2 Fryers

Introduction

Fried foods continue to be popular on the restaurant scene. French-fried potatoes are still the most common deep-fried food, along with onion rings, chicken and seafood. The fryer menu has expanded to include various deep-fried snacks such as mushrooms, zucchini, peppers and mozzarella cheese. Equipment manufacturers have responded by designing fryers that operate more efficiently, quickly, safely and conveniently.

Figure 2-1.
Standard open deep- fat fryer.
Photo: Pitco Frialator, Inc.

Fryers are available in a range of configurations. The kettle, or “frypot”, may be split into more than one vat, allowing the operator to prepare different foods without flavor transfer. Some fryers have automatic lifts that lower and raise food baskets. Fryers may have built-in filters that greatly reduce the labor and risk involved in filtering hot oil. Fryers may be countertop units, freestanding floor units, and in batteries of several fryers in one housing.

All fryers share a common basic design. The kettle contains a sufficient amount of oil so that the cooking food is essentially supported by displacement of the oil rather than by the bottom of the vessel (Figure 2-1). The oil is typically heated by atmospheric or infrared gas burners underneath the kettle or in “fire tubes” that pass through the kettle walls. Electric fryers use heating elements immersed in the oil. Energy inputs range from 30-260 kBtu/h for gas fryers and 2-27 kW for electric fryers.

Fryers range in capacity from about 15 lb (7 kg) of oil for a small, countertop fryer to over 200 lb (90 kg) of fat for the largest floor-model fryers used for donuts and chicken. Most fryers have a “cold zone” at the bottom of the kettle where breadcrumbs and other food particles settle. The cold zone is intended to have no convection current and a relatively low temperature, so that food crumbs will not carbonize and create the breakdown products that limit oil life.

A console fryer is pictured in Figure 2-2. The fryer on the right has a split vat; both have automatic basket lifts. The center is a fry station, for holding cooked product. In the cabinet below the fry station there is a built-in oil filter, which both fryers share.

Figure 2-2.
An example of a console fryer.
Photo: Vulcan-Hart Company

Fryers are most often compared on the basis of width and energy-input rating. Taken together, these two numbers suggest the approximate amount of food a fryer can prepare in a given time, which is one of the most important factors in choosing the proper fryer for a kitchen. The energy cost of operating a fryer can be significant, and different fryers can have quite diverse patterns of energy use. However, fryer-energy use has not been documented until recently, and as a result, initial cost generally plays a more significant role in appliance purchasing than the operating cost.

Cooking Processes

Frying is a process of heating and dehydration. The food product is submerged in the oil, which transfers heat into the food. Moisture in the food is vaporized and forces its way to the food surface. The outside of the food, in addition to being browned by the heat of the oil, is puffed and crisped by this rapid moisture loss. Departing steam increases convection of the hot oil as it rises to the surface of the frypot; this convection and the high oil temperature cause the uniform and rapid cooking that is characteristic of frying.

Fryers may take as little as ten to fifteen minutes to preheat, but they are typically turned on in the morning and left on throughout the day. Some operators use a backup fryer that is turned on as needed to handle increased demand during busy periods. Even in a busy fast-food restaurant, fryers may be idle 75% of the time.

Types of Fryers

Open Deep-Fat Fryers

Open deep-fat fryers are by far the most common type. As distinguished from pressure fryers, open fryers do not have a sealed lid on the kettle and cook at atmospheric pressure. The frypot is not generally insulated, and can lose heat from both the surface of the oil and from the sides of the fryer cabinet. Open fryers are used to prepare all types of fried food.

Figure 2-3.
Pressure fryer.
Photo: Ballantyne

Pressure Fryers

Pressure fryers are less common. They are mainly used for cooking chicken, and are said to reduce moisture loss and oil uptake. The pressure fryer is similar to an open-kettle fryer, but with the addition of a heavy, gasketed lid and a pressure valve. As steam escapes from the food and builds up above the oil, the pressure inside the kettle rises. Moisture in the food reaches higher temperatures before escaping into the kettle, and the cook time is somewhat decreased. Most pressure fryers have a heavy top and a round flat-bottomed kettle, like the unit pictured in Figure 2-3.

