Groen Model HY-6E HyPerSteam Electric Pressureless Steamer

In-Kitchen Appliance Performance Report

FSTC Report 5011.95.23

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The information in this report is based on data generated at PG&E's Food Service Technology Center.

Acknowledgments

The establishment of the Food Service Technology Center reflects PG&E's commitment to the food service industry. The goal of the research project is to provide PG&E's 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 supplied the cooking appliances for testing.

PG&E's Food Service Technology Center is supported by the National Advisory Group that includes:

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Specific appreciation is extended to Groen for supplying the Food Service Technology Center with a HY-6E HyPerSteam electric pressureless steamer for controlled testing in the appliance laboratory and subsequent installation and monitoring in the production-test kitchen.

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Executive Summary

This PG&E Food Service Technology Center (FSTC) research report presents the results of monitoring the Groen Model HY-6E HyPerSteam electric pressureless steamer as it was used for routine menu production in PG&E's production-test kitchen and during tests under controlled laboratory conditions. Groen's steamer has a 6-pan total capacity and two separate steamer compartments, each of which has an independent pressureless steam generation and circulation system. Investigated performance indices included the measured peak energy input rate, preheat energy requirement and time, production energy consumption rate, idle energy consumption rate, and duty cycle. The steamer was monitored in the production-test kitchen over a 5-month test period. A summary of the test results is presented in Table ES-1.

Table ES-1
Summary of Groen Model HY-6E Electric Pressureless Steamer Performance

Rated Energy Input (kW)	18.2
Test Voltage; 3-phase (V)	208
Measured Energy Input Rate (kW)	19.1
Preheat:	
Time (min)	6.8
Energy (one compartment) (kWh)	1.0
Energy (two compartments) (kWh)	2.0
Idle Energy Rate:	
One Compartment (kW)	0.6
Two Compartments (kW)	1.2
Idle Duty Cycle:	
One Compartment (%)	3.1
Two Compartments (%)	6.3
Production Energy Use [a] (kWh/d)	80.9
Appliance On-Time (h/d)	16.3
Average Production Energy Consumption Rate (kW)	5
Production Duty Cycle (%)	26

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

To supplement monitoring information acquired during actual production conditions, controlled energy tests were also conducted.[1] The measured peak energy input rate was 19.1 kW, which was 6.1% higher than its 18.0 kW nameplate input. This steamer consumed 1.0 kWh of energy over the 6.8-minute preheat period required to bring one compartment of the steamer to operating temperature (when the elements first cycle off from an ambient temperature of 70°F). Preheat time was the same for the two compartments, but the energy input rate doubled to 2.0 kWh. The rate of idle energy use averaged 0.6 kW for one compartment and 1.2 kW for two compartments, with an idle duty cycle of 3.1% and 6.3%, respectively.

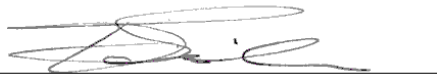
Energy use data for the test period were reduced to include only days that reflected typical steamer usage in the production-test kitchen (i.e., days when the steamer was used for three-meal periods). The hours of operation over the day averaged 16, during which time the steamer consumed 81 kWh. Based on the aggregate preheat, idle, and cooking energy for the entire day of appliance operation, the average rate of production energy use was 5 kW, resulting in a production duty cycle of 26%.

Based on a 5-day per week, 52-week-per-year food service operation, the steamer would consume 21,034 kWh per year and increase billing demands by 5 kW. The total yearly cost to operate the steamer would be $2,144: production accounts for $1,893, and demand accounts for $251. This calculation is based on PG&E's A-10 schedule for commercial electric rates ($0.0892/kWh and $4.18/kW/month) dated May 1, 1997, and a year-round, five-day-per-week food service operation.

The steamer 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, including fresh and frozen vegetables, rice, beans, pasta, sauces, and fish. Over a typical day, the operators cooked about 100 pounds of food. The cooks found the steamer easy to operate and clean. The staff liked the safety of the pressureless steamer and felt that the food quality and cook times were not compromised by using a "pressureless" unit.

