Montague, Model Vectaire HX63A

In-Kitchen Appliance Performance Report

FSTC Report 5011.01.86

Food Service Technology Center
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5011.01.86

Contents

Contents

Executive Summary

This Food Service Technology Center (FSTC) research report presents the results of monitoring the Montague Model Vectaire HX63A, gas convection oven as it was used for routine menu production in Pacific Gas and Electric Company's production-test kitchen and during tests under controlled laboratory conditions[1]. Montague's oven was equipped with a redesigned burner and heat transfer system. An atmospheric burner located beneath the oven cavity heats combustion products that are circulated around the outside of the oven cavity. A ½–horsepower, 2-speed fan circulates air throughout the oven cavity. The oven was monitored in the production-test kitchen over a 7-month test period. A summary of the test results is presented in Table ES-1.

To supplement monitoring information acquired during actual production conditions, controlled energy tests were also conducted.[1] The measured peak energy input rate was 66,000 Btu/h, which was 4.8% higher than its 63,000 Btu/h nameplate input. This oven consumed 13,569 Btu of energy over the 12.8-minute preheat period (the time required to heat the oven cavity air from a room temperature of 70°F ± 5°F to 350°F). The rate of idle energy use averaged 12,890 Btu/h.

Energy use data for the seven-month test period was reduced to include only days that reflected typical oven usage in the production-test kitchen (i.e., days when the oven was used for three-meal periods). The oven was used for an average of 14.5 hours, consuming 334.2 kBtu per day. This includes the aggregate preheat, idle, and cooking energy for the entire day of appliance operation. The average rate of production energy use was 23.0 kBtu/h, resulting in a production duty cycle of 35%.

Executive Summary

Table ES-1. Summary of Montague Model Vectaire HX63A Gas Convection Oven Performance Results.

Rated Energy Input (Btu/h)	63,000
Measured Energy Input Rate (Btu/h)	66,040
Preheat:	
Time to 350°F (min)	12.8
Energy (Btu)	13,569
Rate to 350°F (F/min)	21.5
Idle Energy Rate @ 350°F (Btu/h) [a]	12,890
Idle Duty Cycle (%)[a]	0.0
Pilot Energy Rate (Btu/h)	19.5
Full-Load Cooking Energy Efficiency (%)	43.9
Medium-Load Cooking Energy Efficiency (%)	37.1
Light-Load Cooking Energy Efficiency (%)	19.6
Production Capacity (lb/h) [b]	71.4
Production Energy Use (Btu/h)[c]	23,060
Pilot Production Energy Use (Btu/h) [a]	0
Appliance On-Time (h/d)	14.5
Average Production Energy Consumption Rate (Btu/day)	334,221
Production Duty Cycle (%)	34.9

[a] This oven is equipped with automatic ignition.
[b] Based on the full-load cooking test with a 210°F endpoint.
[c] Includes preheat and idle energy over the hours of operation when oven was in use.

Based on a 5-day per week, 52-week-per-year food service operation, the oven would consume 86,897 kBtu per year or equivalently 868.9 therms per year. The total yearly cost to operate the oven would be $539. This calculation is based on Pacific Gas and Electric Company's G-NR1 schedule for commercial gas rates ($0.62/Therm) dated April 7, 2000.

The oven was one of the most frequently used appliances in the production-test kitchen; it was used heavily to prepare a wide variety of items for lunch and dinner. First thing in the morning, the oven was used to bake pies, cakes, cookies, and other desserts such as puddings and cobblers. Biscuits, scones, and sausages were typical breakfast foods prepared in the oven. For lunch and dinner, the cooks used it for a variety of foods, including roasts, chicken, fish, casseroles, bread, pizza, vegetables and potatoes. Over a typical day, the operators cooked over 250 pounds of food. Although the daily quantity of food was considered "light" compared to high volume full-service restaurants, it was considered representative of many corporate/commercial cafeteria operations offering a diverse menu mix to a broad customer base.

[1] Food Service Technology Center. Montague Model Vectaire HX63A. *Application of ASTM Standard Test Method Designation F1361-95. Report 5011.99.79*, Products and Services Department, San Francisco, California: Pacific Gas and Electric Company.

1 Introduction

Background

Convection ovens are the most widely used appliances in the food service industry. Operators know that fresh-baked signature desserts, crusty breads, and familiar comfort foods, such as roasted meats and potatoes, are irresistible to their customers. In addition to traditional uses such as roasting and baking, these ovens can be used for nearly all types of food preparation, including foods typically prepared using other types of appliances.

Montague's new convection oven incorporates a two-speed fan with a solid-state thermostat, and a zero to 60-minute timer.

With competition heating up among equipment manufacturers, new designs incorporating time saving features via sophisticated control packages are being introduced. In 1993, Pacific Gas and Electric Company's Food Service Technology Center (FSTC) developed a standard test method to quantify the performance of convection ovens. This test method was applicable to both full-size and half-size convection ovens and allowed manufacturers and end users to compare performance indices such as energy efficiency, cooking uniformity, and production capacity.

The draft test procedure was submitted to the American Society for Testing and Materials (ASTM), and in February 1994 was accepted as a standard test method (Designation F 1496-93).[1] Pacific Gas and Electric Company's *Development and Application of a Uniform Testing Procedure for Convection Ovens* documents the developmental procedures and preliminary test results for four (two gas and two electric) convection ovens.[2] Other Pacific Gas and Electric Company reports document results of applying the ASTM test method to different convection ovens.[3-6]

Pacific Gas and Electric Company's Food Service Technology Center monitored the Montague Model Vectaire HX63A gas convection oven under both laboratory and in-kitchen conditions. It was used for routine menu production in Pacific Gas and Electric Company's production-test kitchen from April through November 2000. Four other ovens—two gas and two electric have similarly been monitored at the production-test kitchen facility.[3-6] To supplement production energy monitoring data, controlled energy test data were also documented.[7]

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

Objective

The objective of this appliance performance report was to document the energy consumption characteristics of the Montague gas convection oven during the seven months it was in operation at the production-test kitchen. The report documents oven usage in relationship to its energy consumption and cost while in production. Therefore, the reader should bear in mind that this information is specific to Pacific Gas and Electric Company's production-test kitchen, a corporate, cafeteria-style operation.

The Production Test Kitchen

The 1,500-square-foot kitchen is an integral component of the campus-style dining facility at Pacific Gas and Electric Company's Learning Center in San Ramon, California. Over ten cooking appliances are centrally located on two sides of a utility distribution system (UDS). The UDS functions as a central "spine" that contains all plumbing, wiring, and natural gas 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.

Figure 1-2 is a floor plan of the production-test kitchen and appliance lineup.

