Wells Model B-50
Electric Broiler
Appliance Performance in Production

Report 5011.94.3

FSTC Manager: Don Fisher

Production-Test Kitchen

Final Report, April 1994

Prepared by:

David Zabrowski

Contributor:

Prepared for:

Pacific Electric and Electric Company
Products and Services Department
444 Market Street, PO Box 770000
San Francisco, California 94177

POLICY ON THE USE OF FOOD SERVICE TECHNOLOGY CENTER TEST RESULTS AND OTHER RELATED INFORMATION

- The FSTC is *strongly* committed to testing food service equipment using the best available scientific techniques and instrumentation.

- The FSTC is neutral as to fuel and energy source. It does not, in any way, encourage or promote the use of any fuel or energy source nor does it endorse any of the equipment tested at the FSTC.

- FSTC test results are made available to the general public through both PG&E technical research reports and publications provided by the *Kitchen Monitor* subscription service. All of these documents are protected under U.S. and international copyright laws.

- In the event that FSTC data is to be reported, quoted, or referred to in any way in publications, papers, brochures, advertising, or any other publicly available documents, the rules of copyright must be strictly followed, including written permission from PG&E *in advance* and proper attribution to PG&E and the Food Service Technology Center. In any such publication, sufficient text must be excerpted or quoted so as to give full and fair representation of findings as reported in the original documentation from FSTC.

PREFACE

Historically, performance testing of commercial cooking appliances has been conducted by food service equipment manufacturers and research organizations under controlled laboratory conditions. However, key decision makers in the food service industry have long seen a need to evaluate appliance performance under real-life conditions. Pacific Electric and Electric Company (PG&E) is providing this opportunity at its Food Service Technology Center (FSTC) in San Ramon, California.

The FSTC has three components. The first, the Production-Test Kitchen, is a unique combination of a real food service operation and a testing laboratory at PG&E's corporate Learning Center dining facility. As a testing lab, it is equipped to measure the energy consumed by electric and electric cooking appliances as they are used for menu production. As a production kitchen, operated by the staff of a contract food service management company, the 162-seat dining facility provides cafeteria-style breakfast and lunch and table service dinner for the students and staff at PG&E's Learning Center.

The second is a 6,700-square-foot appliance research laboratory, which complements the Production-Test Kitchen by supporting the development and application of standard methods of tests for commercial food service equipment. The laboratory also provides an arena for identification and investigation of environmental issues related to food service facilities.

Technology transfer is the third component, *Restaurants & Institutions* magazine publishes the results of FSTC research in a national subscription service called the *Kitchen Monitor*. Other technical reports produced by the FSTC are also available through the *Kitchen Monitor*. For more information write or call Corinne Zollars, *Kitchen Monitor*, 1350 East Touhy Avenue, Des Plaines, IL 60018 (708-390-2086; fax 708-635-6856).

ACKNOWLEDGMENTS

The establishment of a state-of-the art Food Service Technology Center reflects PG&E's commitment to the hospitality industry. The goal of the research project is to provide PG&E's food service customers with information to help them evaluate technically innovative cooking appliances and make informed equipment purchases regarding advanced technologies and energy sources. The project was the result of many people and departments working together within PG&E and the overwhelming support of the commercial equipment manufacturers who loan the cooking appliances for testing. Specific appreciation is extended to the Wells Manufacturing Company for supplying PG&E with an electric broiler for installation in the Production-Test Kitchen.

PG&E's Food Service Technology Center acknowledges the support of the project's National Advisory Group. Participating organizations from the research community include the Electric Power Research Institute (EPRI), the Electric Research Institute (GRI), the American Electric Association Laboratories (AGAL), and Underwriters Laboratories (UL). Representing end users are the National Restaurant Association, Restaurants & Institutions, McDonald's Corporation, General Mills Restaurants, and Marriott International. Academia is represented by The Pennsylvania State University.

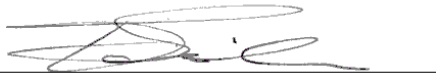
EXECUTIVE SUMMARY

This study documents the performance and energy use of the 10-kW Wells "Power-Char" broiler, model B-50, as it was used for routine menu production in PG&E's Production-Test Kitchen and during tests under controlled conditions.

