

3 Griddles

Introduction

Griddles are used throughout the hospitality industry from the first order of bacon at breakfast to the last seared steak at dinner. The griddle is a work-horse that usually occupies a central position on the short-order line. Its versatility ranges from crisping and browning; for foods like hash brown potatoes, bacon and pancakes, to searing; for foods like hamburgers, chicken, steak and fish, and to warming or toasting; for bread and buns.

The relatively simple design of a griddle can have very different performance characteristics. Knowing the differences between griddles allows a food service operator to choose one that provides them with the best appliance for their kitchen. With increases in electric and gas rates, more kitchen operators are becoming aware that griddles with higher energy efficiency deliver high cooking performance and capacity.

Two factors are currently driving energy efficient griddle designs. First, quick service chains, now followed by casual dining chains, have stimulated research on energy efficient griddles because they recognize the possibility of increasing profits by specifying better equipment. Second, ASTM standard test methods developed by the Food Service Technology Center (FSTC)¹ have allowed testing facilities to produce griddle energy performance data that can be compared between labs. This allows both manufacturers and purchasers to calculate the cost of operating specific griddle models and technologies. Published data shows that energy performance can vary significantly with griddle type and construction details.



*Figure 3-1.
Countertop griddle.*

Photo: AccuTemp Products, Inc.

Griddles vary in size, power input, heating method, griddle-plate construction and control strategy. All designs cook via contact with a heated metal plate that has splashguards attached to the sides and rear and a shallow trough to guide grease and scraps into a holding tray. The griddle plate is heated from underneath by gas burners or electric elements, and controls are generally located on the front of the appliance.

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A griddle's low-profile design (Figure 3-1) enables manufacturers to offer them in a variety of configurations. The same griddle can be placed on a stand (freestanding floor model), a countertop, or be incorporated into a rangetop. Manufacturers also commonly offer griddles as a component of a restaurant range battery.

The cooking surface is commonly 24 inches (610 mm) from front to back, but may be as shallow as 15 inches (380 mm) or as deep as 32 inches (810 mm). Widths range from 1 foot (305 mm) to 7 feet (2130 mm), and the griddle plate may be ½ to 1¼-inches (15 to 30 mm) thick. Energy input rates vary from 20-180 kBtu/h for gas griddles and from 4-36 kW for electric griddles.

Cooking Processes

Griddles transfer heat to food by direct contact with the hot griddle plate. The desired characteristics of this style of cooking are crisping and browning, for foods like hash browns, bacon and pancakes; searing, for foods like hamburgers, steak, and fish; toasting, for bread and buns. Griddle temperatures range from 200 to 450°F (95 to 230°C), depending on the food being cooked.

Because griddles can take as long as 25 minutes to preheat, they are routinely turned on at the beginning of the day and idled at cooking temperature. Some operators turn off sections of the griddle during slow periods to reduce idle energy use.

Types of Griddles

Single-sided Griddles

The most common type of griddle is a single-sided griddle with a flat, polished steel griddle plate. Burners or electric elements are usually spaced 8-12 inches (200-300 mm) apart with one control per 12-inch (300 mm) section. This allows each section of the griddle to be maintained at a different temperature for different products, or turned off during slow periods.

Grooved Griddles

Some manufacturers offer grooved griddles, typically with ½-inch (10 mm) grooved plates as an option (Figure 3-2). These allow the operator to serve products that have the characteristic striped sear mark of a charbroiler without the broiler's high-energy cost or the increased ventilation requirements due to a broiler's smoke and heat. The grooves also drain away some of the grease that forms during cooking. Less of a grooved griddle's surface contacts the food and transfers heat, so operators may compensate by operating the griddle at a higher temperature. As the grooved surface is not appropriate for all food products (i.e., eggs, pancakes and sandwiches), some griddle plates are manufactured with both grooved and flat sections.



Figure 3-2.
Gas griddle with a grooved plate.
Photo: Lang Mfg. Co.

Chrome-Finished Griddles

Several manufacturers offer griddles with a chrome-finished cooking surface. Such a surface is easier to clean and radiates less heat towards the operator and the kitchen. In addition to being more comfortable for the user, this technology exhibits lower heat loss during idle and cooking, offering an indirect savings in the cost of cooling the kitchen. In preliminary testing, a chrome surface reduced an electric griddle's idle rate by a third (1.5 kW vs. 2.25 kW). Both flat and grooved griddles are available with a chrome finish.

Double-Sided Griddles and Duplex Cookers

Double-sided griddles were developed for fast food chains that wanted to shorten cook times and increase hamburger production. A two-sided griddle has a hinged upper griddle plate that swings down to contact the food so that it cooks from both sides at once. The upper section has a manual or automatic adjustment for the thickness of food being cooked. The upper griddle plates are most often electrically heated, even if the lower section uses gas.

Duplex cookers are similar to double-sided griddles, except that the top section incorporates a broiler and hood instead of a griddle plate (See Figure 3-3). When the upper platen is lowered, the broiler, which sits a few inches above the griddle surface, comes to full power and cooks with infrared heat.



Figure 3-3.
Duplex cooker.
Photo: Lang Mfg. Co.

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The radiants in the broiler may be either gas or electric. A variation on the duplex griddle being marketed by Thermodyne Food Service Products, Inc. uses a covered griddle surface with steam injection between the lid and the griddle surface to shorten cook times (Figure 3-4).



Figure 3-4.
Covered griddle surface.
Photo: Thermodyne.

Both double-sided griddles and duplex griddles can cook hamburger patties twice as fast as a traditional single-sided griddle. This allows operators to fill orders faster and save labor involved in cooking the product, since no turning is required. In addition, these griddles are more energy efficient. A duplex cooker or double-sided griddle can produce the same amount of food per hour as a much larger conventional griddle. Its smaller surface area has lower radiant and convective energy losses during idle and cooking. The top sections further reduce heat loss by acting as a cover when in the closed position.

Duplex and double-sided griddles have a high initial cost and require more maintenance. Energy savings alone will probably not make up for the price difference. However, for a high-volume operation the increased production capacity, reduced labor and shorter customer response times justify the higher initial cost.

Controls

Griddle controls are usually quite simple. The temperature of each section is controlled either manually or with a thermostat. Manual controls are analogous to the familiar controls on a gas broiler; the height of the flame is adjusted directly to set the desired level of heat and there is no temperature measurement. The addition of thermostats improves the temperature control of the cooking surface and allows the griddle to be responsive to loads of raw (or frozen) food. This is especially valuable for operators interested in product consistency. The use of thermostats may also allow manufacturers to use lower-mass griddle plates in their construction, since stored heat is not as critical for temperature recovery as with manual controls.

Thermostats sense the plate temperature with either a fluid-filled bulb or a thermocouple. The sensor may be mounted to the underside of the griddle plate, as shown in Figure 3-5, or embedded into each section of the plate (preferred method for maximizing griddle performance). Bulb-type sensors

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Figure 3-5.
*Standard efficiency
thermostat-sensing bulb
placement.*

Photo: Fisher-Nickel, inc

(Figure 3-6) use a working fluid that expands when heated, which closes a valve or electrical contact. Thermocouples generate a small voltage that changes with temperature. Thermocouples are more accurate than bulb-type sensors and are frequently embedded within the griddle plate (rather than positioned underneath), but they are more expensive and are typically used only on advanced-design griddles.