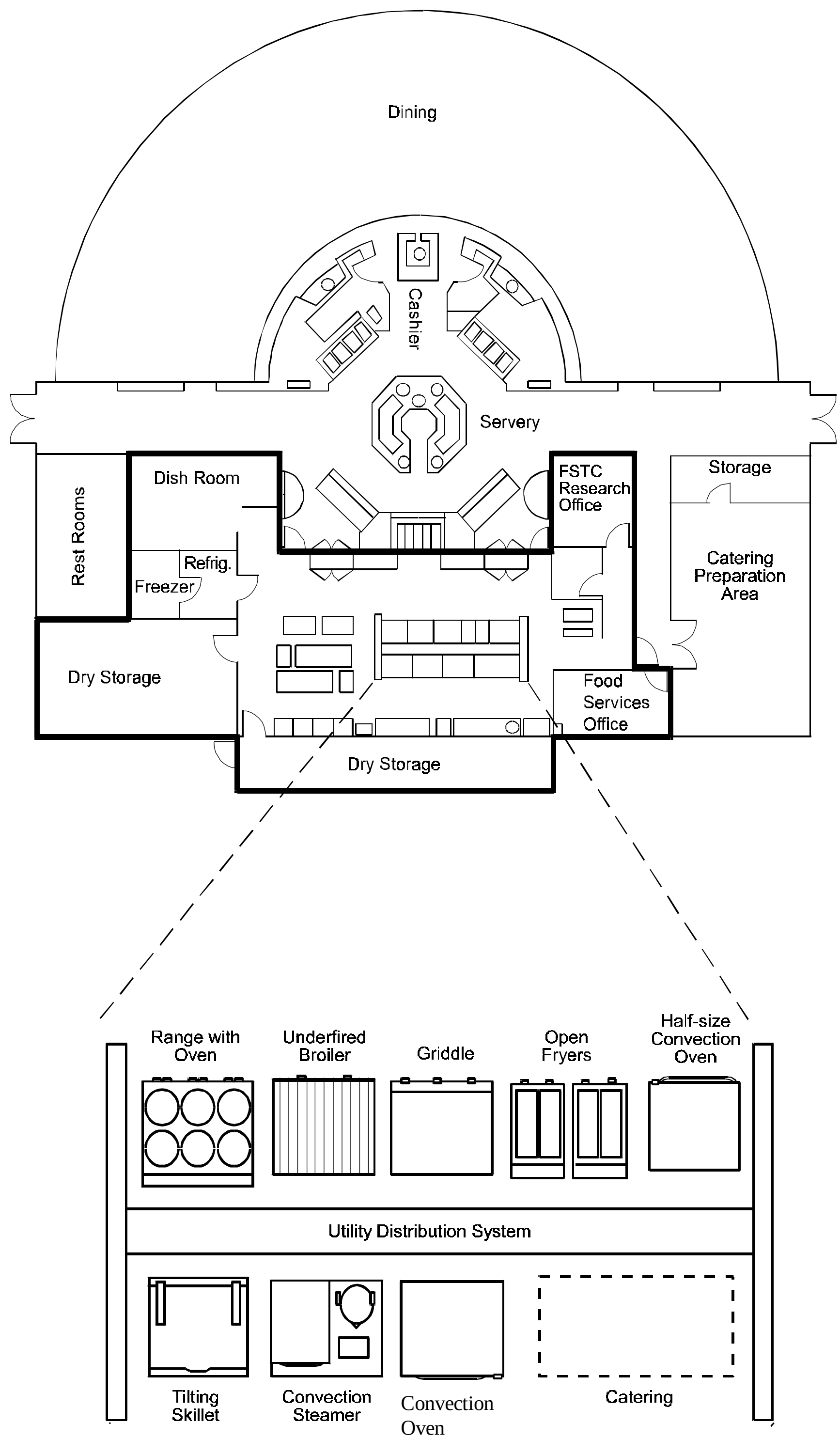

Figure 1-2. Pacific Gas and Electric Company's Learning Center, Production-test kitchen and typical appliance line.

The UDS 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 gas 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 the FSTC research team independent of the food service operation.

Appliance Description and Operation

An atmospheric burner located under the floor of the oven cavity powers the thermostatically controlled convection oven. Heat is transferred to the oven cavity from combustion products as they circulate up through the spaces between the sidewalls of the oven cavity (Figure 1-1) and the outside skin of the oven. The atmospheric gas burner is rated at 63,000 Btu/h. A ½-horsepower, 2-speed (full or half speed) fan circulates air throughout the oven cavity. This oven was equipped with electronic ignition, thus eliminating the need for a standing pilot. Table 1-1 presents the specifications for this Montague oven and the manufacturer's product literature appears in Appendix B.

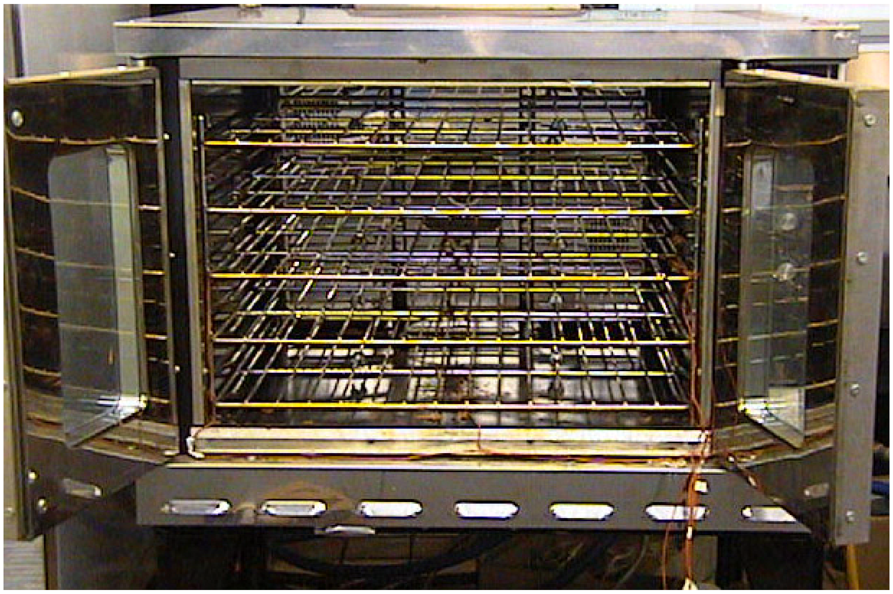

Figure 1-1. Montague Vectaire oven cavity.

Table 1–1. Appliance Specifications: Montague Gas Convection Oven.

Manufacturer	Montague
Model	Vectaire HX63A
Generic Appliance Type	Full-size convection oven
Rated Input	63,000 Btu/h
Dimensions	24” x 35½” x 15¼”
Oven Cavity Volume	15,221 cubic inches
Controls	Single thermostat adjustable from 200 to 500°F, 0 to 60 minute cook timer, and a two-speed fan.

2 Controlled Energy Tests

Purpose

The objective of this section of the report is to examine the operation and performance of the Montague Vectaire gas full-size convection oven, model HX63A, under the controlled conditions of the ASTM standard test method. The scope of this testing is as follows:

1. Verify that the appliance is operating at the manufacturer's rated energy input.
2. Determine the time and energy required to preheat the oven from room temperature to 350°F.
3. Characterize the oven's idle energy use with the thermostat set at a calibrated 350°F.
4. Document the cooking energy consumption and efficiency under three different scenarios: heavy (five pans of potatoes), medium (three pans of potatoes), and light (single pan of potatoes).
5. Determine the oven's production capacity when baking potatoes.

Methods and Results

FSTC researchers operated the Montague Vectaire HX63A gas convection oven under controlled laboratory conditions and in accordance with the *ASTM Standard Test Method for the Performance of Convection Ovens* (Designation F1496-93)[1]. For a detailed discussion of the development of the procedures and test results, refer to Pacific Gas and Electric Company's *Development and Application of a Uniform Testing Procedure for Convection Ovens* (Report 008.1-94.12)[2]. A complete application of the standard test method was applied to the Montague gas convection oven. The results are discussed in the FSTC 1999 report on the Montague oven performance test.[7]

The controlled energy tests were conducted with the thermostat set to a calibrated 350°F set point. The energy input rate was determined as part of the preheat test. Energy consumption and time were monitored until the temperature in the center of the cooking cavity was 350°F. For the idle test, the oven was allowed to stabilize at 350°F for one hour. After the oven had stabilized, the energy was monitored over a minimum of 3-hours.

The cooking energy efficiency and production capacity tests consisted of baking 100-count russet potatoes on full-size sheet pans. The cooking energy efficiency tests were conducted for three distinct loading scenarios: full (five sheet pans), medium (three sheet pans) and light (a single sheet pan).

Each pan was filled with 30 potatoes that had a combined weight of approximately 14½ pounds. Three potatoes per pan were randomly selected and instrumented with thermocouples for monitoring temperature during the test. The potatoes were then baked from 70°F to an average temperature of 210°F. Each of the three cooking energy efficiency tests were replicated a minimum of three times to ensure accuracy in the reported results. Production capacity was determined during the full-load test.

Results of the controlled testing are summarized in Table 2-1. Figure 2-1 plots the oven air temperature and oven energy consumption during the preheat test. Figure 2-2 plots the average potato temperature during a full-load test.

Controlled Energy Tests

Table 2-1. Summary of Controlled Energy Tests of the Montague Vectaire HX63A Gas Convection Oven.

Rated Energy Input Rate (Btu/h)	63,000
Measured Energy Input Rate (Btu/h)	66,040
Fan/Control Energy Rate (kW)	0.41
Preheat:	
Time to 350°F (min)[a]	12.8
Energy to 350°F (Btu)	13,569
Rate to 350°F(°F/min)	21
Idle Energy Rate (Btu/h)	12,890
Idle Duty Cycle (%)	19.5
Full-Load Cooking Energy Efficiency (%)	43.9 ± 1.4
Medium-Load Cooking Energy Efficiency (%)	37.1 ± 0.7
Light-Load Cooking Energy Efficiency (%)	19.6 ± 1.1
Production Capacity (lb/h) [b]	71.4 ± 1.5

[a] This oven was equipped with automatic ignition
[b] Based on the full-load cooking test with a 210°F endpoint.

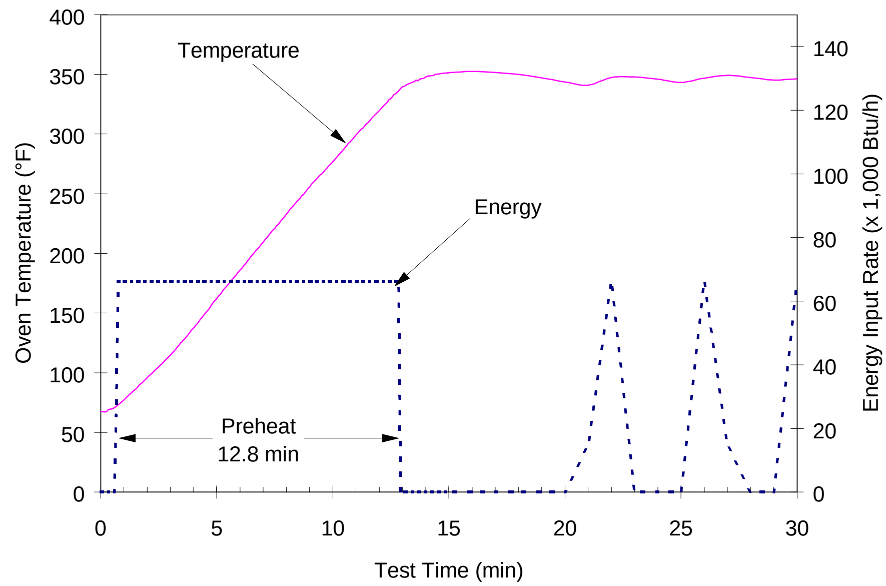

Figure 2-1.
Preheat test at 350°F.