[1] Food Service Technology Center. In Press. *Groen Model HY-6E HyPerSteam Electric Steamer: Application of ASTM Standard Test Method* Designation F1484-93. Report 5011.95.15, Consumer Energy Management Department. San Francisco, California: Pacific Gas and Electric Company.

Executive Summary

FSTC Manager 

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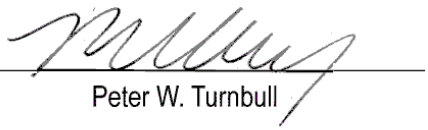
Senior Program Manager 

Peter W. Turnbull

1 Introduction

Background

Commercial compartment pressureless steamers provide an easy, fast way to prepare large quantities of food, and offer good nutrient retention, short cook times, and ease of preparation. Steamers are versatile kitchen cooking appliances that can be used to prepare almost any food item, except those requiring a crust, by allowing direct-steam contact to do the cooking. Delicate vegetables such as asparagus and broccoli are cooked without damage, frozen foods are defrosted and cooked in one step, and it's often said that meat can be wet-roasted with less weight loss than oven roasting.

With steam cooking, the steam, at 212°F, carries six times as much energy as water at the same temperature. When steam condenses on the surface of cold food, it delivers this latent energy to the food. As with baking, a layer of insulating air can form around food in a still steamer cavity, but many atmospheric steamers employ a fan for forced convection steaming to produce short cook times and even cooking throughout the compartment under full-load conditions.

PG&E's Food Service Technology Center monitored the Groen Model HY-6E HyPerSteam electric pressureless steamer under both laboratory and in-kitchen conditions. It was used for routine menu production in PG&E's production-test kitchen from June through October 1994. Three other steamers—one gas presssureless, one electric pressureless, and one gas pressure steamer—have similarly been monitored at the PG&E facility[1,2,3]. To supplement production energy monitoring data, controlled energy test data were also documented.

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 Groen electric pressureless steamer during the five months it was in operation at the production-test kitchen. The report documents steamer 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 PG&E's production-test kitchen, a corporate, cafeteria-style operation.

Introduction

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 in San Ramon, California. Nine 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.

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.

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

Appliance Description and Operation

The Groen Model HY-6E electric pressureless steamer was installed in accordance with the manufacturer's instruction manual. Appliance specifications are summarized in Table 1-1 and the manufacturer's specification sheet is in Appendix B.

Steam is generated by twin, independent atmospheric steam-generating units. The steam is then circulated to the cooking compartments and blown through the cavities by a steam-circulating blower that is integral to each compartment. The HyPerSteam's drainage system includes a spray condenser, which suppresses any escaping steam from the chambers and directs it into an internal condenser collection box. This sink collects condensate that rolls off the door or from the pans. Drain condensate and spray condenser water are collected in a small vented box with a rear drain connection.

The idle rate is the result of two continuously energized 500-watt elements, which maintain a slow boil in the steam generator. The steam generated from this slow boil constantly flows into the cooking compartments. The steam generator is located outside the compartment, and fans in the compartment are used to circulate the steam.