Pressure fryers do incur some additional labor. Because of the locking lid, there are currently no pressure fryers with an automatic basket lift option. Opening and closing the lid adds extra steps to the cooking cycle and partially offsets the advantage of a shorter cook time. Product cannot be checked part way through the cycle, although this is not generally a problem with standardized recipes and procedures.

Specialty Fryers

Most specialty fryers have a rectangular or circular kettle with a deep cold zone at the bottom below the heat source. Specialty fryers include donut and chicken fryers, which are generally wide and shallow to allow a layer of food to float as it cooks. Instead of a standard fry basket, chicken and fish are generally lowered into the oil on a screen or shallow basket that is the same size as the top of the kettle. Donut fryers may have an upper "submerger" screen to immerse certain types of donuts during frying. A typical donut fryer is illustrated in Figure 2-4.

Controls

Fryers are thermostatically controlled, and generally have an over-limit switch to cut off energy to the burners or elements if the oil approaches its ignition point. Some fryers have a special "melt cycle", which toggles the burners on and off to melt solid shortening without becoming hot enough to scorch and burn it.

Figure 2-4.
Donut fryer.
Photo: Pitco Frialator, Inc.

Thermostats sense the oil temperature with either a bulb or a solid-state sensor. Bulb-type sensors use a working fluid, which expands when heated, closing a valve or electrical contact. Solid-state sensors use a thermocouple to detect oil temperature and are more durable and accurate, but more expensive than bulb-type sensors.

Frying computers, or compensating timers, adjust the cook times in response to average-oil temperature. They also have the potential to regulate fryer input to maintain a consistent "cooking curve" and provide more consistent product.

Heating Technologies

The energy performance within each category or type of fryer varies significantly; first, depending on whether the fryer is gas or electric, and second, based on the applied heating technology. Due to the many possible arrangements of the combustion and heat-exchanger systems, there are greater differences in performance among gas fryers on the market than among electric fryers.

The usage of a fryer from one food service operation to another also impacts its energy efficiency and consumption. Both gas and electric fryers are less efficient under part-load operation due to the increased effect that the heat loss from the fryer has on its efficiency. Gas fryers lose even more due to the part-load efficiency penalty that is characteristic of gas burners. Fryers also spend a significant portion of their operating time in stand-by or idle mode. Under such conditions, the energy efficiency of a gas fryer drops even further due to the short duty cycle of the burners. Under idle conditions, the energy consumed by a gas fryer may exceed an electric fryer's energy consumption by a factor of three or more.[1]

Gas

Gas fryers can be separated into three categories: standard, mid-range and high efficiency. Standard gas fryers (the more common of the three) are designed with atmospheric or "blue-flame" burners with simple heat exchangers that either run through the frypot or underneath it. Mid-range gas fryers are fryers that employ an atmospheric burner with a heat-exchanger design that allows more heat to be imparted to the oil than a typical straight-through design (Figure 2-5) by restricting the flow of the hot flue gasses. High-efficiency gas fryers take advantage of new developments in gas technology, such as infrared (IR) burners, heat pipes, pulse combustion, powered burners, and recirculation tubes.

Figure 2-5.
Fire tubes in the vat of a gas fryer.
Photo: Fisher-Nickel, inc.

Advanced Gas Fryer Technologies

A wide bandwidth exists among gas fryer efficiencies. Typically, burners fire into the tubes from the front towards the flue at the rear of the fryer. The tubes may contain catalysts or baffles to increase heat transfer. Infrared burners also may be mounted inside fire tubes. At the high end, various new technologies are incorporated into fryer design, yielding more efficient fryers with greater productivity. Among the new technologies already in place are infrared (IR) burners, powered burners, recirculation tubes, and frypot insulation.