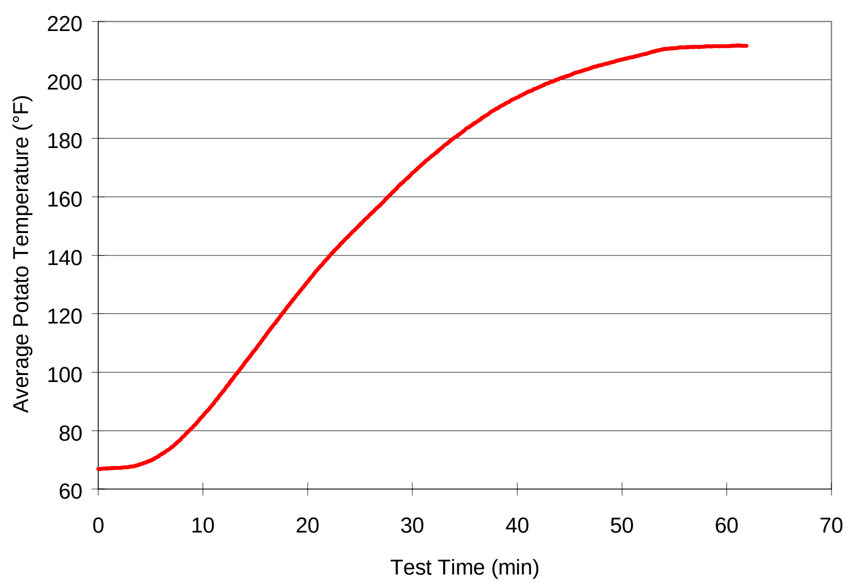

Figure 2-2.
Average potato temperature during a full-load test.

3 Production Monitoring

Energy Performance

The dataset from which the "typical day" characteristics were quantified covered a 7-month period, from April through November 2000. All Fridays, Saturdays, Sundays, and holidays were eliminated from the dataset because these days were not considered typical of oven usage in this operation. The production duty cycle was derived by dividing the average production energy consumption by the appliance's peak energy input rate. The average daily energy performance for the Montague Vectaire HX63A convection oven is summarized in Table 3-1. The energy monitoring system that is used to collect the data is described in Appendix C.

Table 3-1. Average Daily Energy Performance.

Measured Peak Energy Input Rate (Btu/h)	66,040
Daily Production Energy Use (Btu/d) [a]	334,221
Appliance On-Time (h/d)	14.5
Production Energy Consumption Rate (Btu/h)[b]	23,060
Production Duty Cycle (%)	34.9

[a] Includes preheat and idle energy over the hours of operation when the oven was in use.
[b] Note that the average production energy consumption rate was based on aggregate preheat, idle and cooking energy for the hours of operation over the day.

The energy consumption profile plotted in Figure 3-1 characterizes the typical day energy use for the oven in the production-test kitchen. The energy consumption data are presented on a 1-minute basis (dotted line plot) and a 15– minute "sliding window" average (solid line plot). The energy consumption plot illustrates that the oven was used through out the day for a total appliance on time of 14.5 hours. The higher energy consumption peaks at the beginning of each operation reflect the energy required to preheat the oven to a set operating temperature. Following each preheat period, the intermittent spikes above the idle or base rate of energy use reflect the incremental energy required to cook the food product loaded into the oven.

Energy consumption varied from 222.1 kBtu to 476.2 kBtu per day, and appliance on-time varied from 11.5 hours to 19.25 hours per day. The frequency distributions for daily production energy use and hours of operation for the oven are presented in Appendix D.

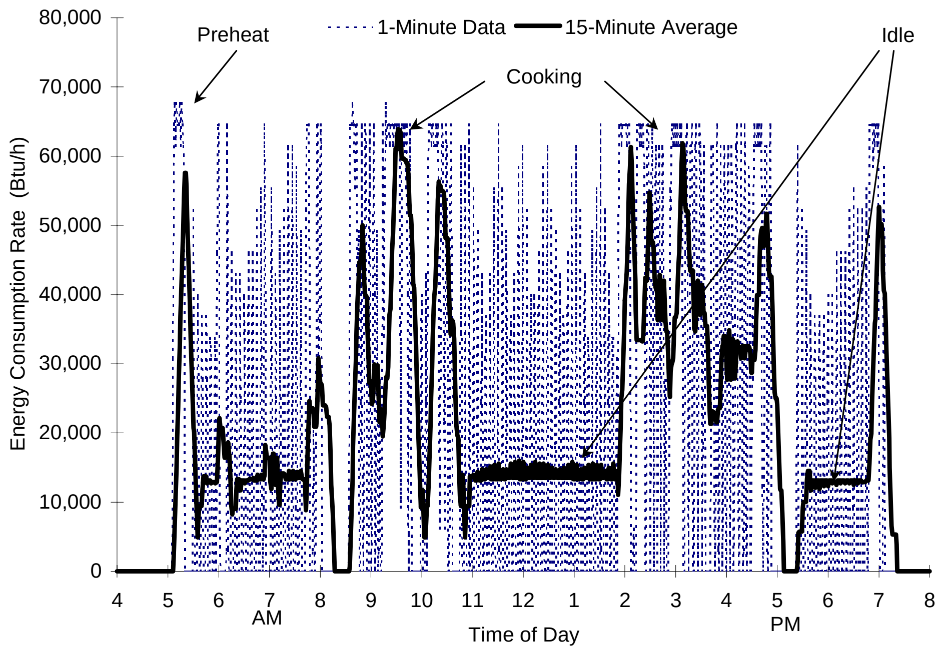

Figure 3-1. Typical day energy consumption profile.

Note: The energy consumption profile for the typical day is plotted on a 15-minute average. The 1-minute plot reflects the instantaneous input of energy into the appliance during preheat and subsequent element cycling during idle, while the 15-minute plot better characterizes the average rate of energy use (see Appendix C).

Estimated Annual Energy Cost

Based on the average daily energy consumption and assuming a 5-day per week, 52-week-per-year food service operation, the oven would consume an estimated 86,897 kBtu per year. At a cost of $0.62 per therm, the total cost to operate the oven would be $539 per year.

These costs of operation, as shown in Table 3-2, were calculated using a seasonally weighted average of Pacific Gas and Electric Company's gas rates (Schedule G-NR1) for small commercial customers, which would be applicable if the production-test kitchen were billed separately (Appendix E).

Table 3-2. Estimated Annual Energy Cost

Annual Production Energy Consumption (334.2 kBtu/d x 5 days x 52 weeks per year) (kBtu)[a]	86,897
Annual Energy Cost[b]	
Total Annual Energy Cost for Oven	$539

[a]Note: Estimates are based on Pacific Gas and Electric Company's G-NR1 rate schedule in effect on April 7, 2000 (see Appendix E).
[b] Does not include customer charges.

Food Production

The Montague gas convection oven was frequently used for preparation of many lunch and dinner items in the production-test kitchen. A FSTC researcher observed the gas convection oven during several periods of normal operation and interviewed the cooks. The cooks' daily worksheets were also reviewed to obtain a list of the food items prepared and to determine how the oven was being used. Figure 3-2 depicts the Montague oven in operation.

Items Cooked

The oven was used daily to prepare similar items for both the lunch and dinner meal periods: bake pies, cakes, cookies, biscuits, scones, roasts, chicken, fish, pizza, casseroles, vegetables, bread and potatoes.

In-Kitchen Observations

In-kitchen observations provided information about actual kitchen staff usage of the oven over a typical day of operation. It was operated about 6 hours over two distinct periods (lunch and dinner), providing more than 500 meals per day and used about 334.2 kBtu of energy per day. The thermostat was typically set at 350°F. The oven was usually turned on at 5:00 A.M. and left on until approximately 7:30 P.M., at which time it was shut off. During these periods, it was used to cook over 250 pounds of food. The period of heaviest cooking occurred between 11:30 A.M. and 12:45 P.M.

Interviews with the cooks also furnished non-energy performance information about the oven. The Montague oven received high praise for ease of use and convenience of its controls. Equipped with a timer, the Montague oven was a food saver, resulting in very little burnt product.