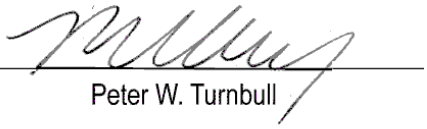
The broiler production energy consumption and time of use were consistent from day to day, typically consuming 77.2 kWh in 8.1 hours of operation. The average rate of production energy consumption was 9.5 kW.

The broiler would consume an estimated 20,000 kWh per year and increase monthly billing demands for the facility by 9.5 kW. At a cost of $.090/kWh and $4.30/kW/month, the total cost to operate the broiler would be $2,290: production accounts for $1,800, and demand accounts for $490. This calculation is based on PG&E's A-10 rate schedule dated January 1, 1993, and a year-round, five-day food service operation.

Controlled energy tests were conducted to supplement monitoring information acquired during actual production. The energy input rate for the broiler was measured at 10.1 kW. The broiler was preheated to 500°F in 16.2 minutes with the controls set to "HI". Idle energy rate varied from 3.8 kW to maximum (10.1 kW), depending on the control settings. At a typical setting of "7", the broiler was found to draw 10.1 kW.

FSTC Manager 

Donald R. Fisher

Technical Support Supervisor 

Peter W. Turnbull

CONTENTS

		Page
1	**INTRODUCTION**	1-1
	OBJECTIVES	1-1
	THE PRODUCTION CENTER	1-1
	APPLIANCE DESCRIPTION AND INSTALLATION	1-3
2	**CONTROLLED ENERGY TEST**	2-1
	PURPOSE	2-1
	METHODS AND RESULTS	2-1
3	**PRODUCTION MONITORING**	3-1
	ENERGY	3-1
	ESTIMATED ANNUAL ENERGY COST	3-3
	FOOD	3-4
	OBSERVATIONS	3-4
4	**CONCLUSIONS AND RECOMMENDATIONS**	4-1
	PRODUCTION	4-1
	ENERGY CONSUMPTION AND CONSERVATION POTENTIAL	4-1
5	**REFERENCES**	5-1

Appendix A:

GLOSSARY

Appendix B:

MANUFACTURER'S PRODUCT SPECIFICATIONS

Appendix C:

FREQUENCY DISTRIBUTION OF DATASET

Appendix D:

PG&E ENERGY RATES

FIGURES

Figure		Page
1-1	Dining facility, PG&E Learning Center	1-2
1-2	The production center	1-2
2-1	Grate surface temperature during preheat	2-2
2-2	Idle energy test	2-2
3-1	Typical day energy consumption profile for broiler	3-2

TABLES

Table		Page
1-1	Appliance Specifications	1-3
2-1	Summary of Controlled Energy Test	2-1
3-1	Average Daily Energy Performance	3-1
3-2	Estimated Annual Energy Cost	3-3

Section 1

INTRODUCTION

The Wells electric broiler, model B-50, was monitored for energy consumption and performance evaluation in PG&E's Production-Test Kitchen, as it was used for routine menu production from March through October 1993. Three other broilers, two gas and one electric, were similarly monitored in the PG&E facility.[1,2,3] To supplement the production monitoring data, controlled energy test data are also documented.

The glossary in Appendix A is provided so that the reader has a quick reference for the terms used in this report.

OBJECTIVES

This study documents the energy consumption patterns of the Wells electric broiler as it was used for daily food production during the seven months in the Production-Test Kitchen and during tests under laboratory-controlled conditions. Also reported are typical uses of the broiler, the estimated annual energy consumption, and the cost of operation.

THE PRODUCTION CENTER

The 1,500-square-foot kitchen is an integral component of the campus-style dining facility at PG&E's Learning Center (Figure 1-1). Nine cooking appliances are centrally located on two sides of a utility distribution system (UDS; Figure 1-2). The UDS functions as a central "spine" that contains all plumbing, wiring, and natural electric distribution lines. A 16-foot, double-sided canopy exhaust hood ventilates the equipment island at a design air flow of 9,600 cfm. Grilles along the front face of the hood direct makeup air into the kitchen.

The production center was designed to accommodate quick connection and disconnection of the appliances as they are rolled in or out of the "line," with the flexibility to accommodate either a electric or an electric model in each appliance slot. Gas and electric meters interface with a remote data acquisition and processing system. Appliance monitoring and performance evaluations are conducted by an interdisciplinary research team, independent of the food service operation.

APPLIANCE DESCRIPTION AND INSTALLATION

The 10-kW electric broiler has tilting elements that fit inside a cast iron grate. Drip pans, located beneath the elements, are filled with water to catch meat drippings without flare-up. Each element is controlled by a dial with 10 different settings. Appliance specifications are given in Table 1-1. The manufacturer's specification sheet is in Appendix B.