The two primary types of thermostat controls are modulating and snap-action. Modulating or throttled thermostats adjust the gas flow incrementally to achieve “soft landing” at the setpoint temperature without overshoot. These types of thermostats typically include a flame bypass, which maintains a minimum flame setting in the burner as long as the griddle is on. Snap-action thermostats are either fully open or fully closed, causing the griddle temperature to cycle around the setpoint. These thermostat valves can either be mechanically controlled by the working fluid from the sensing bulb or electrically controlled by a solenoid. The function of the two types of snap-action thermostats is essentially the same, with the electrically powered thermostats exhibiting a tighter bandwidth around the setpoint than the mechanical variety.



Figure 3-6.
*Bulb-type thermostat
sensor.*

Photo: Fisher-Nickel, inc.

Griddles equipped with modulating controls have historically exhibited sluggish response to a load of product. The controls begin to throttle back the input to the griddle as low as 75°F (42°C) below the thermostat setpoint,

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causing longer preheats as well as longer cooking and recovery times, as illustrated in Figure 3-7. The longer cook and recovery times adversely impact the griddle's efficiency and production capacity.² Additionally, modulating thermostats can be the victim of “creeping,” where the griddle temperature slowly climbs over the course of the day. A griddle with a modulating thermostat may begin the day at 350°F (175°C) and end the day at 450°F (230°C), with no change in thermostat setting. However, modulating thermostats are less expensive than snap-action thermostats and are typically found in lower-efficiency griddles.

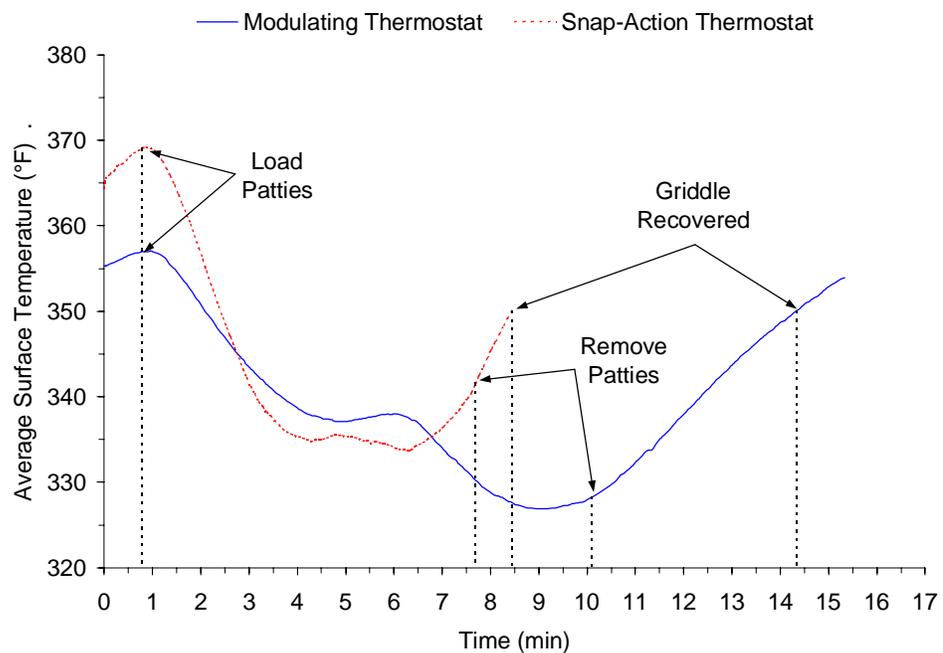


Figure 3-7.
Comparison of griddle cooking profiles.

Some high-end double-sided griddles incorporate elaborate “cooking computers” to automate the cooking process. These griddles use solid-state electronic controls with a thermocouple to sense plate temperature and offer cooking computers that can be programmed with temperatures and times for several different food products. The computers may be programmed on site, or remotely through an optional modem in the griddle.

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Heating Technologies

All varieties of griddle (flat, grooved, double-sided, chromium-finished) are available in both gas and electric models. For each fuel source, there are different strategies for applying heat to the griddle including open flame atmospheric burners, infrared burners and heat pipe technology for gas, and standard elements and induction heating for electricity. Even among appliances that use the same heating technology, there can be significant variations in energy use due to appliance design.

Griddle usage, from one food service operation to another, also impacts its energy efficiency and consumption. Both gas and electric griddles are less efficient under part-load operation due to the increased effect that the heat loss from the cooking surface has on appliance efficiency. Gas griddles lose even more due to the part-load efficiency penalty that is characteristic of gas burners. Griddles also spend a significant portion of their operating time in stand-by or idle mode. Under such conditions, the energy efficiency of a gas griddle drops even further due to the short duty cycle of the burners.

Gas Griddles

Gas griddles can be separated into three categories: low, standard, and high-efficiency. Standard- and low-efficiency griddles are designed with atmospheric or “blue-flame” burners, located directly below the griddle plate. High-efficiency gas griddles take advantage of new developments in gas technology, such as infrared (IR) burners, heat pipes, and thermal fluid or steam.

The primary difference between standard- and low-efficiency griddles is the design of the temperature controls and the placement of the temperature sensing devices. Low-efficiency designs typically employ modulating thermostats and position the thermostat bulbs underneath the griddle plate, where they are secured by angle iron or metal clips (Figure 3-5). Heat from the burners interferes with the bulb’s ability to sense plate temperature, leading to “lazy” thermostat response. Standard-efficiency designs generally use snap-action style thermostats and secure the thermostat bulb in a groove along the underside of the griddle plate or embed the bulb within the plate itself. This creates more contact between the sensing bulb and the griddle

plate, allowing for better temperature response. High-efficiency gas griddle designs employ solid-state controls with a thermocouple embedded within the griddle plate.

Advanced Gas Griddle Technologies

Gas griddles represent approximately 75% of the griddles on the market, based on a 1989 NAFEM study.³ There are several different burner types currently in use and under development.

Atmospheric burners. Atmospheric burner griddles represent the low end of the heavy-load cooking efficiency range for griddles. However, a high-end atmospheric gas griddle approaches the performance of an infrared griddle in heavy-load cooking efficiency and idle energy consumption rate.

Infrared burners. Infrared burners are more expensive and generally more efficient. Gas is forced through a ceramic block perforated with thousands of small holes. Combustion takes place close to the burner surface, causing it to become red-hot (approximately 1,800°F (980°C)) and emit infrared radiation to the underside of the griddle plate. Due to their potentially high initial cost and maintenance cost, IR burners represent only 5% to 10% of the gas griddles in the marketplace.

Thermal Fluid. The Gas Technology Institute (GTI) partnered with a manufacturer to develop a double-sided griddle heated by circulation of hot oil. This technology makes gas heat easy to distribute across the griddle surface and to the upper plate of a double-sided griddle. It takes advantage of well-developed methods for applying gas heat to a liquid, which in devices such as boilers and booster heaters, has proven to be very cost effective. Additionally, thermal fluid technology allows for better distribution of heat across the griddle plate. However, the significant reduction in cook time of a double-sided griddle can amplify the effect of temperature differences across the plate and its impact on cooking uniformity. The cost of the thermal-fluid technology (including a specialized pump to circulate the fluid) is significantly higher than a conventional griddle and this product was not brought to market.