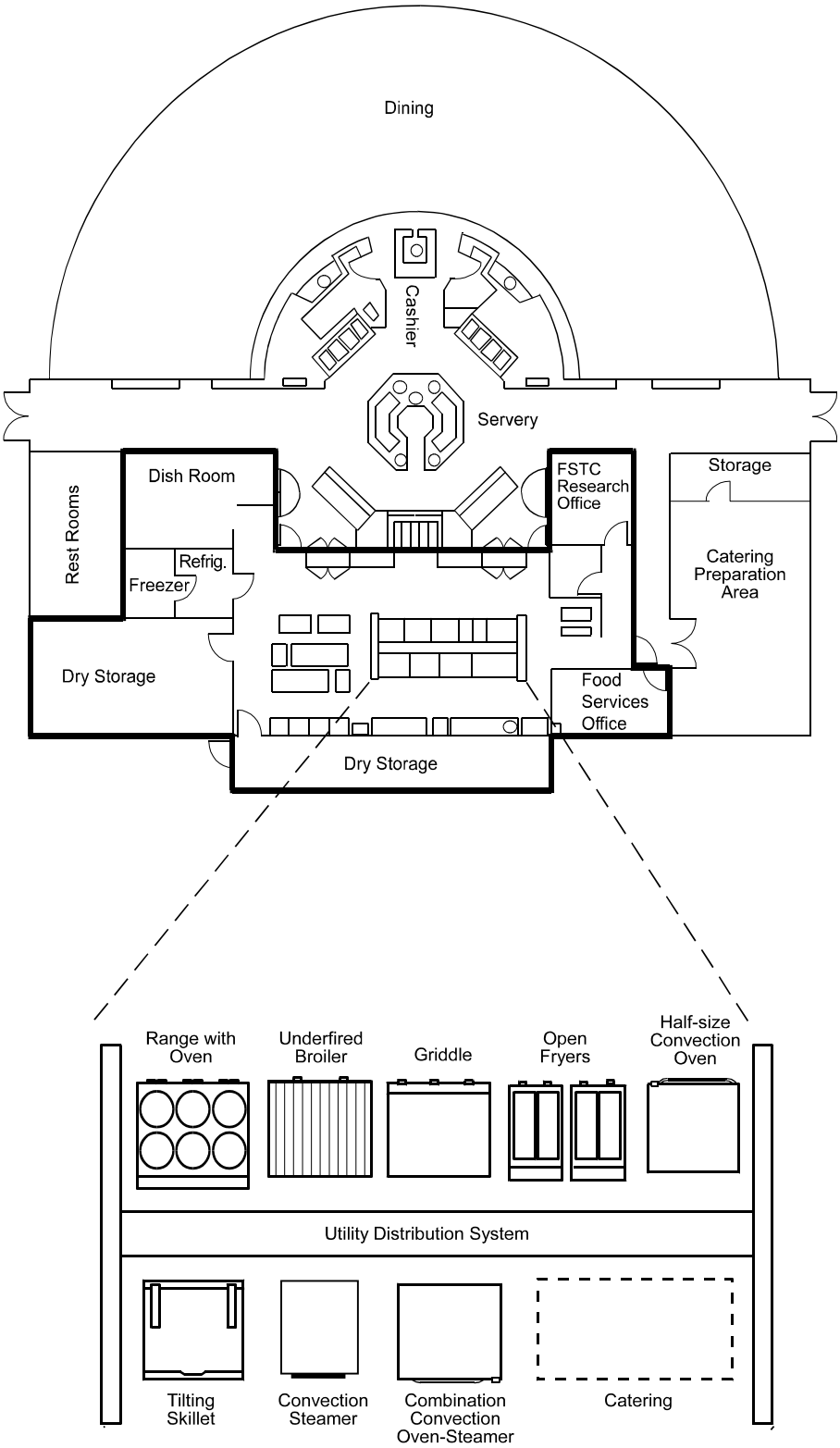


Figure 1-1.
Production-test kitchen, PG&E Learning Center.

Table 1-1.
Appliance Specifications for the Groen Electric Pressureless Steamer.

Generic Appliance Type:	Pressureless steamer
Manufacturer:	Groen, A Dover Industries Company
Model:	HY-6E HyPerSteam electric pressureless steamer
Rated Energy Input:	18.2 kW
Voltage:	208V-3∅
Heat Transfer:	Steam is created in a pressureless boiler and circulated at atmospheric pressure through the compartments by forced convection. A fan increases the velocity of steam in the compartments.
Controls:	Timer dial for 1-60 minutes or manual “on,” and an on/off switch for each compartment
Configuration:	Two compartments
Pan Capacity:	Six - 12” x 20” x 2½” or twelve - 12” x 20” x 1”
Dimensions:	Steamer is $21^{5}/_{8}$” wide by $35^{3}/_{16}$” deep by $57^{5}/_{8}$” high.

2 Controlled Energy Tests

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

FSTC researchers operated the Groen HyPerSteam under controlled laboratory conditions and in accordance with the *ASTM Standard Test Method for the Performance of Steam Cookers* (Designation F1484-93).[4] For a detailed discussion of the development of the procedures and test results, refer to PG&E's *Development and Validation of a Uniform Testing Procedure for Steam Cookers*.[5] A complete application of the Standard Test Method was applied to the HyPerSteam[6] and to three other steamers—one gas pressureless, one electric pressureless, and one gas pressure.[5]

The steamer was tested without a food load, and the energy input rate was determined during the preheat test. Preheat was considered complete when the elements first cycled off, indicating that the steamer boiler had achieved operating temperature (212°F). For the idle test, the steamer was allowed to stabilize for 30 minutes after the preheat was finished. After the steamer had stabilized, energy consumption was monitored over a 4-hour period. Energy consumption rates for the boiler at idle, single compartment unloaded, and both compartments unloaded, were recorded during this test.