Infrared Burners. Infrared burners employ a fine honeycomb matrix to evenly disperse the fuel/air mixture across the burner surface. 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 surrounding heat-transfer-tube walls. In addition to the increased rate of heat transfer, IR burners operate with little excess air (less than 10%), allowing a greater percentage of gas to be burned than in a conventional atmospheric burner. Due to their potentially high first cost and maintenance cost, IR burners represent only 5% to 10% of the gas fryers in the marketplace.

Powered Burners. Powered burners employ a blower to force the fuel/air mixture into the burner at the optimum ratio. Like infrared burners, powered burners operate with little or no excess air, allowing a greater percentage of the energy generated by combustion of gas to be transferred to the frypot.

Recirculation Tubes. Recirculation tubes, or recycle baffles, route the flue gasses through or around the sides of the frypot to provide a greater effective heat-transfer surface for the hot gasses. More heat is transferred to the frying oil, yielding a 10% to 15% increase in efficiency. More restrictive designs require a blower to pull the flue products through the heat exchangers.

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 frying oil. This technology was found to be too expensive to market successfully. Currently, no manufacturers are producing pulse combustion fryers.

Convection/Thermal Fluids. Thermal fluids enable the use of an enclosed, highly efficient burner, independent of fryer design. Specially formulated oil acts as a medium to transfer heat from the burner to the frypot. Inefficiencies in the heat transfer to the thermal fluid and the requirement of a specialized pump to circulate the fluid make this a less attractive possibility.

Heat Pipe. Heat pipes are enclosed tubes that connect the heat source to the frypot. The tubes are filled with a working fluid that vaporizes at the heat-source end and condenses at the end connected to the frypot. This technology requires extremely tight tolerances and was found to be too expensive to successfully market. As such, there are no heat-pipe gas fryers available on the market.

Electric

Electric fryers typically use immersed elements in the frypot to provide heat to the frying oil. New developments in element design and controls are beginning to change the landscape of the electric fryer market.

Advanced Electric Fryer Technologies

Induction Heating. Induction fryers use electromagnetic coils inside stainless steel immersion tubes. The electromagnetic fields created by these coils induce eddy currents in the surrounding metal, causing it to heat up. The amount of heat generated is controlled by changing the frequency of the magnetic field in the coils. Although an induction-based fryer was introduced in the U.S. in the early nineties, the manufacturer has ceased production and there are currently no induction fryers on the market.

Frypot Insulation. Insulation around the frypot reduces standby convective heat losses by as much as 25%. Frypot insulation is currently being applied to a few high-end electric fryers. Apparently, manufacturers do not currently insulate their gas fryers due to safety limitations.

Low Watt-Density Elements. Low watt-density elements provide an even distribution of heat to the frying oil by spreading the power across a greater surface area than standard cal-rod elements. This enables the elements to provide quick temperature recovery without scorching the frying oil. Low watt-density elements are used in many electric fryer designs.

Triac Controls. TRIAC controls provide a high current electricity supply to the elements without the use of a mechanical contactor. The controller works in conjunction with a resistive thermal device (RTD) to modulate power to the elements during preheat and frying-oil recovery. The TRIAC controller provides an effective option for modulating power to the elements of a fryer.

Fryer Performance

The work of the fryer can be outlined as bringing the oil from room temperature up to cooking temperature (preheating), holding the oil at cooking temperature until cooking begins (idling), and restoring heat to the oil when cold food is dropped into the fryer (recovery).

An ASTM standard test method for fryers[2] developed at the Food Service Technology Center in California now allows manufacturers and users to gauge fryers' production directly, and to evaluate fryer-energy performance as well. As hard data on fryers becomes available, it is apparent that certain technologies and designs yield better performance.

Fryer performance is characterized by preheat time and energy consumption, idle energy consumption rate, pilot energy consumption rate, cooking-energy efficiency and production capacity.

Energy Input Rate

Energy input rate is one of the performance characteristics usually included in product literature. It is the maximum rate at which the fryer draws energy, expressed in kBtu/h or kW. Energy input rate is an important factor in production capacity. The more energy a fryer can deliver to the oil, the faster it can preheat and recover between loads. However, efficiency also plays an important part. A very efficient fryer may be able to supply more energy to the oil while requiring less input than an inefficient fryer with a higher energy input rate.