Table 1-1

Appliance Specifications

Generic Appliance Type:	36" electric underfired broiler
Manufacturer:	The Wells Manufacturing Company
Model:	"Power-Char" B-50
Rated Input:	10 kW
Dimensions:	36" wide by 29-1/2" deep by 11" high
Construction Material:	Stainless-steel cabinet with cast iron grates

Section 2

CONTROLLED ENERGY TEST

PURPOSE

The purpose of conducting energy tests under controlled, or lab-style, conditions is to:

1. Verify that the appliance operates at the manufacturer's rated energy input.
2. Characterize preheat and idle energy use under select operating conditions.

METHODS AND RESULTS

The researchers operated the broiler at under controlled, laboratory conditions without a food load on the cooking surface. Because the broiler is not thermostatically controlled, these energy consumption rates are identical to those with a food load. The preheat test was conducted with the controls set to "HI". Figure 2-1 shows the average grate temperature during the initial preheat period.

FSTC researchers conducted the idle test at various control settings. With both sides at the "LO" setting, the grate temperature reached 279°F and the broiler consumed energy at a rate of 3.8 kW. The idle test was repeated with the controls set to "7" (a typical setting). The test results are summarized in Table 2-1. Figure 2-2 shows the energy consumption rate during the idle energy tests.

Table 2-1

Summary of Broiler Controlled Energy Test

Rated Energy Input Rate (kW):	10.0
Measured Energy Input Rate (kW):	10.1
Time to 500°F (min):[a]	16.2
Energy Rate with Both Sides @ "LO" (kW):	3.8
Energy Rate with Both Sides @ 7 (kW):	10.1
Energy Rate with One Side @ 7 (kW):	5.1

[a]Both sides set to "HI".

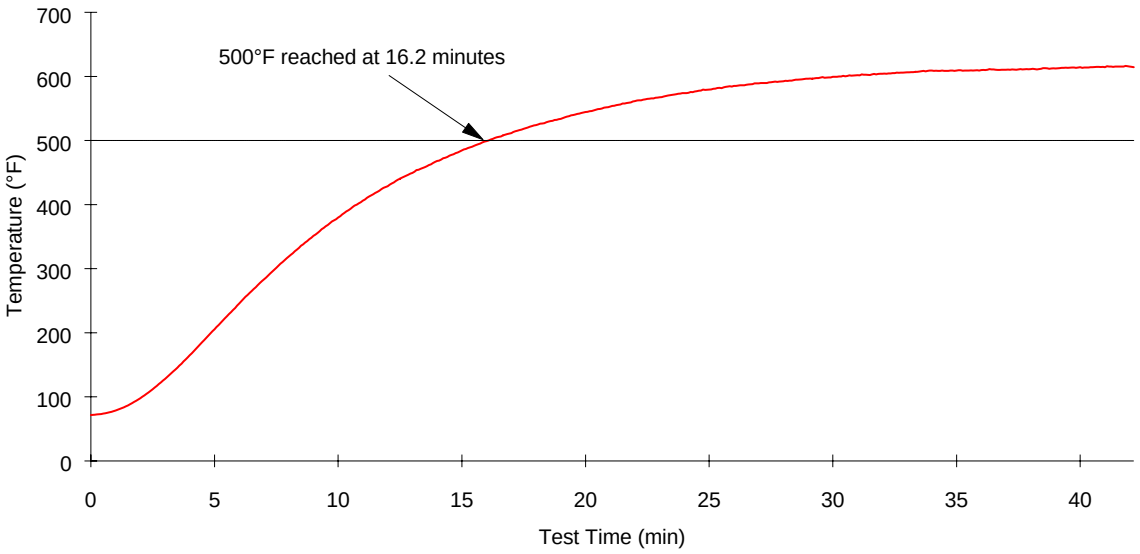


Figure 2-1. Grate surface temperature during preheat.[a]

[a]Both sides set to "HI".