Figure 3.2.
Montague gas convection oven in the production-test kitchen.

Production Monitoring

Estimating Energy Usage Based on Test Results

While the daily production-test kitchen energy usage of the Montague HX-63 oven was as much as 10% lower then another gas convection oven by the same manufacturer, it was thought that the percentage of savings would have been greater based on the oven's ASTM laboratory test results. In-kitchen observations and checking of food logs revealed that the usage of the ovens in the production test kitchen has increased (i.e., more food cooked) since the first oven was monitored. The increased oven usage was a result of changes in the menu, increased reliance on ovens to cook food, and larger meal and catering counts. With more food being cooked in the ovens today, it was deemed unfair to compare the energy usage of Montague HX-63 oven to ovens that previously did not cook as much food. Using the proposed procedure for calculating the energy consumption of a convection oven based on reported test results, an estimated daily energy consumption for the Montague HX-63 gas convection oven was compared to a previously tested gas convection oven by the same manufacturer. The formulas that were used for estimating the daily energy consumption are presented in Appendix F.

The estimated daily energy consumption was calculated using the laboratory test data and the current estimated quantity of food cooked in the production-test kitchen. The laboratory test data included preheat energy and time, idle energy consumption rate, the production rates and cooking energy consumption rates for light-, medium- and heavy-cooking loads for both Montague convection ovens. The model assumptions were that the oven cooked 275.5 pounds of food (potatoes). Two hundred and seventy five pounds of food cooked would represent a typical heavy day of cooking at the production-test kitchen. The 275.5 pounds of food cooked was based on completing one heavy load, three medium loads, one light load and one preheat during the day. Table 3-3 contains both the controlled energy test result data and in-kitchen test data for the Montague HX-63 and SE70AH gas convection ovens. See Appendix G for ASTM performance indices and energy usage model assumptions for both ovens.

Production Monitoring

Based on the model, the Montague HX-63 gas convection oven would use an estimated 325.3 kBtu of energy per day with a production energy rate of 23.1 kBtu per hour, both of which are representative to the oven's "true" production-test kitchen energy usage. The other gas convection oven would use an estimated 436.8 kBtu per day with a production energy rate of 31.0 kBtu/h. Thus, the estimated daily energy usage for the HX-63 based on laboratory data was 34% lower then the estimated energy usage of the standard convection oven when cooking larger amounts of food, quantities that were typical of the production-test kitchen's production recent history.

Production Monitoring

Table 3-3. Comparison Between The Montague SE70AH and HX-63 Gas Convection Oven Performance.

	SE70AH	HX63A
Rated Energy Input (Btu/h)	70,000	63,000
Measured Energy Input Rate (Btu/h)	68,500	66,040
Preheat:		
Time to 350°F (min)	17.8	12.8
Energy (Btu)	19,900	13,569
Rate to 350°F (F/min)	15.8	21.5
Idle Energy Rate @ 350°F (Btu/h) [a]	18,200	12,890
Idle Duty Cycle (%)[a]	26.5	19.5
Pilot Energy Rate (Btu/h)	1,100	0
Full-Load Cooking Energy Efficiency (%)	31.6	43.9
Medium-Load Cooking Energy Efficiency (%)	28.4	37.1
Light-Load Cooking Energy Efficiency (%)	16.4	19.6
Production Capacity (lb/h) [b]	72.0	71.4
Production Energy Use (Btu/h)[c]	24,600	23,060
Pilot Production Energy Use (Btu/h) [a]	10,100	0
Appliance On-Time (h/d)	14.8	14.5
Average Production Energy Consumption Rate (Btu/day) [d]	374,100	334,221
Production Duty Cycle (%)	35.9	34.9

[a] This oven is equipped with automatic ignition.
[b] Based on the full-load cooking test with a 210°F endpoint.
[c] Note that the average production energy consumption rate was based on aggregate preheat, idle and cooking events.
[d] Includes preheat and idle energy over the hours of operation when the oven was in use.

4 Conclusions and Recommendations

Production Usage

The energy performance of the Montague Vectaire HX63A gas convection oven was successfully monitored and documented as it was operated in the production-test kitchen. In-kitchen observations were beneficial to understanding how the food service staff used the appliance. Oven usage was typical of many food service operations in that the oven cooked and baked a variety of foods including, chicken, roast, pizza, breads and pastries. Although the quantity of food cooked (an average of over 225 pounds per day) would be considered "light" compared to high-volume full-service restaurants, it was considered representative of many corporate/commercial cafeteria operations offering a diverse menu mix to a broad customer base. The oven was operated on an average of 14.5 hours per day. It was not routinely turned off between these two meal periods. The oven thermostat typically was set at 350°F, a standard temperature setting in commercial food service operations.

Production Energy Consumption

The estimated yearly energy consumption of 86,897 kBtu was a 10% reduction as compared to another gas convection oven by the same manufacturer. It was estimated that the oven would consume 86,897 kBtu per year for this 5-day per week food service operation. This corresponded to an annual energy cost of $539 based on Pacific Gas and Electric Company's applicable gas rates (G-NR1) for small, commercial core customers.

Laboratory testing at the FSTC found the Montague HX-63 gas convection oven to have the highest cooking energy efficiency of any gas convection ovens tested by the laboratory to date. In the production-test kitchen, the production energy consumption rate was slightly lower for this oven then another gas convection oven by the same manufacturer. It was thought that the HX-63 oven's production energy savings would have been greater based on both oven's ASTM test data. The predicted reduction in energy usage for the HX-63 oven at the production-test kitchen was reduced by the increased usage of the oven (i.e., more food cooked).

Using standardized formulas for estimating energy consumption of a convection oven, latest test data for the Montague HX-63 and SE70AH ovens, and a typical quantity (pounds) of food cooked in the ovens at the production-test kitchen during a busy day, the daily energy consumption was calculated. Based on the energy model, the Montague HX-63 gas convection oven would use an estimated 325.3 kBtu of energy per day with a production energy rate of 23.1 kBtu per hour, both of which are close to the oven's "true" production-test kitchen energy usage. The other gas convection oven would use an estimated 436.8 kBtu of energy per day with a production energy rate of 31.0 kBtu/h. Thus, the estimated Montague HX-63 oven's daily energy usage based on laboratory data was 34% lower then the estimated energy usage of the standard convection oven when cooking the larger amounts of food typical of the production-test kitchen's production recent history.

Production Energy Conservation Potential

The chefs generally turned the oven on at 5 A.M. and left it on until 7:30 P.M. An 8% reduction in energy use is possible if the oven would be turned off for 2 hours each day. Even under such heavy-use patterns, as seen in the production-test kitchen, a 2-hour non-production period is feasible between the lunch period and the start of dinner preparations (see Figure 3-1).

The Montague gas convection oven is a "workhorse" appliance and was well liked by the kitchen staff. Both the laboratory and in-kitchen performance data reflect that this oven is a solid performer that will go easy on an operation's energy budget.

5 References

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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.

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.

Average Production Energy Consumption Rate =

$$\frac{\text{Production Energy Consumption}}{\text{Operating Time}}$$

Baseload Energy Consumption (Btu 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.

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.

Glossary

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.

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.

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.

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.)

Glossary

Heating Value (Btu/ft^3)

Heating Content

The quantity of heat (energy) generated by the combustion of fuel. For natural gas, this quantity varies depending on the constituents of the gas.

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 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.

Production Duty Cycle =

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

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.

Glossary

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 range in operating hours.
- A specified mode of operation (or combination of modes) may be associated with a typical day's operation.

Test Method

A definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system, or service that produces a test result.

B Manufacturer’s Product Specifications

MONTAGUE VECTAIRE·HX

Gas Convection Ovens
HX-63 Series

HX-63A
with Tri-Therm™ Heating System

GENERAL
Single, **indirect fired** "muffled" oven, 38-1/4" wide x 41-1/4" deep x 57-1/2" high (97.2 x 104.8 x 146.1 cm) overall, including standard gusset-style adjustable legs. 27" wide x 27" deep x 20-1/2" high (68.6 x 68.6 x 52.1 cm) interior accommodates 18" x 26" (45.7 x 66.1 cm) pans lengthwise or widthwise. Burner with heat exchanger boosts the oven heating efficiency for improved cooking performance. Electronic controls for greater baking consistency. Used for general purpose baking and roasting.

MODELS:
HX-63A - Standard Electronic Controls and Electric Timer
HX-63AH - Cook-n-Hold Electronic Controls and Digital Timer

STANDARD FEATURES
- Porcelainized 16 gauge steel interior.
- Removable 9-position bright nickel rack guides.
- Five 26" x 27" (66.1 x 68.6 cm) bright nickel racks with rack stop and non-tip feature.
- High efficiency Euro design burners, S/S.
- Sealed heat exchanger, S/S.
- Burner pilot with reliable spark ignition system.
- Double layers of 2" (5.1 cm) thick insulation.
- Door style is split-type, vertical opening, side mounted. Each door has a double pane thermal viewing window. A single handle opens both doors. Durable S/S door gaskets.