Preheat

Preheat Time. Preheat time is the time required to raise the oil from room temperature to cooking temperature (typically 350°F (175°C)). Fryers are usually left on during the day, so preheat time may not be important to the operator. Preheat time is determined by energy input rate, oil capacity, heating technology and control strategy.

Preheat Energy. The energy required to preheat a fryer is a function of the oil capacity of the fryer and its heat-up efficiency. However, preheat energy consumption represents less than 15% of the daily energy consumption for a fryer that was turned on twice over an 8-hour operating period.[3] For longer fryer operations (e.g., 16 hours) with only one preheat, the energy performance of the fryer during this phase of its operation becomes less important.

Idle Energy Consumption

Both gas and electric fryers consume energy while maintaining the frying medium at the desired cooking temperature. This is due to the heat that is lost from the surface of the oil and through the sides and bottom of the frypot. The idle-energy consumption rate is a function of the thermostat setpoint and the effective resistance of the fryer to heat loss. Figure 2-6 illustrates more than a three-to-one range in idle energy rates for 14-inch (350 mm), open deep-fat gas fryers.[3-13]

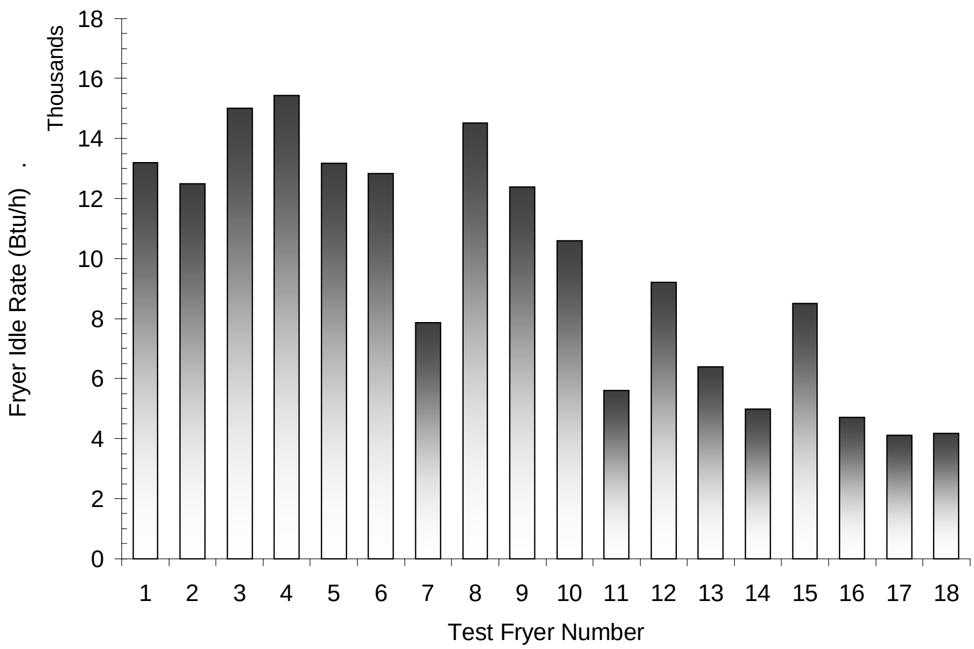

Figure 2-6.
Gas fryer idle rates.

Monitoring the usage of fryers in commercial kitchens[14] has demonstrated that fryers spend a significant proportion of their "on time" in idle mode and that the rate of idle energy consumption has a significant impact on total daily energy consumption.