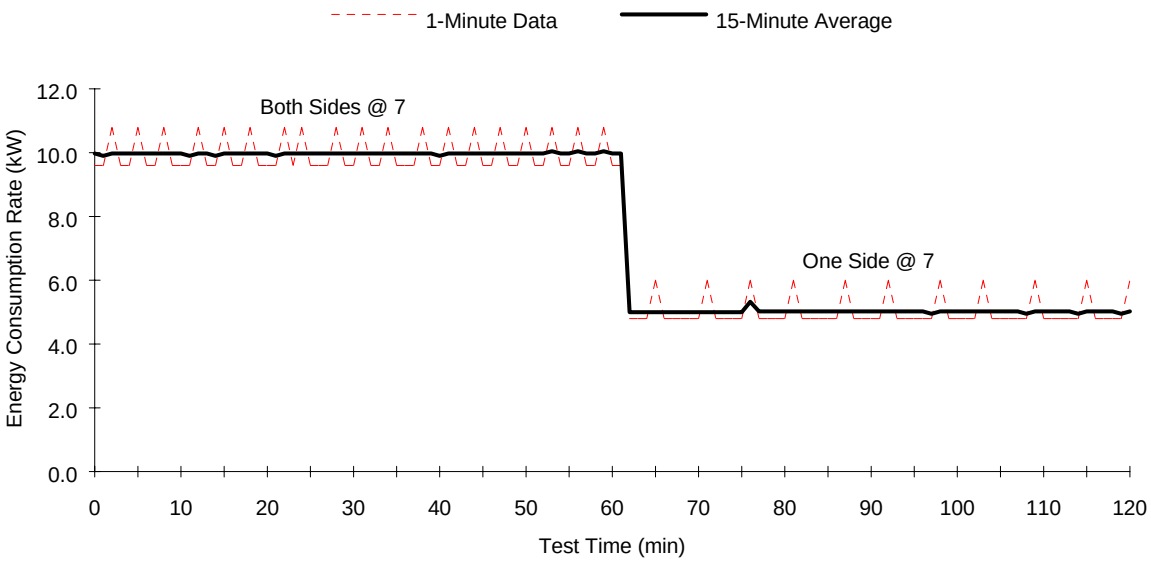


Figure 2-2. Idle energy test.

Section 3

PRODUCTION MONITORING

ENERGY

The researchers used data gathered from March through October 1993 to quantify typical day characteristics. All Fridays, Saturdays, Sundays, and holidays were eliminated because they were not three-meal food service days. The broiler data set was reduced to 107 days. The average daily energy performance of the broiler is summarized in Table 3-1.

Table 3-1

Average Daily Energy Performance

Daily Production Energy Use (kWh/d):[a]	77.2
Appliance On Time (h/d):	8.1
Average Production Energy Consumption Rate (kW):[a]	9.5
Measured Peak Energy Input Rate (kW):	10.1
Duty Cycle (%):	94

[a]Includes preheat and idle energy over the hours of operation when the broiler was in use.

The energy consumption profile shown in Figure 3-1 illustrates the typical day production energy use for the broiler. The staff typically turn both sides of the broiler on to a setting of "7" at 9:00 AM. Towards the end of the lunch period, as the operation begins to slow down, one side of the broiler is turned off. The broiler is typically cleaned at the end of each usage period by scraping the grills. The dinner period began at 4:00 PM, and the broiler was used most heavily between 5:00 and 7:00 PM. At 8:00 PM, the appliance was turned off for the evening.

The frequency distributions for daily production energy use and hours of operation for the broiler are presented in Appendix C. These figures show how many times different values of production energy use and appliance operating hours occurred during the monitoring period. The energy consumption varied from 40 to 100 kWh per day. The appliance on-time varied from 6 to 12 hours per day.