CONTROLS, with universal symbols:
❑ *Standard* - Solid State Thermostat, 200°F (93°C) to 500°F (260°C) with "Burner/On" indicator light. One-hour electric countdown timer and alarm.

OPTIONAL, (*extra cost):
❑ **Cook-n-Hold* - Solid State Thermostat, 150°F (66°C) to 500°F (260°C) with "Burner/On" indicator light. 24-hour digital countdown timer and electronic alarm. Preprogrammed HOLD feature permits slow Roast-n-Hold operations.

LEGS
❑ Gusset-style legs, standard. Black finish.

OPTIONAL, (*extra cost):
❑ *Enclosed base (cabinet style) w/6" (15.2 cm) legs. Black finish.
  ❑ *S/S Front ❑ *S/S left side ❑ *S/S right side
  ❑ *S/S back ❑ *S/S bottom shelf
  Doors for enclosed base: ❑ *S/S ❑ *Black
❑ 9-position removable rack guides for enclosed base.
❑ *Modular Stand (open base) w/4" (10.2 cm) frame . S/S front and lower shelf. 19-1/2" (49.5 cm) S/S legs.
  ❑ Sides and Back will match oven.
  ❑ *9-position removable rack guides for Modular Stand.

FINISH
Satin stainless steel front, sides and top. Aluminized steel back and flue extensions. Black gusset-style legs.
OPTIONAL, (*extra cost):
❑ Oven: *S/S back.
❑ Flue Deflector: S/S
❑ Legs: *S/S Gusset-style legs.

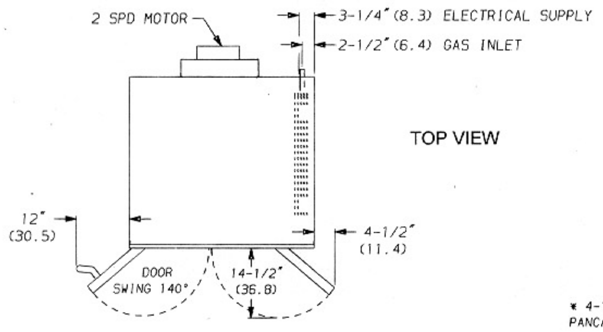
MOTOR
Split phase, air cooled, **two-speed** 1725/1140 RPM, 1/2 Hp with thermal overload protection. Sealed, self-lubricating ball bearing requires no lubrication for the life of the bearing. Motor is serviceable from the front through the oven chamber.

ELECTRICAL, (*extra cost):
❑ 120V, 1Ph, 60Hz, 7.2 amps. 6' (182.8 cm) grounded supply cord.
❑ 208-240V, 1Ph, 60Hz, 2.9 amps, (3 wire).
❑ *208-240V, 3Ph, 60Hz available. Consult factory.

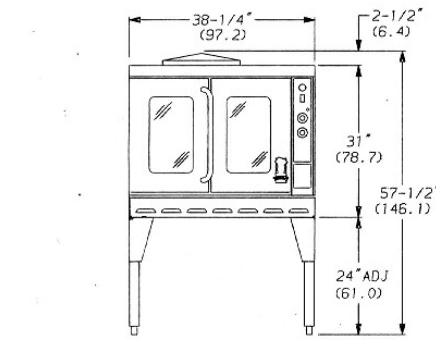
OPTIONS, (*extra cost):
❑ *CASTERS - Set of 4
  ❑ Gusset-style Legs: 5" (12.7 cm) stem casters.
  ❑ Enclosed Base: 5" (12.7 cm) plate casters.
  ❑ Modular Stand: 3-1/2" (8.9 cm) stem casters.
❑ *DOWN DRAFT DIVERTER, (in-lieu-of std. flue deflector).
  ❑ *S/S ❑ *Black
❑ *DRIP TRAY, S/S. - (To be placed on oven rack).
❑ FLEX CONNECTOR KIT, per deck - hose, disconnect and restaining device: 3' x 1/2" (91.4 cm x 1.3 cm).
❑ *HEAT SHIELD KIT - **refer min. clearances on back.
❑ OVEN INTERIORS:
  ❑ *Full stainless steel oven lining, (**ASC**).
❑ *PANCAKE MOTOR, **3/4 Hp. Two-speed** 1725/1140 RPM. Note: Reduces OA oven depth to 39-1/2" (100.3 cm).
  ❑ *120V, 1Ph, 60Hz, 11.6 amps 6' grounded supply cord.
  ❑ *208-240V, 1Ph, 60 Hz, 5.9 amps (3 wire).
❑ *RACKS, EXTRA:
  ❑ *____Standard ❑ *____Extra Heavy (for roasting).
❑ RACK GUIDES, 11-position.
❑ *SECURITY OPTIONS, (prisons, etc). Consult factory.
  ❑ SOLID DOORS - (in-lieu-of windows).

Dimensions in parenthesis are centimeters.

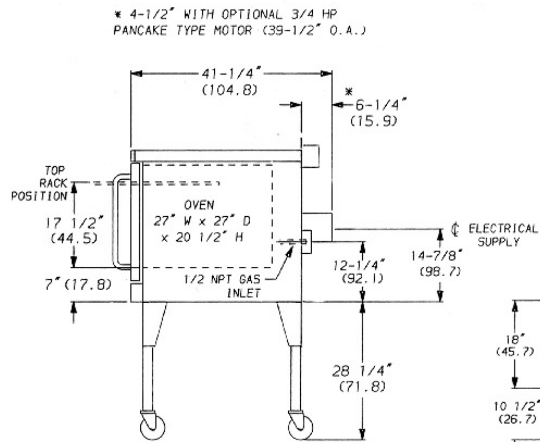
RACK SPACING	
# Racks/Oven Section	Clearance
5	3-3/8" (8.6)
9	1-1/2" (3.8)



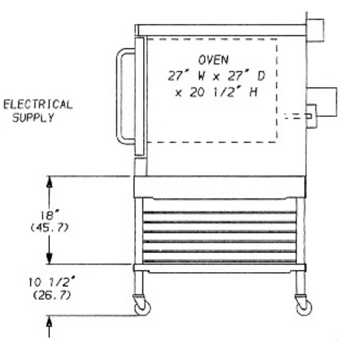
TOP VIEW



FRONT VIEW - Shown with standard gusset-style legs.



SIDE VIEW - Shown with standard gusset-style legs and 5" (12.7 cm) casters.



SIDE VIEW - Horizontal Doors. Shown w/optional modular stand with lower shelf, rack guides and 3-1/2" (8.9 cm) casters.

IMPORTANT

Commercial oven(s) must be installed in accordance with local codes or, in the absence of local codes, with the National Fuel Gas Code ANSI Z223.1, National Gas Installation Code CAN/CGA-B149.1 or B149.2. Compliance with codes is the responsibility of the Owner and Installer.

Adequate Ventilation System required. Must be installed in accordance with local codes.

AGA and CGA Design Certified: In accordance with ANSI Z83.12/CGA 1.10-M. Gas Foodservice Equipment - Ovens. NOTE: These appliances are intended for commercial use by professionally trained personnel. *NOT Intended For Household Use.*

Minimum Clearances:	Combustible Construction	Noncombustible Construction
Back Wall:	7" (17.8 cm)	7" (17.8 cm)
Left & Right Side:	6" (15.2 cm)	**0"
With 24" (61 cm) legs: suitable for installation on combustible floors.		
**HX Vectaire spacing to adjacent equipment: 6" (15.2 cm) minimum clearance on right side between similar ovens or other cooking equipment. Optional heat shield kits are available to reduce the clearance between similar ovens to 1" (2.5 cm) and between other equipment to 2" (5 cm). Consult factory.		

TYPE OF GAS Manifold Pressure		Natural 3.5" WC	Propane 10.0" WC
Model	# burners	BTU/HR	BTU/HR
All HX-63	1	63,000	63,000

GAS INLET SIZE (for all models):
One 1/2" (1.3 cm) NPT at right rear. Pressure regulator included in combination gas valve - no additional exterior regulator required.

NOTE: Specify type of gas ❑Natural ❑Propane
Specify elevation if installing above 2000 feet.

ENTRY CLEARANCE: 31-1/2" (80 cm) uncrated

APPROX. CU. FT/CU. METER:		SHP WGT: (Class 70)	
Oven, w/ Gusset-style legs	34/0.96	500 Lbs.	227 kg.
Enclosed base:	21/0.59	90 Lbs.	41 kg.
Modular stand and shelf	21/0.59	78 Lbs.	35 kg.

Montague's continuing commitment to quality/product improvement can cause specification and design changes without prior notice.

THE MONTAGUE COMPANY
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http://www.montague.itrade.net

Vectaire 2
26645-0 3/97
Printed in U.S.A.