Cooking Energy Rate and Efficiency

Cooking energy rate is the rate at which a fryer 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:

$$CookingEfficiency = \frac{E_{Food}}{E_{Appliance}} \times 100\%$$

The ASTM standard test method defines cooking rates and efficiencies for heavy-load (3-pounds (1.4 kg)), medium-load (1 ½-pound (0.7 kg)) and light-load (¾-pound (350 g)) conditions. Due to variances in burner and heat-exchanger design, gas fryers demonstrate a dramatic difference in heavy-load cooking energy efficiencies (Figure 2-7). Electric fryers are much closer in performance since the elements are directly submerged in the frying medium.[3-13]

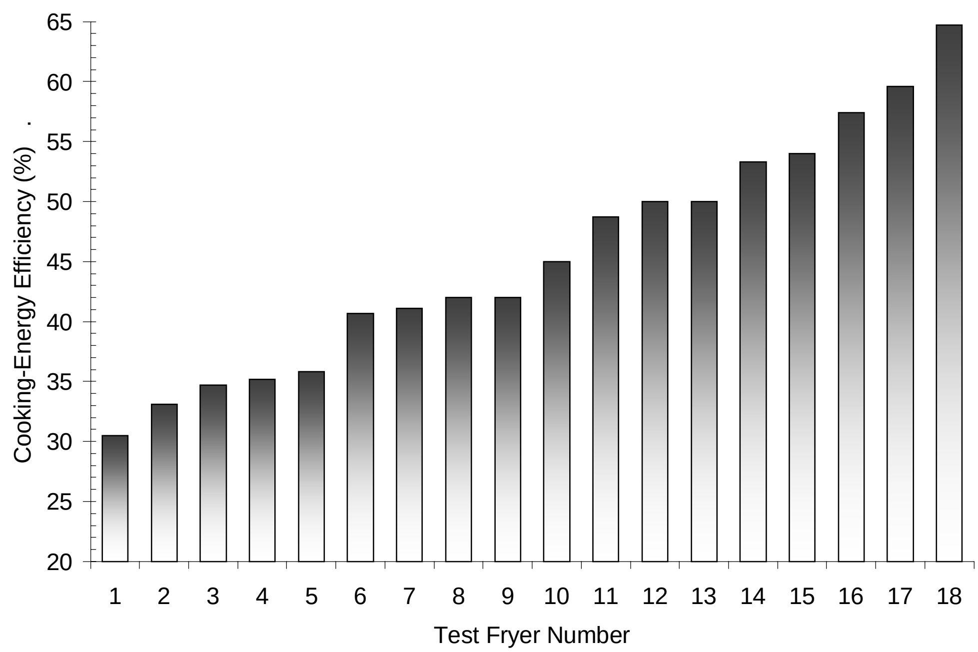

Figure 2-7.
Gas open deep-fat fryer cooking-energy efficiency.

Production Capacity

Production capacity is the amount of product that can be cooked in a fryer in a given time. For open fryers, this figure is typically given in product literature and in the standard test method as the number of pounds of frozen French fries that can be cooked per hour. Production capacity is determined by the cook time and the recovery time of the fryer. These, in turn, depend strongly on energy input rate, heating technology and control strategy. Figure 2-8 shows the range in production capacity for gas fryers.[3-13]