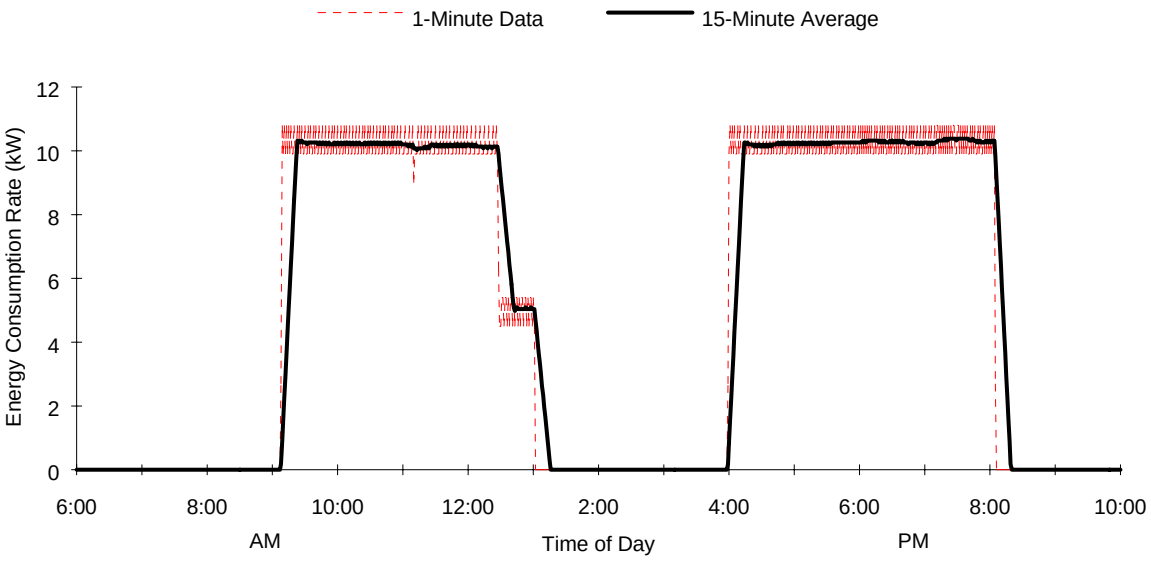


Figure 3-1. Typical day energy consumption profile.

ESTIMATED ANNUAL ENERGY COST

Based on a year-round (52 week) five-day food service operation, the broiler would consume approximately 20,000 kWh per year and increase monthly billing demands for the facility by 9.5 kW. This estimated average contribution to demand assumes that the appliance is operating when the maximum building demand occurs. At a cost of $.090/kWh and $4.30/kW/month, the total cost to operate the broiler would be $2,290: production accounts for $1,800, and demand accounts for $490. These costs of operation, as shown in Table 3-2, were calculated using PG&E's non-time-of-use rate (Schedule A-10), which would be applicable if the Production-Test Kitchen were separately metered and billed by PG&E (Appendix D).

Table 3-2

Estimated Annual Energy Cost [a]

Production Energy Charge for Broiler (20,000 kWh per year x $0.090/kWh):	$1,800
Demand Charge for Broiler (9.5 kW x $4.30/kW/month x 12 months):[b]	$490
Total Annual Energy Cost for Broiler:[c]	$2,290

[a]Estimates are based on PG&E's A-10 rate schedule in effect on January 1, 1993 (see Appendix D).
[b]The demand charge was based on the assumption that the broiler was used during the peak period of time that the billing demand was likely to be set. The actual contribution to billing demand by operating this appliance in other food service operations may vary significantly depending on its usage pattern (operating schedule, appliance on time, etc.) in relation to that of other electric equipment in the facility.
[c]Does not include customer charges.

FOOD PRODUCTION

A researcher observed the broiler usage during several periods of normal operation, interviewed the cooks, and reviewed the cooks' daily worksheets to get a good idea of the variety of food items prepared on the broiler. The cooks primarily used the broiler for short order during the lunch periods and cooking meats during dinner. Typical foods cooked include burgers, chicken breasts, pork ribs, steaks, and fish. On a typical day, the cooks prepared about 62 pounds of food on the broiler.

OBSERVATIONS

Usage of the broiler was heaviest in the evening when it was used to finish off ribs or cook steaks, chicken, or fish. The broiler was primarily used to cook-to-order hamburgers and chicken breasts during the lunch period. Occasionally, the broiler was used prior to lunch for charring assorted menu items, such as beef fajita strips or chicken halves.

Section 4

CONCLUSIONS AND RECOMMENDATIONS

PRODUCTION

The cooks found the broiler easy to operate and clean and were impressed with the quality of the cooked product it produced. The water trough beneath the elements effectively minimized flare-up, but did pose some inconvenience in cleaning. Overall, the broiler performed well in the kitchen, keeping up with the facility's production needs.

ENERGY CONSUMPTION AND CONSERVATION POTENTIAL

Because the broiler usage at PG&E's Learning Center dining facility is typical of food service operations catering to a mixed customer base, the opportunities for reducing energy costs pertain to other operations as well. Energy cost can be dramatically reduced through efficient operation.

Staff typically turn the broiler on 90 minutes prior to the beginning of a meal period and leave both sides on until they begin cleaning up at the end. By reducing the preheat period to 20 minutes, this operation could realize a savings of $546 per year, based on two preheats per day. Additionally, one side of the broiler may be left off during light-use periods, such as lunch, reducing the midday demand by as much as 5 kW. On days where a large customer count is expected, one side could be left in a "standby" setting such as "LO" until it is needed.