Pulse Combustion. Pulse combustion is a technology adapted from high efficiency boilers. The process is essentially a series of controlled explosions at a rate of 40 to 60 times a second. A forced-draft blower initially delivers the fuel/air mixture to the combustion chamber, where it is ignited by a spark plug or glow coil. Once the combustion chamber heats up, the process becomes self-perpetuating and no longer requires the ignition device. The advantage of this technology is that it allows the use of a compact, highly efficient heat exchanger to deliver heat to the griddle plate. Griddles with pulse combustion were perceived as too expensive for the market place (at least when compared with IR burner griddles) and remain in the experimental stage.

Heat Pipe. Heat pipes are enclosed tubes that connect the heat source to the griddle plate. The tubes are filled with a working fluid that vaporizes at the heat-source end and condenses at the end connected to the griddle plate. Like the thermal-fluid griddle, heat-pipe technology has the potential to evenly distribute heat across the griddle plate, yielding good temperature uniformity. A version of this technology has successfully been introduced by AccuTemp Products, Inc.

Electric Griddles

Electric griddles use heating elements that are attached to the bottom of the griddle plate or embedded into it. Depending on the pattern of the elements, surface temperature uniformity can be very good from edge to edge. New technologies, such as the induction griddle, are highlighting temperature uniformity as a desirable performance parameter. Electric griddles typically use solid-state thermostats with a thermocouple embedded within the griddle plate to control the temperature of the cooking surface.

Advanced Electric Griddle Technologies

Electric griddles are generally more efficient than gas griddles, but in most areas have higher energy costs.

Standard Elements. Standard electric griddles use heating elements that are either attached to the bottom of the griddle plate or embedded into it. Placement of the elements affects surface temperature uniformity. One manufacturer uses a loop element near the perimeter of the griddle to reclaim the area where temperature usually falls off due to radiant losses from the sides of the griddle plate.

Insulation. Insulation along the bottom of the griddle reduces standby convective heat losses by as much as 25%. Griddle insulation is currently being applied to a few high-end electric griddles. Apparently, manufacturers do not currently insulate their gas griddles due to safety limitations.

Infrared Heat Panels. Infrared heat panels have greater control over the distribution of heat than standard elements. Electricity runs through a filament wound back and forth through a ceramic composite block. The block heats evenly, allowing for a uniform cooking surface.

Induction. Induction technology has been developed for griddles, but not successfully marketed. Induction griddles use an induction coil below the griddle plate to generate a magnetic field that induces a current in the plate itself. This current heats up the plate with little energy lost in the transmission from coil to plate, and the griddle temperature can be regulated by adjusting the current in the coil.

In a variation on this technology, the plate itself regulates the griddle temperature. The plate is built with a tri-metallic composite whose Curie point (temperature where a metal will transition from a magnetic to a non-magnetic state) is near the desired cooking temperature determined by the design of the metal composite plate. When the plate reaches its Curie point, it loses its magnetic properties and stops drawing energy from the induction coil below. This characteristic allows this induction-heated appliance to provide a constant temperature across the cooking surface. Also, when food draws heat from the griddle, the cooled plate can again gain energy from the magnetic field. The area of the griddle plate directly under the food falls below the Curie point and becomes magnetic. The plate “senses” the food’s presence and generates an amount of heat sufficient to replace what it transfers to the food.

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Metcal, Inc. built a prototype induction griddle based on the temperature-limiting alloy plates. Each section of the griddle is a 12-inch (300 mm) wide removable plate with a fixed temperature setpoint. The operator selects and arranges plates to configure different temperature zones for the griddle. Metcal reported a cooking-energy efficiency of 80%, well above the best-reported figure of 70% for a standard electric griddle. They also claimed excellent surface temperature uniformity and a two minute preheat. Although induction technology holds promise for electric griddle performance and efficiency, it is likely to remain a very expensive type of griddle due to the cost of the induction coils and, for some induction griddles, the cost of fabricating the griddle plate. Furthermore, Metcal, Inc. (with EPRI support) failed to license this technology and/or bring the product to market. However, more recently, Luxine, Inc., Malibu, California, has secured rights to the technology and is working with U.S. appliance manufacturers in an effort bring it to market.

Griddle Performance

The ASTM Standard Test Method for the Performance of Griddles¹ quantifies energy use and efficiency, surface temperature uniformity and production capacity. Other factors that may affect the actual performance of a griddle include ergonomics, ease of cleaning and quality of construction.

Input Rating

Input rating is the performance characteristic usually included in product literature. It is the maximum rate at which a griddle draws energy, expressed in kBtu/h or kW. Energy input rate varies from 20-180 kBtu/h for gas griddles, 4-36 kW for electric griddles.

Surface Temperature Uniformity

Surface temperature uniformity is the ability to maintain the desired temperature across the entire surface of the griddle, without hot or cold spots that the operator must work around. Griddle surface temperature typically falls off along the perimeter, due to radiant losses from the sides and burner/element

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positioning. The ASTM test method measures uniformity by welding thermocouples directly to the griddle plate (Figure 3-8). The resulting plot provides a visual reference to the hot and cool spots on the griddle surface during an idle state. Figure 3-9 presents a sample uniformity plot.

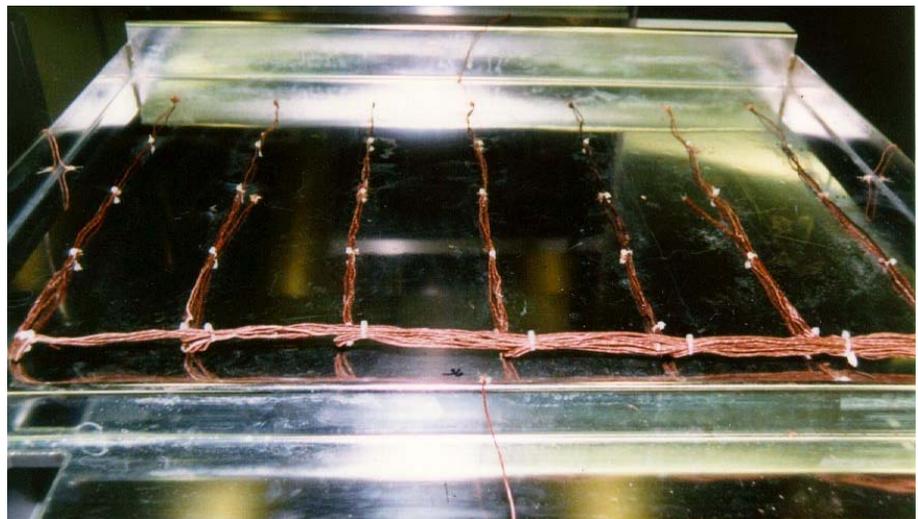


Figure 3-8.
Welded thermocouples
to a griddle surface.