C Energy Monitoring System

Energy data are collected once each minute, which means that the highest resolution measurement of energy rate is a 1-minute average. This 1-minute average, shown as the dotted line on the graph of the typical day profile, differs from actual instantaneous power explained in the following paragraphs.

Short periods of full input are not reflected as full input. Heating elements and burners are usually either full on or off. A plot of 1-minute data may show some less-than-full-on 1-minute values because the elements or burners operate on full for only part of the minute.

Long periods of constant input rate are usually reflected as a sawtooth pattern. Gas pulses are generated by the meter, which measures the flow of gas to the appliance. Each pulse corresponds to a specific quantity of gas energy consumed. The system stores the number of pulses for each minute, but it only stores an integer value for the number of pulses even though the actual energy consumed during the period corresponds to a non-integer value. For example, if the actual consumption during a 1-minute period corresponds to 6.6 pulses, only the integer "6" will be stored for that minute. The "0.6" will be carried forward and added to pulses generated during the next minute. If the energy consumed during the next minute is also 6.6 pulses, then the pulse value stored will be the integer portion of 7.2 (6.6 + 0.6) and the 0.2 will be carried to the next time interval.

D Frequency Distribution of Dataset

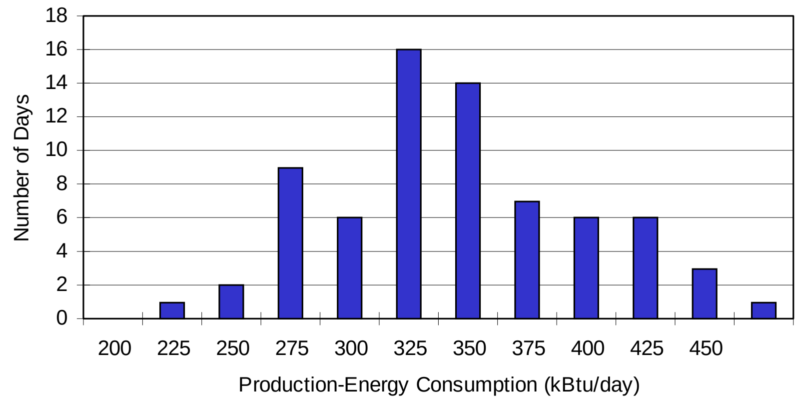

Figure D-1.
Frequency of gas convection oven daily production energy consumption.

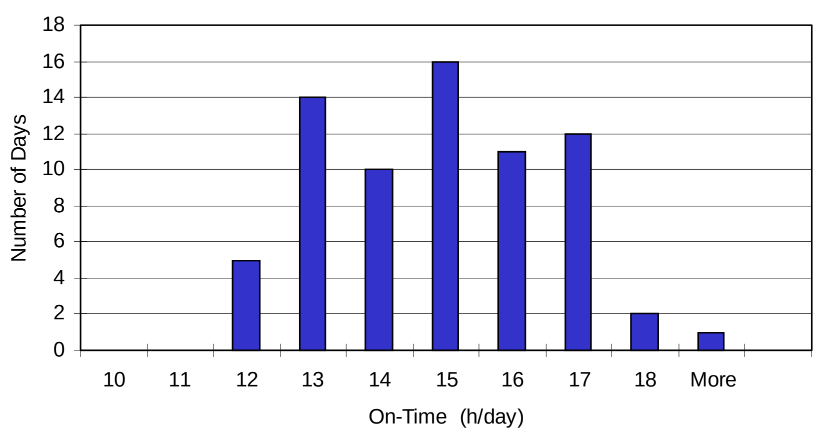

Figure D-2.
Frequency of gas convection oven daily on-time.

E Pacific Gas and Electric Company Gas Energy Rates

F Procedure for Calculating the Energy Consumption of a Convection Oven Based on Reported Test Results

Draft Appendix

(Nonmandatory Information. This draft Appendix is being proposed to be added to the ASTM Standard Test Method for the Performance of Convection Ovens, F 1496-99)

I. X1.Procedure for Calculating the Energy Consumption of a Convection Oven Based on Reported Test Results

X1.1 Appliance test results are useful not only for benchmarking appliance performance, but also for estimating appliance energy consumption. The following procedure is a guideline for estimating convection oven energy consumption based on data obtained from applying the appropriate test method.

X1.2 The intent of this Appendix is to present a standard method for estimating oven energy consumption based on ASTM performance test results. The examples contained herein are for information only and should not be considered an absolute. To obtain an accurate estimate of energy consumption for a particular operation, parameters specific to that operation should be used (e.g., operating time, and amount of food cooked under heavy-, medium-, and light-loads)

X1.3 The appropriate oven performance parameters are obtained from section 11 in the test method.

X1.4 *Procedure:*

Note X1.1—Sections X1.5 and X1.6 show how to apply this procedure.

X1.4.1 The calculation will proceed as follows: First, determine the appliance operating time and total number of preheats. Then estimate the quantity of food cooked and establish the breakdown among heavy- (fully-loaded oven), medium- (half-loaded oven), and light- (single-pan) loads. For example, a oven operating for 12 hours a day with two preheats cooked 100 pounds of food: 50% of the food was cooked under heavy-load conditions, 40% was cooked under medium-load conditions, and 10% was cooked under light-load conditions. Calculate the energy due to cooking at heavy-, medium-, and light-load cooking rates, and then calculate the idle energy consumption. The total daily energy is the sum of these components plus the preheat energy. For simplicity, it is assumed that subsequent preheats require the same time and energy as the first preheat of the day.

X1.4.2 *Step 1*—Determine the oven operating time, number of preheats, and amount of food cooked under heavy-, medium-, and light-load conditions.

X1.4.3 *Step 2*—Calculate the time and energy involved in cooking heavy- (full) loads. Heavy-loads are the equivalent of loading every rack in the oven with food to be cooked.

X1.4.3.1 The total time cooking heavy-loads is determined as follows:

$$t_h = \frac{\%_h \times W}{PC} \qquad \text{(X1.1)}$$

where:

t_h = total time cooking heavy-loads, h
$\%_h$ = the percentage of food cooked under heavy-load conditions during the day,
W = total weight of food cooked per day, lb
PC = the oven's production capacity as determined in 11.9.4, lb/h,

X1.4.3.2 The heavy-load energy consumption is calculated using the following set of equations. For gas ovens, any electric energy shall be determined separately using the electric equations.

$$E_{gas,h} = q_{gas,h} \times t_h$$
$$E_{elec,h} = q_{elec,h} \times t_h \quad \textit{(X1.2)}$$

where:

$E_{gas,h}$ = total gas heavy-load energy consumption, Btu,
$q_{gas,h}$ = gas heavy-load cooking energy rate as determined in 11.9.1, Btu/h,
$E_{elec,h}$ = total electric heavy-load energy consumption, kWh,
$q_{elec,h}$ = electric heavy-load cooking energy rate as determined in 11.9.1, kW.

X1.4.4 *Step 3*—Calculate the time and energy involved in cooking medium- (half) loads. Medium-loads are the equivalent of loading about half of the oven's racks with food to be cooked.

X1.4.4.1 The total time cooking medium-loads is determined as follows:

$$t_m = \frac{\%_m \times W}{PR_m} \quad (X1.3)$$

where:

t_m = total time cooking medium-loads, h
$\%_m$ = the percentage of food cooked under medium-load conditions during the day,
W = total weight of food cooked per day, lb
PR_m = the oven's medium-load production rate as determined in 11.9.5, lb/h,

X1.4.4.2 The medium-load energy consumption is calculated using the following set of equations. For gas ovens, any electric energy shall be determined separately using the electric equations.

$$E_{gas,m} = q_{gas,m} \times t_m$$
$$E_{elec,m} = q_{elec,m} \times t_m \quad (X1.4)$$

where:

$E_{gas,m}$ = total gas medium-load energy consumption, Btu,
$q_{gas,m}$ = gas medium-load cooking energy rate as determined in 11.9.1, Btu/h,
$E_{elec,m}$ = total electric medium-load energy consumption, kWh,
$q_{elec,m}$ = electric medium-load cooking energy rate as determined in 11.9.1, kW.

X1.4.5 *Step 4*—Calculate the time and energy involved in cooking light- (single-pan) loads. Light-loads are the equivalent of cooking only one pan of food.

X1.4.5.1 The total time cooking light-loads is determined as follows:

$$t_l = \frac{\%_l \times W}{PR_l} \quad (X1.5)$$

where:

t_l = total time cooking light-loads, h
$\%_l$ = the percentage of food cooked under light-load conditions during the day,
W = total weight of food cooked per day, lb

PR_l = the oven's light-load production rate as determined in 11.9.5, lb/h,

X1.4.5.2 The light-load energy consumption is calculated using the following set of equations. For gas ovens, any electric energy shall be determined separately using the electric equations.

$$Egas,l = q_{gas,l} \times tl$$

$$E_{elec,l} = q_{elec,l} \times t_l \qquad \text{(X1.6)}$$

where:
$E_{gas,l}$ = total gas light-load energy consumption, Btu,
$q_{gas,l}$ = gas light-load cooking energy rate as determined in 11.9.1, Btu/h,
$E_{elec,l}$ = total electric light -load energy consumption, kWh,
$q_{elec,l}$ = electric light-load cooking energy rate as determined in 11.9.1, kW.