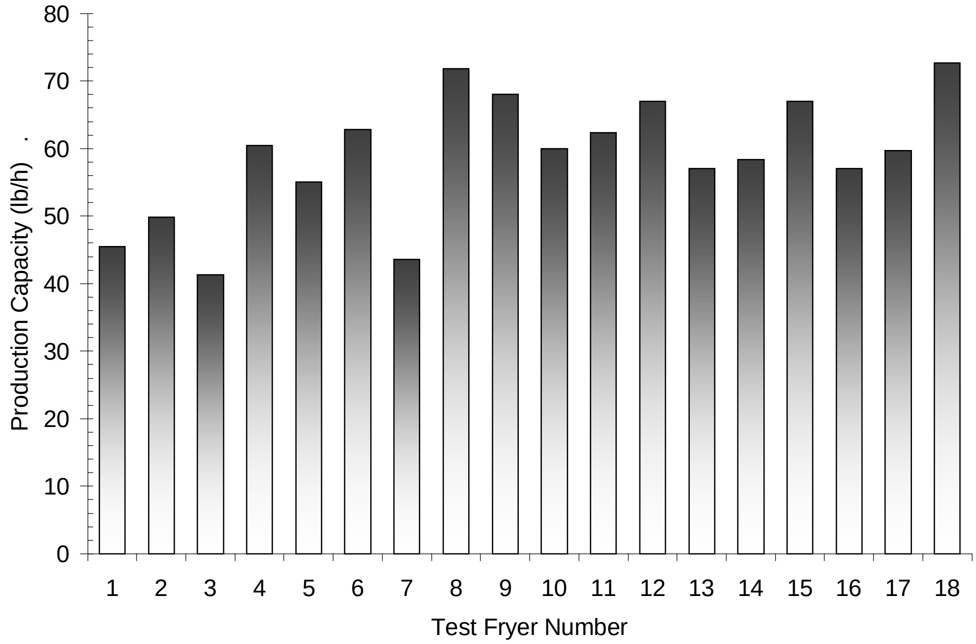

Figure 2-8.
Gas open deep-fat fryer production capacity.

Recovery Time

Recovery time is the time it takes a fryer to return to within 10°F (5°C) of the thermostat setpoint after the food is removed from the oil. It is determined by energy input rate, control strategy and the heating technology, among other factors.

Benchmark Energy Performance

Water-Boil Versus Cooking-Energy Efficiency

Although a water-boil test has historically been used to determine fryer efficiency, it fails to accurately characterize fryer performance during cooking. A fryer’s job is to maintain a vat of oil at a relatively high temperature (e.g., 350°F (175°C)) while cooking food. During this time, the burners or elements may cycle off as the thermostat is satisfied. But during a water-boil test the frypot 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 fryer's controls are effectively bypassed during a water-boil test. Thus, the ability of a water-boil efficiency test to reflect in-kitchen performance has been challenged by restaurant operators, and a new, standardized test method for the performance of fryers was developed (ASTM test method F1361). This test method uses the more representative "French fry test" for cooking-energy efficiency, along with a test for energy use in the idle ("ready") mode.

Evaluating performance with real food allows both energy efficiency and productivity (production capacity) to be determined with the same test. Important performance characteristics such as recovery time can also be evaluated. The cooking-cycle temperature illustrated in Figure 2-9 helps highlight why an efficient fryer is more desirable than a base-model fryer. In general, the higher the average oil temperature, the better the product quality. With shorter cooking and recovery times, the more efficient fryer is able to produce nearly twice the amount of food as the base-model fryer.