Results of the controlled testing are summarized in Table 2-1.

Figure 2-1 shows the preheat and idle test energy consumption rate profiles of a boiler preheat, boiler idle, single compartment unloaded, and both compartments unloaded. One-minute data and a 15-minute average are presented. The 15-minute average reflects the impact that the appliance would have on a 15-minute-interval demand meter for all possible 15-minute windows of demand. The 15-minute average also serves to better illustrate the average rate of energy consumption as it smoothes out the sharp peaks and valleys of the 1-minute plot.

Table 2-1.
Summary of Controlled Energy Tests of the Groen Pressure-less Steamer.

Rated Energy Input Rate (kW)	18.2
Test Voltage, 3-phase (V)	208
Measured Energy Input Rate (kW)	19.1
Preheat:	
Time (min) 6.8	
Energy (one compartment) (kWh)	1.0
Energy (two compartments) (kWh)	2.0
Idle Energy Rate:	
One Compartment (kW)	0.6
Two Compartments (kW)	1.2
Unloaded Input Rate:	
One Compartment (kW)	9.5
Two Compartments (kW)	18.6

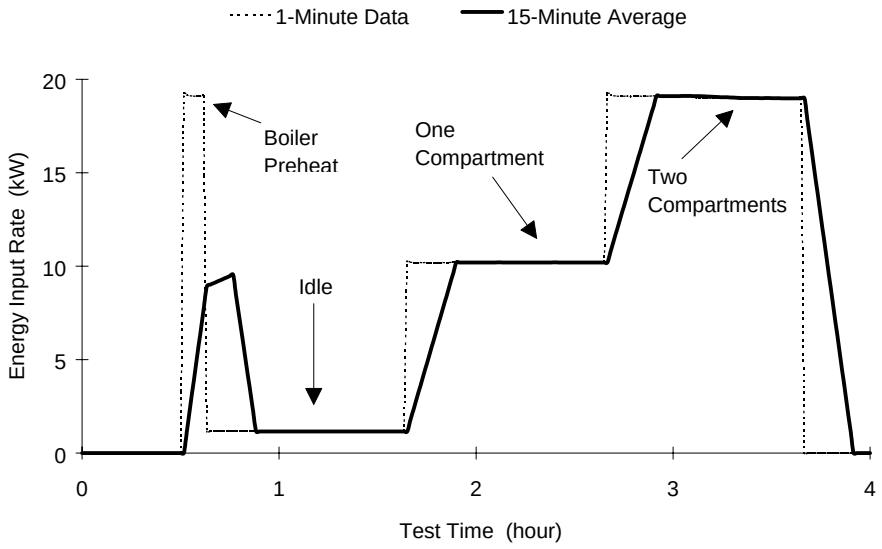


Figure 2-1.
Preheat and idle energy test at 212°F.

Note: The energy consumption profile for the typical day is plotted on a 1-minute basis and 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).

3 Production Monitoring

Energy

The dataset from which "typical day" characteristics were quantified covers a 5-month period, from June through October 1994. All Fridays, Saturdays, Sundays, and holidays were eliminated from the dataset because they were not three-meal food service days typical of this food service operation. The steamer dataset was therefore reduced to 75 days. The average daily energy performance of the steamer is summarized in Table 3-1. The energy monitoring system used to collect the data is described in Appendix C.

Table 3-1.
Average Daily Energy Performance.

Measured Peak Energy Input Rate (kW)	19.1
Daily Production Energy Use[a] (kWh/d)	80.9
Appliance On-Time (h/d)	16.3
Production Energy Consumption Rate (kW)	5
Production Duty Cycle (%)	26

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

The energy consumption profile plotted in Figure 3-1 illustrates the typical day production energy use for the steamer as used in the production-test kitchen. This day was chosen because the daily energy consumption, operating hours, and average production rate closely matched the average values shown in Table 3-1. The energy consumption plot illustrates that the steamer boiler was operating much of the day, for a total appliance on-time of 16 hours.