X1.4.6 *Step 5*—Calculate the total idle time and energy consumption.

X1.4.6.1 The total idle time is determined as follows:

__(X1.7)

where:
ti = the total idle time, h
ton = the total daily on-time, h
np = the number of preheats,
tp = preheat time, as determined in 11.6.1, min

X1.4.6.2 The idle energy consumption is calculated using the following set of equations. For gas ovens, any electric energy shall be determined separately using the electric equations.

Egas,i = qgas,i (ti

Eelec,i = qelec,i (ti (X1.8)

where:
Egas,i = total gas idle energy consumption, Btu,
qgas,i = gas idle energy rate as determined in 11.7.1, Btu/h,
Eelec,i = total electric idle energy consumption, kWh,
qelec,i = electric idle energy rate as determined in 11.7.1, kW.

X1.4.7 Step 6—The total daily energy consumption is calculated as follows:

Egas,daily = Egas,h + Egas,m + Egas,l + Egas,i + np (Egas,p

Eelec,daily = Eelec,h + Eelec,m + Eelec,l + Eelec,i + np (Eelec,p (X1.9)

where:
Egas,daily = the total daily gas energy consumption, Btu/d
np = the total number of preheats per day,
Egas,p = gas preheat energy consumption as determined in 11.6.1, Btu
Eelec,daily = the total daily electric energy consumption, kWh/d
Eelec,p = electric preheat energy consumption as determined in 11.6.1, Btu

The complete formulae for calculating daily energy consumption are as follows:

$$E_{gas,\,daily} = \frac{\%_h \times W}{PC} \times q_{gas,\,h} + \frac{\%_m \times W}{PR_m} \times q_{gas,\,m} + \frac{\%_l \times W}{PR_l} \times q_{gas,\,l} + \left(t_{on} - \frac{\%_h \times W}{PC} - \frac{\%_m \times W}{PR_m} - \frac{\%_l \times W}{PR_l} - \frac{n_p \times t_p}{60} \right) \times q_{gas,\,i} + n_p \times E_{gas,\,p}$$

$$E_{elec,\,daily} = \frac{\%_h \times W}{PC} \times q_{elec,\,h} + \frac{\%_m \times W}{PR_m} \times q_{elec,\,m} + \frac{\%_l \times W}{PR_l} \times q_{elec,\,l} + \left(t_{on} - \frac{\%_h \times W}{PC} - \frac{\%_m \times W}{PR_m} - \frac{\%_l \times W}{PR_l} - \frac{n_p \times t_p}{60} \right) \times q_{elec,\,i} + n_p \times E_{elec,\,p} \quad \text{(X1.10)}$$

X1.4.8 *Step 7*—The average electric demand for ovens may be calculated according to the following equation:

$$q_{avg} = \frac{E_{elec,\,daily}}{t_{on}} \quad \text{(X1.11)}$$

NOTE X1—It has been assumed that the appliance's probable contribution to the building's peak demand is the average demand for the appliance. This is useful because 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. If data exists otherwise for a given operation, the probable contribution to demand can be other than the average demand.

where:

q_{avg} = the average demand for the oven, kW
$E_{elec,daily}$ = the total daily electric energy consumption, kWh/d
t_{on} = the total daily on-time, h

X1.4.9 *Step 8*—The estimated monthly appliance energy cost may be determined as follows:

$$C_{gas,\,monthly} = r_{gas} \times \frac{E_{gas,\,daily}}{100{,}000\ \frac{Btu}{therm}} \times d_{op} \quad \text{(X1.12)}$$

$$C_{elec,\,monthly} = r_{elec} \times E_{elec,\,daily} \times d_{op} + r_{demand} \times q_{avg} \quad \text{(X1.13)}$$

where:

$C_{gas,monthly}$ = the monthly appliance gas cost, \$/mo,
r_{gas} = the appropriate utility gas rate, \$/therm,
$E_{gas,daily}$ = the total daily gas energy consumption, Btu/d,
d_{op} = the average number of operating days per month,
$C_{elec,monthly}$ = the monthly appliance electric cost, \$/mo,
r_{elec} = the appropriate utility electric rate, \$/kWh,
$E_{elec,daily}$ = the total daily electric energy consumption, kWh/d,

r_{demand} = the appropriate utility demand charge, \$/kW,
q_{avg} = the average demand for the griddle, kW.

X1.5 *Example of Calculating the Daily Energy Consumption for an Electric Oven:*

X1.5.1 Application of the test method to an electric oven yielded the following results:

Table X1.1: Electric Oven Test Results—Example.

Test	Result
Preheat Time	11.0 min
Preheat Energy	1.5 kWh
Idle Energy Rate	2.1 kW
Heavy-Load Cooking Energy Rate	9.2 kW
Medium-Load Cooking Energy Rate	6.7 kW
Light-Load Cooking Energy Rate	3.7 kW
Production Capacity	73 lb/h
Medium-Load Production Rate	49 lb/h
Light-Load Production Rate	15 lb/h

X1.5.2 *Step 1*—The following appliance operation is assumed:

Table X1.2: Oven Operation Assumptions.

Operating Time	12 h
Number of Preheats	2 preheats
Total Amount of Food Cooked	100 lb
Percentage of Food Cooked Under Heavy-Load Conditions	50% (× 100 lb = 50 lb)
Percentage of Food Cooked Under Medium-Load Conditions	40% (× 100 lb = 40 lb)
Percentage of Food Cooked Under Light-Load Conditions	10% (× 100 lb = 10 lb)

X1.5.3 *Step 2*—Calculate the total heavy-load energy.

X1.5.3.1 The total time cooking heavy-loads is as follows:

$$t_h = \frac{\%_h \times W}{PC},$$

$$t_h = \frac{50\% \times 100\ lb}{73\ lb/h}, \qquad \text{(X1.14)}$$

$$t_h = 0.68\ h$$

X1.5.3.2 The total heavy-load energy consumption is then calculated as follows:

$$E_{elec,h} = q_{elec,h} \times t_h,$$

$$E_{elec,h} = 9.2\ kW \times 0.68\ h, \qquad \text{(X1.15)}$$

$$E_{elec,h} = 6.3\ kWh$$

X1.5.4 *Step 3*—Calculate the total medium-load energy.

X1.5.4.1 The total time cooking medium-loads is as follows:

$$t_m = \frac{\%_m \times W}{PR_m},$$

$$t_m = \frac{40\% \times 100\ lb}{49\ lb/h}, \qquad \text{(X1.16)}$$

$$t_m = 0.82\ h$$

X1.5.4.2 The total medium-load energy consumption is then calculated as follows:

$$E_{elec,m} = q_{elec,m} \times t_m,$$

$$E_{elec,m} = 6.7\ kW \times 0.82\ h, \qquad \text{(X1.17)}$$

$$E_{elec,m} = 5.5\ kWh$$

X1.5.5 *Step 4*—Calculate the total light-load energy.

X1.5.5.1 The total time cooking light-loads is as follows:

$$t_l = \frac{\%_l \times W}{PR_l},$$

$$t_l = \frac{10\% \times 100\ lb}{15\ lb/h}, \qquad \text{(X1.18)}$$

$$t_l = 0..67\ h$$

X1.5.5.2 The total light-load energy consumption is then calculated as follows:

$$E_{elec,l} = q_{elec,l} \times t_l,$$

$$E_{elec,l} = 3.7\ kW \times 0.67\ h \qquad \text{(X1.19)}$$

$E_{elec,l}$ = 2.5 kWh

X1.5.6 *Step 5*—Calculate the total idle time and energy consumption.

X1.5.6.1 The total idle time is determined as follows:

$$t_i = t_{on} - t_h - t_m - t_l - \frac{n_p \times t_p}{60},$$

$$t_i = 12.0\ h - 0.68\ h - 0.82\ h - 0.67\ h - \frac{2\ preheats \times 11.0\ min}{60\ min/h} \quad \text{(X1.20)}$$

t_i = 9.46 h

X1.5.6.2 The idle energy consumption is then calculated as follows:

$$E_{elec,i} = q_{elec,i} \times t_i,$$

$$E_{elec,i} = 2.1\ kW \times 9.46\ h \quad \text{(X1.21)}$$

$$E_{elec,i} = 19.9\ kWh$$

X1.5.7 *Step 6*—The total daily energy consumption is calculated as follows:

$$E_{elec,daily} = E_{elec,h} + E_{elec,m} + E_{elec,l} + E_{elec,i} + n_p \times E_{elec,p},$$

$$E_{elec,daily} = 6.3\ kWh + 5.5\ kWh + 2.5\ kWh + 19.9\ kWh + 2 \times 1.5\ kWh \quad \text{(X1.22)}$$

$$E_{elec,daily} = 37.2\ kWh/day$$

X1.5.8 *Step 7*—Calculate the average demand as follows:

$$q_{avg} = \frac{E_{elec,daily}}{t_{on}},$$

$$q_{avg} = \frac{37.2\ kWh}{12.0\ h}, \quad \text{(X1.23)}$$

$$q_{avg} = 3.10\ kW$$

X1.6 *Example of Calculating the Daily Energy Consumption for a Gas Oven:*

X1.6.1 Application of the test method to a gas oven yielded the following results:

Table X1.3: Gas Oven Test Results—Example.