Broilers are among the most intensive energy users in the kitchen. They will consume a constant amount of energy, regardless of load. Operating only one side of the appliance during low usage periods effectively cuts the cost of operation in half for that period.

Section 5

REFERENCES

1. Pacific Electric and Electric Company. 1990. *PG&E Production-Test Kitchen: Cooking Appliance Performance Report.* Report 008.1-90.8, Department of Research and Development. San Ramon, California: Pacific Gas and Electric Company.

2. Pacific Electric and Electric Company. 1992. *Appliance Performance in Production: "Hobart" Electric Char Broiler Model CB51*. Report 008.1-92.4, Department of Research and Development. San Ramon, California: Pacific Gas and Electric Company.

3. Pacific Electric and Electric Company. 1993. *Wolf Commander Range-Match SUPER Char-Broiler: Appliance Performance in Production*. Report 008.1-91.28, Department of Research and Development. San Ramon, California: Pacific Gas and Electric Company.

Appendix A

GLOSSARY

GLOSSARY

Appliance On-Time (minute, hour)
Hours of Operation
Operating Period
Operating Time

The total period of time that an appliance is operated (from the perspective of food service staff) from the time it is turned "on" to the time it is turned "off." Appliance on-time excludes any "off" periods between the first and last appliance operation.

Average Daily Production Energy Consumption Rate (kW or kBtu/h)

The average rate of production energy consumption based on the daily production energy consumption and the appliance operating or "on" time.

$$\text{Average Daily Production Energy Rate} = \frac{\text{Daily Production Energy Consumption}}{\text{Appliance On - Time}}$$

Note: By basing the total daily production energy consumption on a 24-hour period, the total quantity of pilot energy (if applicable) is considered within the average production energy consumption rate and is based on the actual period of appliance usage.

Average Production Energy Consumption Rate (kW or kBtu/h)
Average Production Energy Rate
Average Production Energy Use Rate

The average rate of production energy consumption based on the production energy consumption and the appliance operating or "on" time for a specified period of appliance operation.

$$\text{Average Production Energy Consumption Rate} = \frac{\text{Production Energy Consumption}}{\text{Operating Time}}$$

Baseload Energy Consumption (kWh or kBtu)
Baseload Energy

The total amount of energy that would be consumed over the operating period of an appliance if it had never been used to cook food.

Baseload Energy Consumption Rate (kW or kBtu/h)
Base Rate
Baseload Energy Rate
Baseload Rate

The lowest rate of energy consumption reflected by the energy consumption profile (based on a 15-minute sliding window average) recorded during appliance operation. Generally, this definition is not extended to include the rate of pilot energy consumption. It is typically equal to the lowest value of idle energy consumption rate.

Cold Zone

The volume in the fryer below the heating element(s) or heat exchanger surface designed to remain cooler than the fry zone and hot zone.

Cook Zone
Cooking Zone

The volume of oil in the fryer where the fries are cooked. Typically, the entire volume from the heating element(s) of a heat exchanger surface to the surface of the frying medium.

Cooking Energy Consumption (kWh or kBtu)

The total energy consumed by an appliance during the cooking period.

Cooking Energy Consumption Rate (kW or kBtu/h)

The average rate of energy consumption during the cooking period.

Cooking Energy Efficiency

The quantity of energy input to the food products; expressed as a percentage of the quantity of energy input to the appliance during the heavy-, medium-, and light-load test.

Cooking Period (minute, hour)

The period of time (derived from in-kitchen monitoring or by interpreting the energy consumption profile) that an appliance is actually used for cooking.

Daily Energy Consumption (kWh or kBtu)
Daily Energy Use
Daily Production Energy Consumption
Daily Production Energy Use

The total amount of energy consumed by an appliance as it is used within the Production-Test Kitchen over a 24-hour period.

Note: By basing the total daily production energy consumption on a 24-hour period, the total quantity of pilot energy (if applicable) is considered within the average production energy consumption rate.

Duty Cycle (%)
Load Factor
Production Energy Factor
Production Factor

The average production energy consumption rate (based on a specified operating period for the appliance) expressed as a percentage of the measured energy input rate.

$$\text{Duty Cycle} = \frac{\text{Average Production Energy Consumption Rate}}{\text{Measured Energy Input Rate}} \times 100$$

Energy Consumption Profile
Energy Use Profile

A plot of appliance energy consumption showing energy consumption rate on the Y-axis and time on the X-axis.