On the typical day, the staff preheated one compartment of the steamer (by energizing the boiler) at about 4:30 A.M., then turned the second compartment on at 6 A.M. Preheats and cooking events are characterized by brief peaks of high-energy consumption rising above the boiler idle rate (1.2 kW), indicating that the steamer timer had been activated. Both steamer boilers were on and idling throughout the entire day, as denoted by the constant baseline energy consumption. The steamer was used to cook food products for the different meal periods from 6 A.M. until 7 A.M., then from just before 9 A.M. until about 12:30 P.M., and again starting about 3:30 P.M. until just before 7 P.M.

Energy consumption varied from 57.0 kWh to 130.0 kWh per day, and appliance on-time varied from 14 hours to 18 hours per day. The frequency distributions for daily production energy use and hours of operation for the steamer are presented in Appendix D.

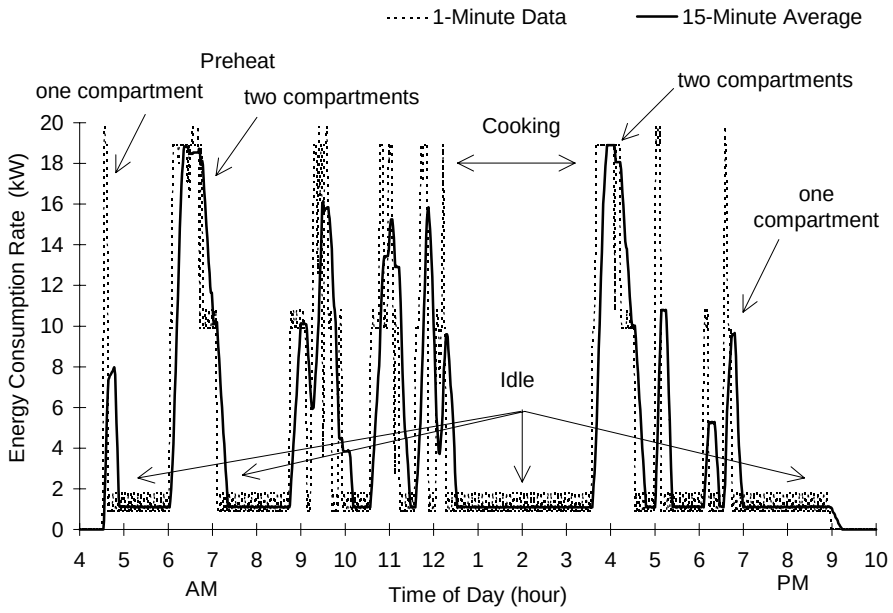


Figure 3-1.
Typical day energy consumption profile.

Note: The energy consumption profile for the typical day is plotted on a 1-minute basis and a 15-minute average. The 1-minute plot reflects the instantaneous input of energy into the appliance during pre-heat 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 steamer would consume an estimated 21,034 kWh per year, and increase monthly billing demands for the facility by 5 kW. This estimated average contribution to demand assumes that the appliance is operating when the maximum building demand occurs. At a cost of $0.0892/kWh and $4.18/kW/month, the total cost to operate the steamer would be $2,144 per year: production accounts for $1,893, and demand accounts for $251.

These costs of operation, as shown in Table 3-2, were calculated using a seasonally weighted average of PG&E's electric rates (Schedule A-10) for small commercial customers (Appendix E).

Table 3-2.
Estimated Annual Energy Cost.

Energy Consumption Charge (21,034 kWh per year x $0.09/kWh):	$1,893
Probable Demand Charge (5 kW x $4.18/kW/month x 12 months):[a]	$251
Total Annual Energy Cost for Steamer:[b]	$2,144

Note: Estimates are based on PG&E's A-10 rate schedule in effect on May 1, 1997 (see Appendix E).