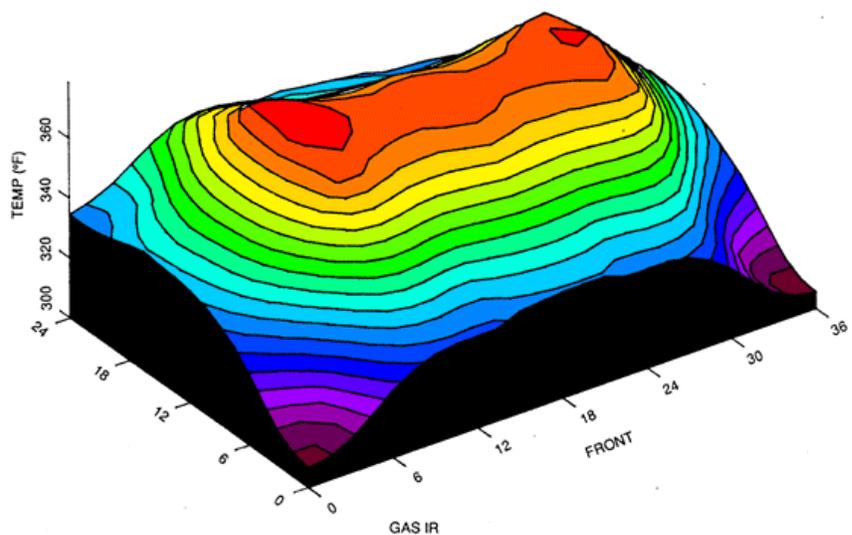


Figure 3-9.
Griddle temperature uni-
formity plot.

Temperature uniformity is affected by the type and placement of burners or elements, the thermostat and controls, and the thickness of the griddle plate. A thicker griddle plate will distribute heat more evenly, but has the disadvantages of additional cost and slower response.

Preheat Energy Consumption

The energy required to preheat a griddle is a function of the size of the griddle plate and its heat-up efficiency. However, preheat energy consumption represents less than 15% of the daily energy consumption for a griddle that was turned on twice over an 8-hour operating period.² For longer griddle operations (e.g., 12 hours) with only one preheat, the energy performance of the griddle during this phase of its operation becomes less important.

Idle Energy Consumption

Both gas and electric griddles consume energy while holding the griddle plate at the desired cooking temperature. This is due to the heat that is lost from the cooking surface or through the sides of the griddle. The idle energy consumption rate is a function of the thermostat setpoint and the effective resistance of the griddle to heat loss. Monitoring the usage of griddles in commercial kitchens has demonstrated that griddles spend a significant portion of their on time in idle mode and that the rate of idle energy consumption has a significant impact on total daily energy consumption.² Figure 3-10 summarizes the idle rates for thirteen 3-ft gas griddles tested at the FSTC. Cooking-energy efficiency and production capacity data for the same thirteen griddles are presented in Figures 3-11 and 3-12, respectively.⁴⁻¹¹

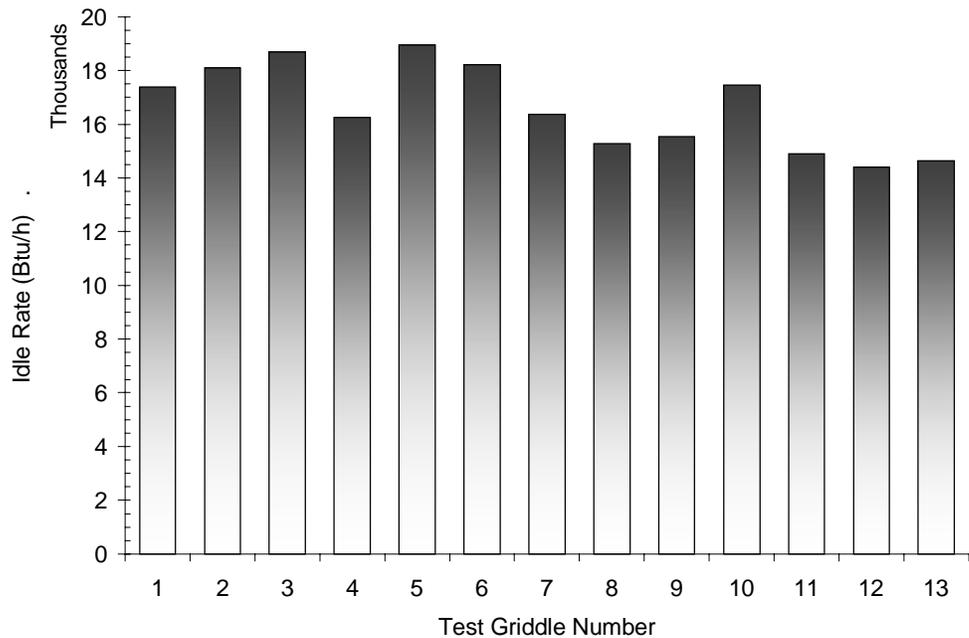


Figure 3-10.
3-ft. gas griddle idle energy rates.

Cooking Energy Rate and Efficiency

Cooking energy rate is the rate at which a griddle consumes energy while it cooks a load of food product. It is reported in kBtu/h or kW. Cooking-energy efficiency is the ratio of energy added to the food and total energy supplied to the appliance during cooking:

$$\text{Cooking Efficiency} = \frac{E_{\text{Food}}}{E_{\text{Appliance}}} \times 100\%$$

The ASTM standard test method (F1275-99) defines cooking rates and efficiencies for heavy-load (8 hamburger patties per foot (300 mm) of griddle width), medium-load (4 patties per foot (300 mm) of griddle width) and light-load (4 hamburger patties per load) conditions. Due to variances in burner and control design, gas griddles demonstrate a dramatic difference in heavy-load cooking energy efficiencies (Figure 3-11). Electric griddles are much closer in performance since the elements are typically embedded in the griddle plate.⁴⁻¹¹

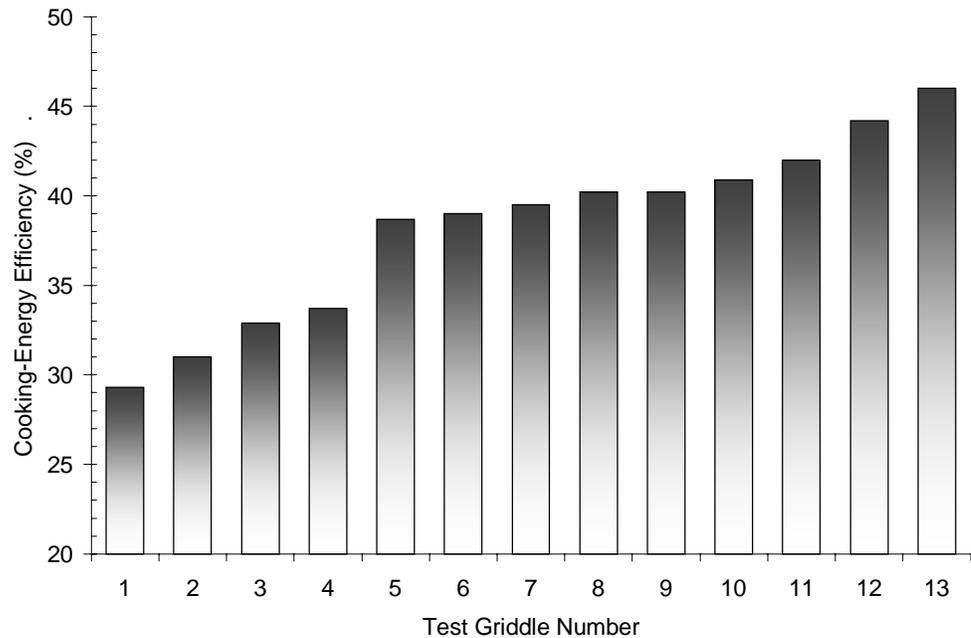


Figure 3-11.
3-ft. gas griddle cooking-
energy efficiencies.

