210 + $1000) = $16,210 | ($15,210 + $1000)-  ($11,552+$1000) = $3,659 |

Measure labor costs are the costs to install the automatic conveyor broiler. The installation costs are the same for the baseline and energy efficient automatic conveyor broilers. The cost of purchasing an automatic conveyor broiler usually includes delivery, installation and setup costs if purchased directly from the factory or an authorized retailer. In other cases, broiler delivery and installation costs can be up to $1000, this cost will be used for both the measure labor and base labor cost.

# Attachments

1. WPSCGNRCC171226A\_Rev00\_Cost Effectiveness
2. WPSCGNRCC171226A\_Rev00\_Field Data Compton 1
3. WPSCGNRCC171226A\_Rev00\_Field Data Compton 2
4. WPSCGNRCC171226A\_Rev00\_Field Data La Palma 1
5. WPSCGNRCC171226A\_Rev00\_Field Data La Palma 2
6. WPSCGNRCC171226A\_Rev00\_Field Data Moorpark 1
7. WPSCGNRCC171226A\_Rev00\_Field Data Moorpark 2
8. WPSCGNRCC171226A\_Rev00\_Field Data Ontario 1
9. WPSCGNRCC171226A\_Rev00\_Field Data Ontario 2

# References

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