Note: The area under the curve (plot) represents the total energy consumption for the period of integration. For uniformity in production reports, use the following terms and units for the coordinate labels:

y-axis: Energy Rate (kW or kBtu/h)

x-axis: Time (AM & PM)**:** (Hour) (Min)

Energy Consumption Rate (kW or kBtu/h)
Energy Input Rate
Energy Rate

The rate of appliance energy consumption over a specified period of operation (see Energy Consumption Profile).

Energy Use Data Set

A set of daily energy consumption data compiled in accordance with typical day criteria.

Hot Zone

The area surrounding the heating element(s) or heat exchanger surface.

Idle Energy Consumption (kWh or kBtu)
Idle Energy Use

The amount of energy consumed by an appliance operating under an idle condition over the duration of an idle period.

Idle Energy Consumption Rate (kW or kBtu/h)
Idle Energy Input Rate
Idle Energy Rate
Idle Rate

The rate of appliance energy consumption while it is "idling" or "holding" at a stabilized operating condition or temperature.

Idle Duty Cycle (%)
Idle Energy Factor
Idle Load Factor

The idle energy consumption rate expressed as a percentage of the measured energy input rate.

$$\text{Idle Energy Factor} = \frac{\text{Idle Energy Consumption Rate}}{\text{Measured Energy Input Rate}} \times 100$$

Idle Temperature (°F, Setting)

The temperature of the cooking cavity/surface (selected by the appliance operator or specified for a controlled test) that is maintained by the appliance under an idle condition.

Idle Time (minutes, hour)
Idle Period

A period of time that an appliance is consuming energy at its idle energy consumption rate while maintaining a specified stable operating condition or temperature.

Note: Idle time may include both necessary or unnecessary appliance "idling." This is simply differentiated by applying the appropriate adjective to the idle energy period term (e.g., needless idle time, necessary idle period.)

Measured Energy Input Rate (kW, W or kBtu/h, Btu/h)
Measured Input
Measured Peak Energy Input Rate
Peak Rate of Energy Input

The maximum or peak rate at which an appliance consumes energy, measured during appliance preheat or while conducting a water-boil test (i.e., the period of operation when all burners or elements are "on").

Pilot Energy Consumption (kBtu)
Pilot Energy Use
Standing or Constant Pilot Energy Consumption
Standing or Constant Pilot Energy Use

The amount of energy consumed by the standing pilot of an appliance over a specified period of time.

Pilot Energy Rate (kBtu/h)
Average Pilot Energy Rate
Average Pilot Energy Use Rate
Pilot Energy Consumption Rate

The rate of energy consumption by the standing or constant pilot while the appliance is not being operated (i.e., when the thermostats or control knobs have been turned off by the food service operator).

Preheat Energy Consumption (kWh or kBtu)
Preheat Energy

The total amount of energy consumed by an appliance during the preheat period.

Note: The reporting of preheat energy must be supported by the specified temperature/operating condition.

Preheat Energy Rate

The rate of appliance energy consumption while it is "preheating" to a predetermined temperature.

Preheat Time (minute, hour)
Preheat Period

The time required for an appliance to "preheat" from the ambient room temperature (75 ± 5°F) to a specified (and calibrated) operating temperature or thermostat set point.

Production Day
Production Period

The time period when an appliance is used by the kitchen staff, typically between the hours of 5 A.M. and 8 P.M.

Production Energy Consumption (kWh or kBtu)
Production Energy Use

The total amount of energy consumed by an appliance as it is used within the Production-Test Kitchen over a specified time period (e.g., 10 A.M. to 1 P.M., dinner period). Production energy consumption is numerically equal to daily energy consumption if the production period is not specified.

Note: This integrated energy use includes preheat energy, idle energy, and pilot energy associated with the specified time period.

Rated Energy Input Rate (kW, W or kBtu/h, Btu/h)
Input Rating (ANSI definition)
Nameplate Energy Input Rate
Rated Input

The maximum or peak rate at which an appliance consumes energy as rated by the manufacturer and specified on the nameplate.