Production Capacity

Production capacity is the amount of food that can be cooked on a griddle in a given time. For griddles, this figure is commonly reported as the number of pounds of frozen hamburger patties that can be cooked per hour. For single-sided griddles, production capacity is most strongly linked to the size of the griddle plate. Figure 3-12 illustrates that the range in production capacities for the 3-ft. griddles can be as much as two-to-one.⁴⁻¹¹ Figure 3-13 further examines griddle production capacity in relation to rated energy input. The lack of any correlation in the data points out that the difference between high and low-production models is more than sheer horsepower.

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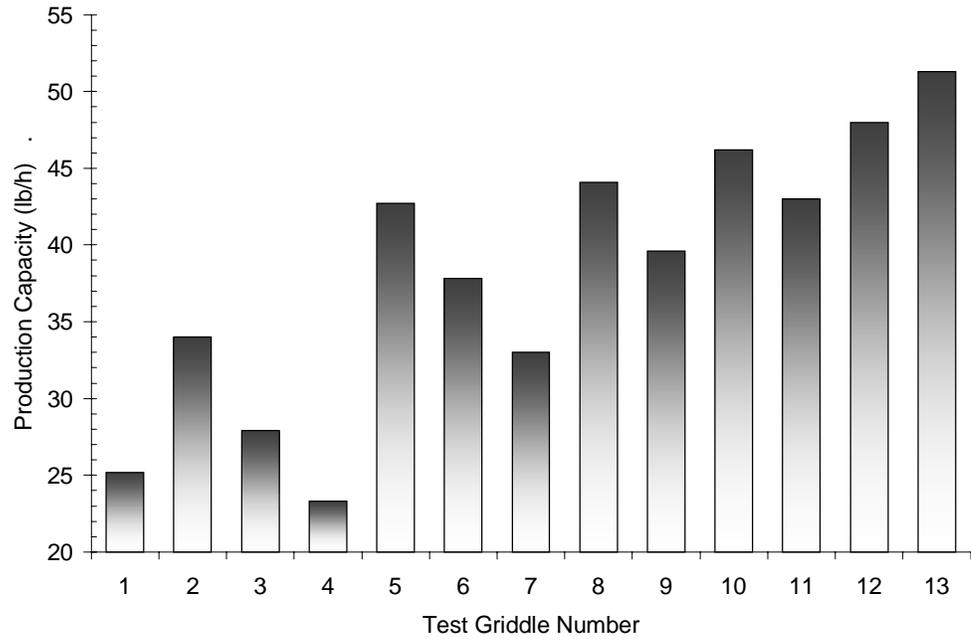


Figure 3-12.
3-ft. gas griddle production capacity.

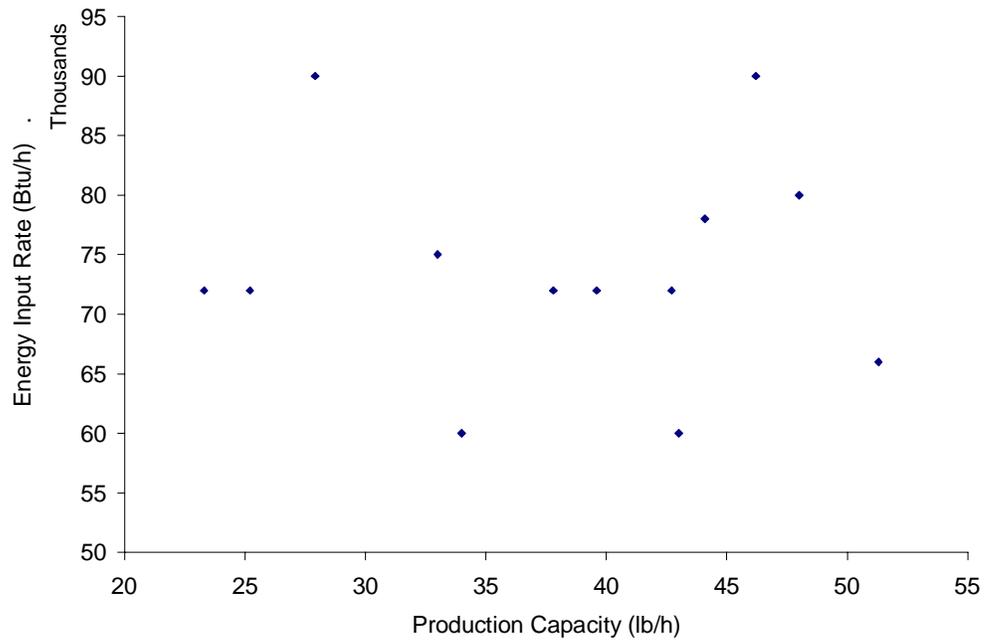


Figure 3-13.
3-ft. griddle input rate vs. productivity.

Recovery Time

Recovery time is the time it takes a griddle to come back up to 350°F (175°C) after the previous load has been cooked. Slow recovery time reduces the production capacity and cooking-energy efficiency of a griddle. Testing of multiple griddles from different manufacturers revealed that a griddle's recovery temperature could be relaxed from 10°F (5°C) below the thermostat setpoint to 25°F (15°C) below the setpoint without adversely affecting griddle-cooking performance. High-performance griddles were unaffected by this change as they had recovered by the time the previous load had been removed and the cooking surface had been scraped.

Energy input rate, efficiency, control strategy and the thickness of the griddle plate are factors that directly affect recovery times. Reported recovery times range from less than one minute to over seven minutes.⁹⁻¹¹

Benchmark Energy Performance

Water-Boil Versus Cooking-Energy Efficiency

In the body of published data on griddles, two different tests are commonly reported as “cooking efficiency” tests: a water-boil test, in which a dam is built on the griddle surface to contain a set quantity of water, which is weighed before and after boiling for a set period of time, and a test in which frozen hamburger patties are cooked.