[a]The probable demand charge was based on the assumption that the steamer was operating during the peak period of time that the billing demand was likely to be set. The actual contribution to billing demand may vary significantly at other food service operations, depending on the steamer usage pattern (operating schedule, appliance on-time, etc.) in relation to other electric equipment at the facility.

[b]Does not include customer charges.

Food Production

The Groen steamer was frequently used for preparation of many lunch and dinner items in the production-test kitchen. An FSTC researcher observed the HyPerSteam 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 steamer was being used.

Items Cooked

The steamer was used daily to prepare similar items for both the lunch and dinner meals: fresh and frozen vegetables, potatoes, beans, rice, pasta, and sauces. The steamer was also frequently used to scald milk, melt butter, steam the fish of the day, and other daily specials. Most precooked foods, such as soups, chili, and hot dogs, were rethermalized with the HyPerSteam.

In-Kitchen Observations

In-kitchen observations provided information about actual kitchen staff usage of the steamer over a typical day of operation. The steam generators were usually turned on before 5 A.M. and remained on until after 8 P.M., when the dinner service was finished. While it operated throughout the entire day, the steamer was used most heavily for preparing lunch and dinner, when several cooks would be cooking different menu items at the same time. The doors of the steamer were constantly opened and shut while lunch and dinner were being prepared. Over a typical day, the operators cooked about 100 pounds of food, and the steamer consumed an average of 81 kWh of energy. The steam generators were left idling throughout the day.

Figure 3-2 shows the Groen HyPerSteam being used by a chef in the production-test kitchen.

Figure 3-2.
Groen HyPerSteam in the production-test kitchen.

Interviews with the cooks also furnished non-energy performance information about the steamer. The Groen steamer received high praise for its ease of cleaning and operation. The cooks at the production-test kitchen had used pressure steamers and preferred the safety of a pressureless steamer. They felt that the cook time and food quality were not sacrificed by the lack of pressure. The cooks also noted that it was much easier to open the steamer for loading, unloading, or checking on food. This was an important criterion for an operation such as the production-test kitchen, which frequently uses a steamer.

The cooks were unanimous in their praise of the dual compartment design. As they frequently steam fish, flavor transfer was a potential problem, that was alleviated with the HyPerSteam design. The only staff-recommended change was for the timer buzzer to shut off automatically when the steamer door was opened.

4 Conclusions and Recommendations

Production

The energy performance of the Groen Model HY-6E HyPerSteam electric pressureless steamer was successfully monitored and documented as it was operated in the production-test kitchen. Daily steamer usage was heavy, and a wide variety of items were cooked. The steamer cooked an average of 100 pounds of food over a 16-hour day, consuming an average of 81 kWh of energy. This corresponded to a production energy consumption rate of 5 kW and a 26% duty cycle.

Interviews with the cooks also furnished non-energy performance information about the steamer. The cooks liked the steamer and found it easy to operate and clean. They all appreciated that it was a safer appliance than a pressure steamer with no loss of food quality or increase in cook time. During the preparation of meals, it was easier to open and shut the steamer doors because of the pressureless system. A two compartment steamer was a good match for this operation. Both compartments were needed for peak production, and fish, which was cooked almost daily, could be separated from other foods prepared in the steamer.

Energy Consumption and Conservation Potential

Laboratory testing at the FSTC found the Groen steamer to have slightly higher cooking energy efficiencies and production capacities than the other tested electric pressureless steamer.[6] In the production-test kitchen, the production energy consumption rate was slightly lower for this steamer, which demonstrated the increased efficiency.[4]

It was estimated that the steamer would consume 21,034 kWh per year for this 5-day per week food service operation. This corresponds to an annual energy cost of $2,144 based on PG&E's applicable electric rates (A-10) to small, commercial core customers. Of this projected annual cost, $1,893 was associated with the electrical consumption, and $251 was associated with probable demand charges.

The chefs generally turned the steamer boiler on first thing in the morning and left it on until the end of the dinner period. The steamer is left on so that it will be immediately ready to begin cooking food, although it requires less than 7 minutes from a cold start to be "ready" to steam. A 10% reduction in energy use is possible if the steamer could be turned off for 3 hours each day. Even under such heavy-use patterns, as seen in the production-test kitchen, a 3-hour non production period is feasible between the lunch period and the beginning of dinner preparation (see Figure 3-1). Pressureless steamer boilers

are insulated and self contained and use little energy at idle. Reducing the idle time by 1 hour reduces the energy use by about 3% per day or $50 per year if the steamer is operated 5 days per week, 52 weeks per year.