Test	Result
Preheat Time	15.0 min
Preheat Energy[a]	20,000 Btu + 110 Wh
Idle Energy Rate[a]	18,000 Btu/h + 450 W
Heavy-Load Cooking Energy Rate[a]	62,000 Btu/h + 450 W
Medium-Load Cooking Energy Rate[a]	48,000 Btu/h + 450 W
Light-Load Cooking Energy Rate[a]	28,000 Btu/h + 450 W
Production Capacity	72 lb/h
Medium-Load Production Rate	49 lb/h
Light-Load Production Rate	17 lb/h

[a]Includes electric energy consumed by the fan and controls.

X1.6.2 *Step 1*—The following appliance operation is assumed:

Table X1.4: Oven Operation Assumptions.

Operating Time	12 h
Number of Preheats	2 preheats
Total Amount of Food Cooked	100 lb
Percentage of Food Cooked Under Heavy-Load Conditions	50% (× 100 lb = 50 lb)
Percentage of Food Cooked Under Medium-Load Conditions	40% (× 100 lb = 40 lb)
Percentage of Food Cooked Under Light-Load Conditions	10% (× 100 lb = 10 lb)

X1.6.3 *Step 2*—Calculate the total heavy-load energy.

X1.6.3.1 The total time cooking heavy-loads is as follows:

$$t_h = \frac{\%_h \times W}{PC},$$

$$t_h = \frac{50\% \times 100\ lb}{72\ lb/h}, \quad \text{(X1.24)}$$

$$t_h = 0.69\ h$$

X1.6.3.2 The total heavy-load energy consumption is then calculated as follows:

$$E_{gas,h} = q_{gas,h} \times t_h, \qquad E_{elec,h} = q_{elec,h} \times t_h,$$

$$E_{gas,h} = 62{,}000\ Btu/h \times 0.69\ h, \qquad E_{elec,h} = 450\ W \times 0.69\ h, \quad \text{(X1.25)}$$

$$E_{gas,h} = 42{,}800\ Btu \qquad E_{elec,h} = 310\ Wh$$

X1.6.4 *Step 3*—Calculate the total medium-load energy.

X1.6.4.1 The total time cooking medium-loads is as follows:

$$t_m = \frac{\%_m \times W}{PR_m},$$

$$t_m = \frac{40\% \times 100\ lb}{49\ lb/h}, \quad \text{(X1.26)}$$

$$t_m = 0.82\ h$$

X1.6.4.2 The total medium-load energy consumption is then calculated as follows:

$$E_{gas,m} = q_{gas,m} \times t_m, \qquad E_{elec,m} = q_{elec,m} \times t_m,$$

$$E_{gas,m} = 48{,}000\ Btu/h \times 0.82\ h, \qquad E_{elec,m} = 450\ W \times 0.82\ h, \quad \text{(X1.27)}$$

$$E_{gas,m} = 39{,}400\ Btu \qquad E_{elec,m} = 370\ Wh$$

X1.6.5 *Step 4*—Calculate the total light-load energy.

X1.6.5.1 The total time cooking light-loads is as follows:

$$t_l = \frac{\%_l \times W}{PR_l},$$

$$t_l = \frac{10\% \times 100\ lb}{17\ lb/h}, \quad \text{(X1.28)}$$

$$t_l = 0.59\ h$$

X1.6.5.2 The total light-load energy consumption is then calculated as follows:

$$E_{gas,l} = q_{gas,l} \times t_l, \qquad E_{elec,l} = q_{elec,l} \times t_l,$$

$$E_{gas,l} = 28{,}000\ Btu/h \times 0.59\ h \qquad E_{elec,l} = 450\ W \times 0.59\ h \quad \text{(X1.29)}$$

$$E_{gas,l} = 16{,}500\ Btu \qquad E_{elec,l} = 265\ Wh$$

X1.6.6 *Step 5*—Calculate the total idle time and energy consumption.

X1.6.6.1 The total idle time is determined as follows:

$$t_i = t_{on} - t_h - t_m - t_l - \frac{n_p \times t_p}{60},$$

$$t_i = 12.0\ h - 0.69\ h - 0.82\ h - 0.59\ h - \frac{2\ preheats \times 15.0\ min}{60\ min/h} \qquad \text{(X1.30)}$$

$$t_i = 9.4\ h$$

X1.6.6.2 The idle energy consumption is then calculated as follows:

$$E_{gas,i} = q_{gas,i} \times t_i, \qquad E_{elec,i} = q_{elec,i} \times t_i,$$

$$E_{gas,i} = 18{,}000\ Btu/h \times 9.4\ h \qquad E_{elec,i} = 450\ W \times 9.4\ h \qquad \text{(X1.31)}$$

$$E_{gas,i} = 169{,}200\ Btu \qquad E_{elec,i} = 4{,}230\ Wh$$

X1.6.7 *Step 6*—The total daily energy consumption is calculated as follows:

$$E_{gas,daily} = E_{gas,h} + E_{gas,m} + E_{gas,l} + E_{gas,i} + n_p \times E_{gas,p},$$

$$E_{gas,daily} = 42{,}800\ Btu + 39{,}400\ Btu + 16{,}500\ Btu + 169{,}200\ Btu + 2 \times 20{,}000\ Btu \qquad \text{(X1.32)}$$

$$E_{gas,daily} = 307{,}900\ Btu/day = 3.08\ therms/day$$

$$E_{elec,daily} = E_{elec,h} + E_{elec,m} + E_{elec,l} + E_{elec,i} + n_p \times E_{elec,p},$$

$$E_{elec,daily} = 310\ Wh + 370\ Wh + 265\ Wh + 4{,}230\ Wh + 2 \times 110\ Wh$$

$$E_{elec,daily} = 5{,}395\ Wh/day$$

X1.6.8 *Step 7*—Calculate the average demand as follows:

$$q_{avg} = \frac{E_{elec,\ daily}}{t_{on}},$$

$$q_{avg} = \frac{5{,}395\ Wh}{12.0\ h}, \qquad \text{(X1.33)}$$

$$q_{avg} = 450\ W$$

G ASTM Test Results and Model Assumption for Calculating the Energy Consumption of a Convection Oven

ASTM Performance Indices

Montague HX63 gas convection oven

Preheat Time	12.8	min
Preheat Energy	9.7	kBtu
Idle Rate	12.9	kBtu/h
Heavy Production Rate	71.4	lb/h
Heavy Cooking Energy Rate	44.1	kBtu/h
Medium Production Rate	49.4	lb/h
Medium Cooking Energy Rate	36.3	kBtu/h
Light Production Rate	16.8	lb/h
Light Cooking Energy Rate	22.8	kBtu/h

Baseline Model Assumptions

Operating Hours	14.1	
Preheats	1	
Heavy Loads	1	
Medium Loads	3	
Light Loads	5	
Total Food	**275.5**	**lb**

Constants

Heavy Load	72.5	lb
Medium Load	43.5	lb
Light Load	14.5	lb

Estimated Average Energy Consumption Rate	**23.1**	**kBtu/h**
Published Production Energy Rate	**23.1**	**kBtu/h**
Estimate Daily Energy Consumption	**325.1**	**kBtu**
Published Production Energy Consumption	**334.2**	**kBtu**

ASTM Performance Indices

Montague SE 70 gas convection oven

Preheat Time	17.8min
Preheat Energy	19.9kBtu
Idle Rate	18.2kBtu/h
Heavy Production Rate	72.0lb/h
Heavy Cooking Energy Rate	62.3kBtu/h
Medium Production Rate	49.3lb/h
Medium Cooking Energy Rate	48.1kBtu/h
Light Production Rate	16.9lb/h
Light Cooking Energy Rate	28.0kBtu/h

Baseline Model Assumptions

Operating Hours	14.1
Preheats	1
Heavy Loads	1
Medium Loads	3
Light Loads	5
Total Food	**275.5lb**

Constants

Heavy Load	72.5lb
Medium Load	43.5lb
Light Load	14.5lb

Estimate Average Energy Consumption Rate **31.0kBtu/h**

Published Production Energy Rate **24.6kBtu/h**

Estimate Daily Energy Consumption **436.8kBtu**

Published Production Energy Consumption **374.1kBtu**