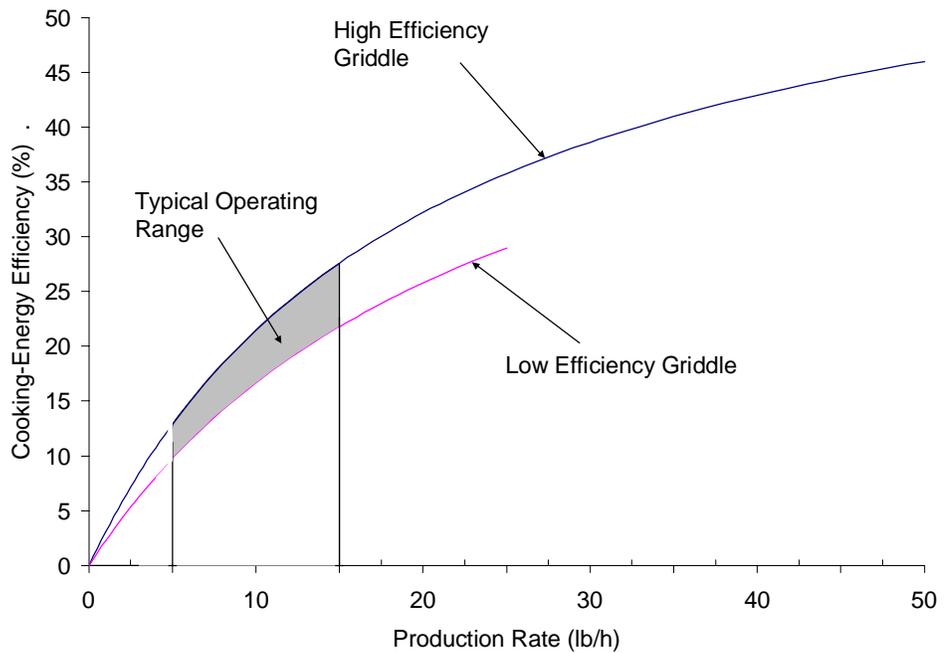
Water-boil efficiencies of 88%, 44% and 51% have been reported for an electric, a gas atmospheric burner and a gas infrared (IR) burner 3-foot griddle, respectively, whereas cooking-energy efficiencies (cooking hamburgers under heavy-load conditions) for the same griddles were 65%, 31% and 42%.² A water-boil test does not emulate the operation of a griddle in a real food service operation. A griddle's job is to maintain a cooking surface at a relatively high temperature (e.g., 375°F (190 °C)) while cooking food product. During this time, the burners or elements may cycle off as the thermostat is satisfied. During a water-boil test the cooking surface temperatures cannot exceed 212°F (100°C). Furthermore, the thermostat is never satisfied during this test and the duty cycle of the elements or burners remains at 100%. The ASTM method specifies the more representative hamburger patty test, exclusively.

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Table 3-1 summarizes the energy performance parameters for gas and electric griddles. Figure 3-14 and Figure 3-15 show the cooking-energy efficiency curves for gas and electric griddles.

Table 3-1. Energy Efficiency for 3-foot Griddles.

	Electric	Low-Eff Gas	Std-Eff Gas	High-Eff Gas
Rated Energy Input (kBtu/h)	25 - 60	40 - 80	40 - 80	60 - 80
Cooking-Energy Efficiency (%)	65 - 75	25 - 35	35 - 45	> 45
Idle Energy Rate (kBtu/h)	5 - 9	> 18	15 - 18	10 - 15



*Figure 3-14.
Gas 3-ft. griddle
cooking-energy effi-
ciency characteristics.*

Griddles

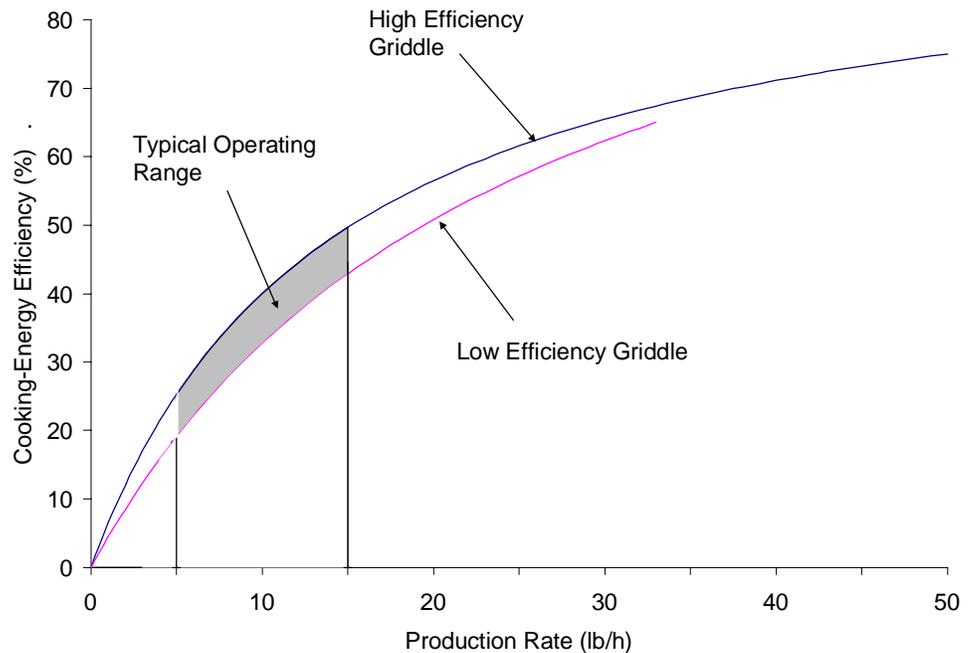


Figure 3-15.
Electric 3-ft. griddle
cooking-energy effi-
ciency characteristics.

Gas Versus Electric Griddle Performance

Electric griddles typically use elements either located directly below or embedded in the griddle plate to impart heat to the cooking surface. This heating technology exhibits higher energy efficiencies due to the absence of the flue losses associated with gas griddles. Figure 3-16 compares the gas and electric efficiency bandwidths for 3-foot (910 mm) griddles.

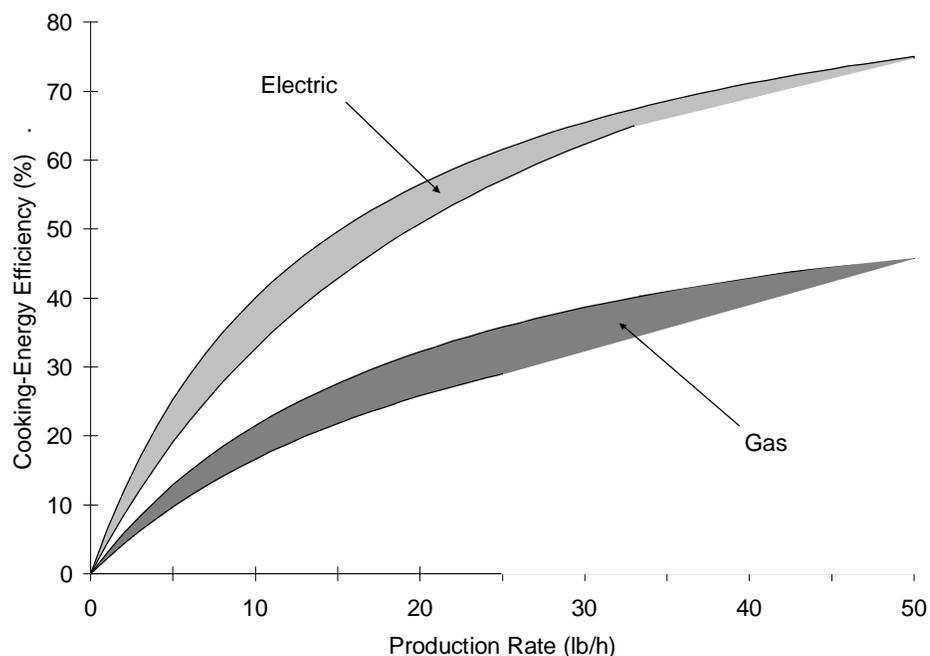
Griddle Energy Consumption

Energy Use Models

In support of the development of standard test methods for cooking appliances, a model has been reported that simplifies cooking appliance energy analysis.¹² This model, described as a two-mode model, is based on the assumption that any condition of appliance operation can be described as the sum of proportionate idle and heavy-load cooking operations, with preheat as an additional factor. The model, therefore, requires measurement of only