Typical Day

A selected day of energy usage based on predetermined criteria that will generate a production energy consumption profile reflecting typical production usage for a specific appliance. The typical day criteria may comprise:

- Typical day energy consumption should approximate average daily energy consumption for energy use data set.
- A specified number of appliance operations and/or cooking periods (e.g., lunch and dinner only).
- A specified broiler in operating hours.
- A specified mode of operation (or combination of modes) may be associated with a typical day's operation.

Appendix B

MANUFACTURER'S PRODUCT SPECIFICATIONS

Appendix C

FREQUENCY DISTRIBUTION OF DATA SET

FREQUENCY DISTRIBUTION OF DATA SET

The frequency distribution of daily production energy consumption for the broiler is shown in Figure C-1. The frequency distribution of daily on-time for the broiler is shown in Figure C-2.

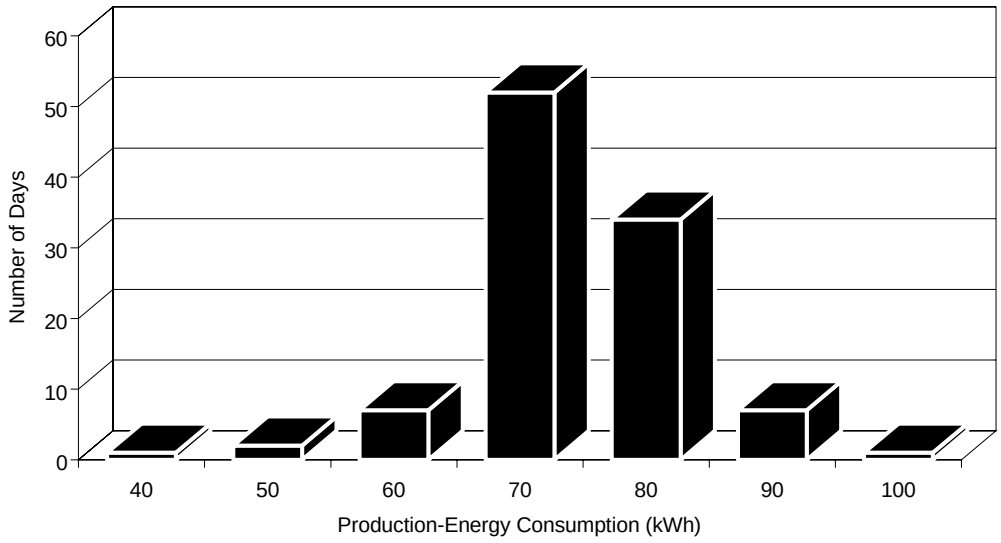


Figure C-1. Frequency of broiler daily production energy consumption.

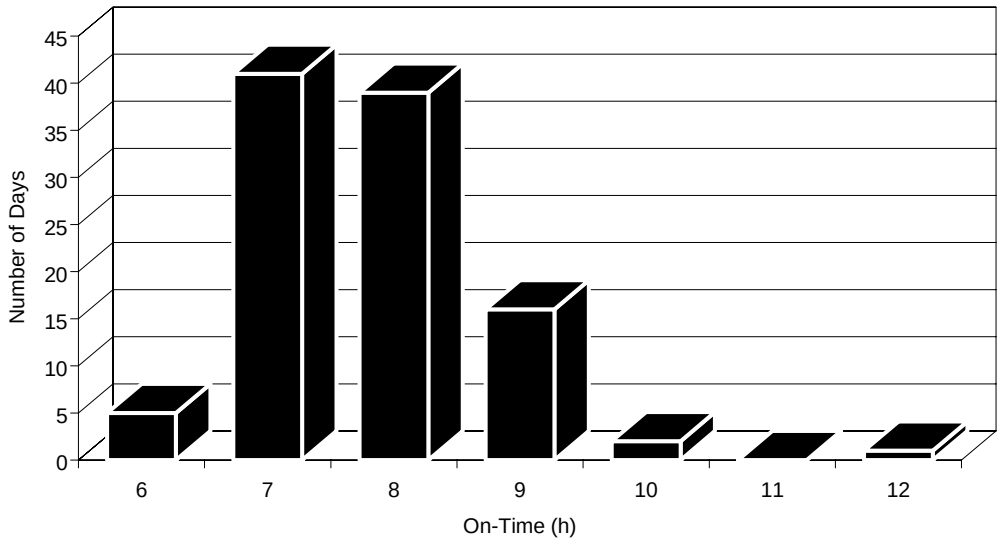


Figure C-2. Frequency of broiler daily on-time.