The Groen HyPerSteam is a “workhorse” appliance and, as supported by interviews with the kitchen staff, performed favorably. Both the laboratory and in-kitchen performance indices reflect that this steamer is an energy efficient appliance.

5 References

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Appendixes

A Glossary

B Manufacturer's Product Specifications

Appendix B contains Groen's product specifications for its model HY-6E HyPerSteam electric pressureless steamer.

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. Electronic pulses are generated by the meter, which measures the flow of electricity or gas to the appliance. Each pulse corresponds to a specific quantity of electric or 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

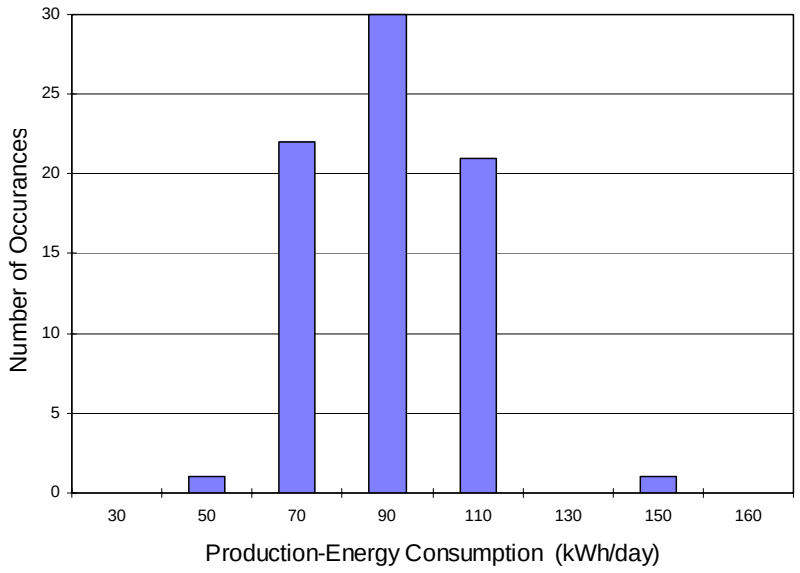

Figure D-1.
Frequency of pressureless steamer daily production energy consumption.

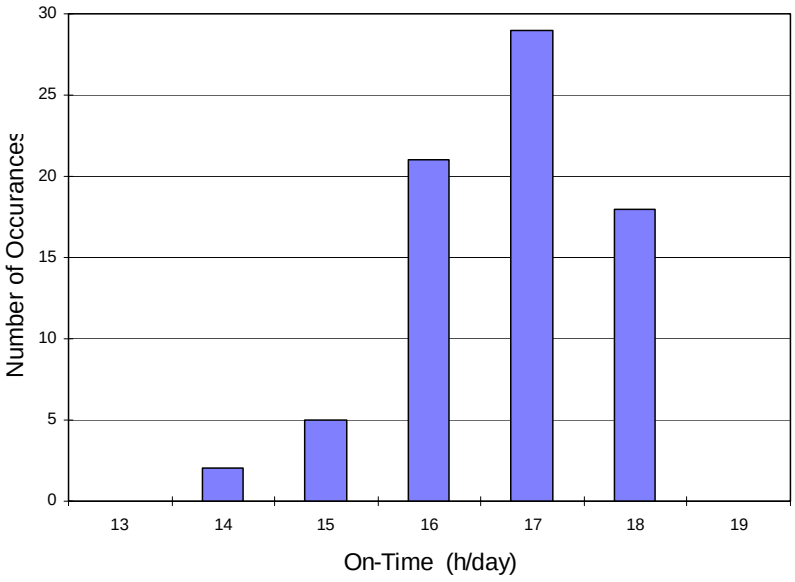

Figure D-2.
Frequency of pressureless steamer daily on-time.

E PG&E Energy Rates

Appendix E contains Schedule A-10, PG&E's electric rate schedule for small commercial customers.