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*Figure 3-16.
3-ft. griddle cooking-
energy efficiency band-
widths.*

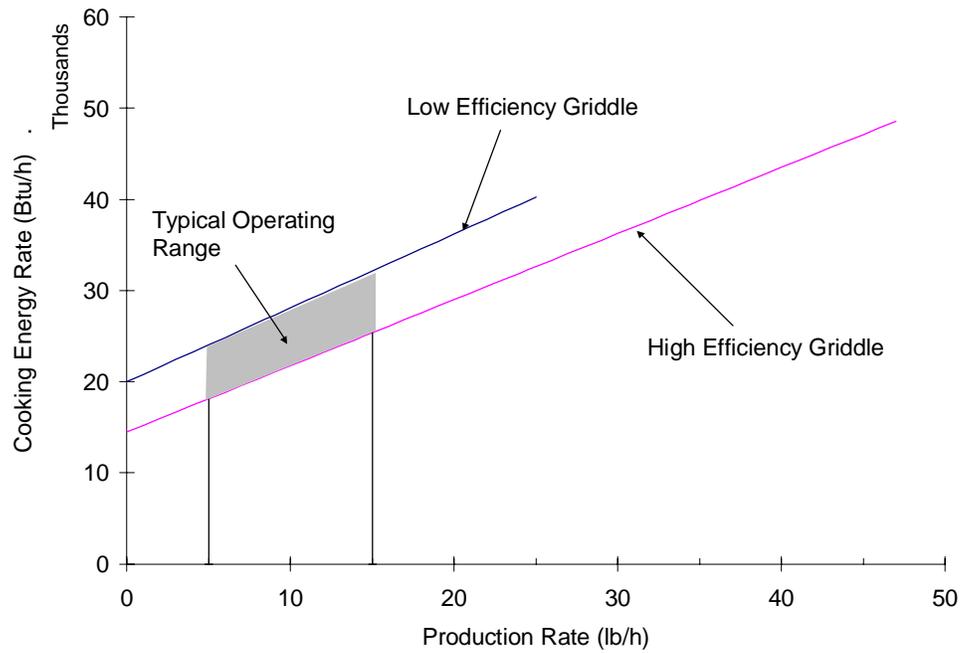


preheat, idle and heavy-load cooking parameters. This model was based on work contained in U.S. Department of Energy regulations for hot water heaters and, with some limitations, is considered applicable to griddles.

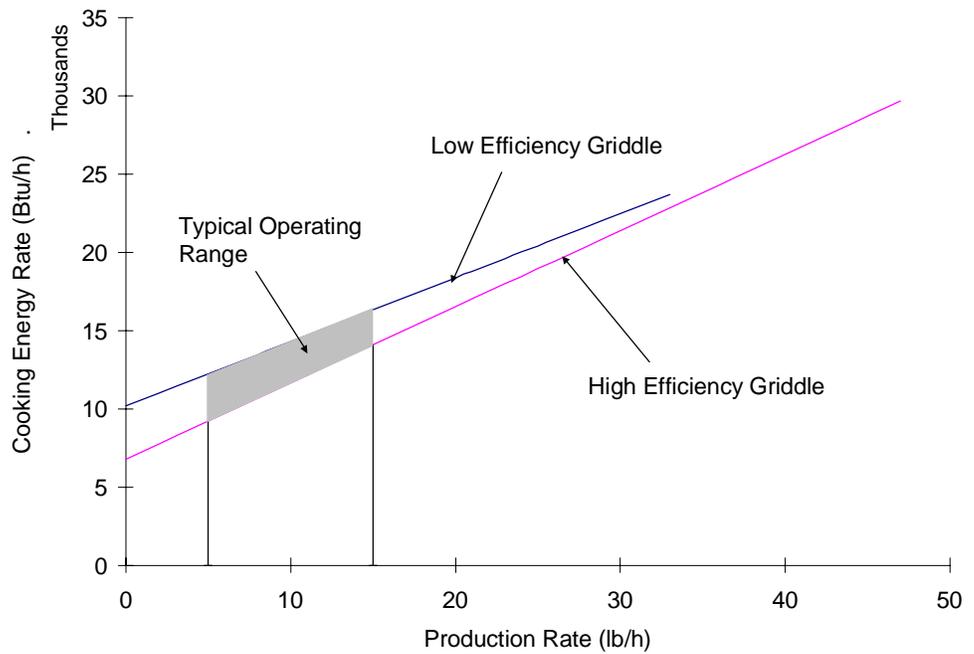
The model can be applied to estimate part-load efficiencies for a griddle installation where only the operating time (e.g., 8h/day) and quantity of food cooked (e.g., 100 lb/day) is known, assuming that the entire griddle is left on during operating hours. Figure 3-17 and Figure 3-18 show estimated energy consumption rates and typical operating ranges for gas and electric 3-foot (910 mm) griddles based on this model.

A more robust energy model has been included in subsequent revisions of the ASTM Test Method for the Performance of Griddles.¹ In this model, cooking-energy use is broken down between heavy-, medium-, and light-load conditions. Annual energy use is calculated based on preheat, idle, cooking energy rate, and production rate test results from applying ASTM F1275-99. The ASTM energy model also can be used to predict total daily energy consumption and/or the average rate of energy consumption for a given griddle.

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*Figure 3-17.
Gas 3-ft. griddle energy consumption based on the two-mode model.*



*Figure 3-18.
Electric 3-ft. griddle energy consumption based on the two-mode model.*

Griddles

Projected annual energy consumption for gas and electric griddles is presented in Table 3-2 and Table 3-3. Energy consumption was based on duty cycles of 34% for gas and 25% for electric as determined from Figure 3-17 and Figure 3-18. The duty cycle is defined as the average rate of energy consumption expressed as a percentage of the rated energy input or the peak rate at which an appliance can use energy.

Table 3-2. Projected Energy Consumption for Gas Griddles.

	Nominal Size	Rated Energy Input (kBtu/h)	Duty Cycle (%)	Avg. Energy Consumption (kBtu/h)	Typical Operating Hours (h/d) ^a	Annual Energy Consumption (kBtu) ^b
Single Sided	3-foot	60 - 80				
(Median)		70	34	23^c	12	86,100

^a Operating hours or appliance "on time" is the estimated period of time that an appliance is typically operated from the time it is turned "on" to the time it is turned "off".

^b The annual energy consumption calculation is based on the average energy use rate x the typical operating hours x 6 days per week x 52 weeks per year.

^c The average energy consumption rate is based on a median production rate of 10 lb/h generated from the two-mode energy model.¹² An associated duty cycle of 34% was calculated.

Table 3-3. Projected Energy Consumption for Electric Griddles.

	Nominal Size	Rated Energy Input (kW)	Duty Cycle (%)	Avg. Energy Consumption (kW)	Typical Operating Hours (h/d) ^a	Annual Energy Consumption (kWh) ^b (kBtu) ^c
Single Sided	3-foot	8 - 16				
(Median)		12	25	3^d	12	11,232 38,300

^a Operating hours or appliance "on time" is the estimated period of time that an appliance is typically operated from the time it is turned "on" to the time it is turned "off".

^b The annual energy consumption calculation is based on the average energy consumption rate x the typical operating hours x 6 days per week x 52 weeks per year.

^c Conversion Factor: 1 kW = 3.413 kBtu/h

^d The average energy consumption rate is based on a median production rate of 10 lb/h generated from the two-mode energy model.¹² An associated duty cycle of 25% was calculated.

Griddles

Ventilation Requirements

The effluent generated by a griddle depends on the type of food being cooked. For example, hamburgers generate significantly more effluent than pancakes or hash brown potatoes. Since there is the potential for a high amount of grease-laden air, griddles can require ventilation rates in the range of 250 to 350 cfm (120 to 165 L/s) per linear foot of wall-mounted canopy.

The large cooking surface tends to be a good radiator of heat to the kitchen space. Typical griddles with polished steel griddle plates have a high emissivity and may represent a significant load on the ventilation system. Griddles are now being offered with chrome-finished cooking surfaces that have a low emissivity. Such a surface will reduce the thermal load to the kitchen space.

Improving Performance

The most cost-effective method for improving griddle performance is improved temperature feedback. Traditional designs have focused on heavy-duty construction with inexpensive controls. If a thermostat is included (a significant number of griddles in the marketplace are manually controlled), the sensing device is generally attached to the bottom of the griddle plate. By improving the contact between the thermostat bulb and the griddle plate, it is possible to dramatically improve the griddle's performance. With respect to Figure 3-11, the same manufacturer produces griddle #4 and #9. The only difference between the two griddles is the method of contact between the thermostat bulb and the griddle plate. Griddle #4 attached the bulb to the bottom of the plate, whereas Griddle #9 embedded the bulb within a groove in the plate. This simple design change yielded a 19% increase in cooking-energy efficiency (from 33.7% to 40.2%) and a 70% increase in production capacity (from 23 to 40 lb/h (from 10.5 to 18 kg/h)).

Research and Development

Gas griddles have a large energy performance bandwidth, due to the many different burner designs and control strategies. Griddles will continue to be burdened by a high idle rate as a result of keeping a large exposed plate at operating temperature (e.g., 375°F (190°C)). One of the more important aspects of griddle performance is temperature uniformity. As the majority of griddles in the marketplace exhibit a difference of 50 to 100°F (28 to 56°C)

between the highest and the lowest temperature on the griddle plate, there is significant room for improvement.

Research issues related to developing an advanced gas griddle include:

Griddle Plate Temperature Measurement. Embedding the thermostat sensor into the griddle plate has been shown through FSTC testing to dramatically improve response. Although a long, narrow bulb running three quarters of the depth of the plate can improve response (over a short temperature bulb), the key is to measure plate temperature and not be affected by the burner below. Overall, different strategies for plate temperature sensing (and feedback) need to be investigated.

NAFEM Online Kitchen Protocol. An advanced-design griddle needs to comply with the NAFEM Online Kitchen Protocol, particularly with respect to griddle plate temperature feedback and recording. The introduction of microprocessor based thermostat control using thermocouples to sense plate temperature would be a major step in this direction.

Improved Burner/Heat Exchanger Design. Assess the potential of different burner/heat exchanger designs to improve the cooking-energy efficiency, response and uniformity of the cooking surface. This includes looking into the potential of inshot or powered burners with an increased surface area for heat (which was successful in the Ultrafryer gas fryer¹³). Heat transfer fins along the underside of the griddle plate may assist with distributing the available heat from the burners to the edges of the plate.

The effect of griddle plate thickness needs to be documented. If mass is not the critical issue for a fast response heating system, then alternative strategies could be used to achieve plate rigidity and prevent warping (e.g., fins beneath griddle plate could be both structural and enhance heat transfer).

Temperature Uniformity. Improving the temperature uniformity of conventional griddle designs goes hand-in-hand with increased heat transfer and overall efficiency. Again, finning may be an effective strategy.

Insulation. Incorporating a thin layer of high-tech insulation along the outer edges of the griddle plate could reduce temperature fall-off, as well as standby losses. For electric griddles, insulation could be applied below the plate and elements, significantly reducing idle energy consumption.

Low-Emissivity Griddle Plate. Griddles lose a substantial amount of energy by radiating heat to the kitchen space, due to their large, hot cooking surface. Preliminary testing by the FSTC showed that a low-emissivity griddle plate (i.e., polished chrome surface) loses a third less energy in stand-by. Several griddle manufacturers offer this feature, however, better documentation of the benefits is needed—including reduced heat gain to space.

Lids. An optional lid could further energy reduction during idle, and potentially increase cooking performance. A lid could potentially enhance cooking performance, and most definitely, reduce idle energy requirements and heat gain to space. A lid is being marketed by one manufacturer, Thermodyne Food Service Products, Inc., as an integral compliment to steam injection within the cavity formed between the lid and the griddle plate.

Another variation could include a removable “dam” along the front edge of the griddle that could effectively convert the griddle into a shallow braising pan.

Deeper Griddle Plates. Simply extending the depth (front to back) of the cooking surface from 24 to 30 inches (610 to 760 mm) makes more use of the available heat from the burners and improves the griddle’s production potential. The high-efficiency griddles tested by the FSTC incorporated 30-inch deep (760 mm deep) cooking surfaces, allowing for an extra row of patties to be cooked during the heavy-load cooking tests.⁵⁻¹¹

Industry Market Focus

First cost is a major factor in food service equipment purchases. New, energy efficient technologies have a high premium associated with them, which deter many food service operators from purchasing these units. An attractive option for the gas industry involves developing a lower first-cost, advanced atmospheric-burner griddle with tighter control and reduced standby losses.

Better understanding and marketing of double-sided griddles or broiler-tops is needed to help independent operators understand the value of investing in an upper heating system.

Revisions to the Standard Test Method

Temperature uniformity is a major aspect of griddle performance. While griddles have historically exhibited poor uniformity within a 3-inch boundary, the falloff near the edges was even more pronounced. New griddle designs, such as the Metcal induction griddle and AccuTemp steam griddle, exhibit little or no temperature falloff along the edges of the griddle plate. With manufacturers pushing the limits of griddle temperature uniformity, the test method needs to measure cooking surface temperatures along the edges to confirm manufacturer claims.

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Information in this module also references Manufacturers Product Literature, catalogues, and appliance specification sheets.