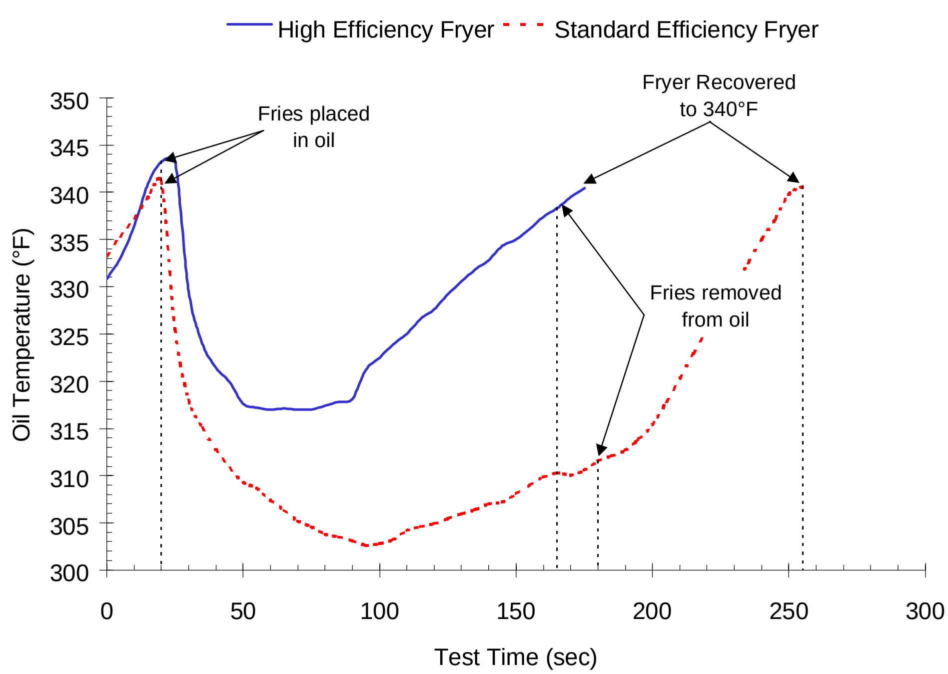

Figure 2-9.
Fryer oil temperature while cooking a heavy (3-pound) load of fries.

Table 2-1 summarizes the energy performance parameters for gas and electric open deep-fat fryers. Figure 2-10 and 2-11 show the cooking-energy efficiency curves for gas and electric open deep-fat fryers. Under light-load testing (approximately 20 lb/h (9 kg/h)), the cooking energy efficiencies for these three fryers dropped further to 66%, 28% and 35%, respectively. Although the light-load efficiencies are dramatically lower than the respective water-boil efficiencies for these fryers, they better reflect real-world energy performance where the average rate of cooking is typically less than 20 lb/h (9kg/h).

Table 2-1. Energy Efficiency for 14-inch Open Deep-Fat Fryers.

	Electric	Std-Eff Gas	Med-Eff Gas	High-Eff Gas
Rated Energy Input (kBtu/h)	40 – 60	80 – 120	80 – 120	80 – 90
Idle Energy Rate (kBtu/h)	2.5 – 3.5	12 – 18	8 – 12	4 – 8
Cooking-energy efficiency (%)	75 – 85	25 – 35	35 – 50	50 – 65
Production Capacity (lb/h)	60 – 70	30 – 45	45 – 60	60 – 70

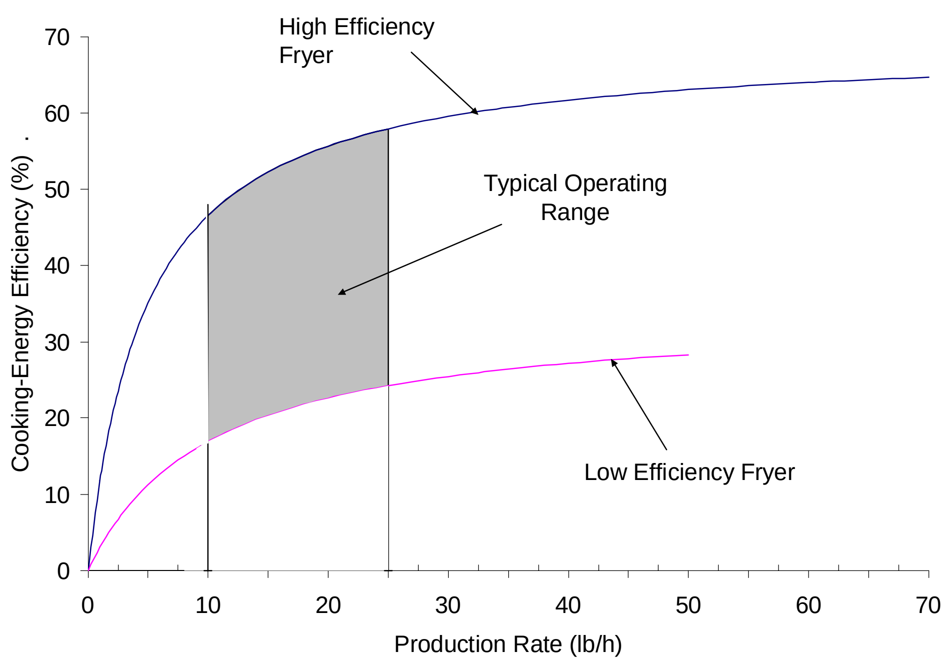

Figure 2-10.
Gas open deep-fat fryer cooking-energy efficiency characteristics.

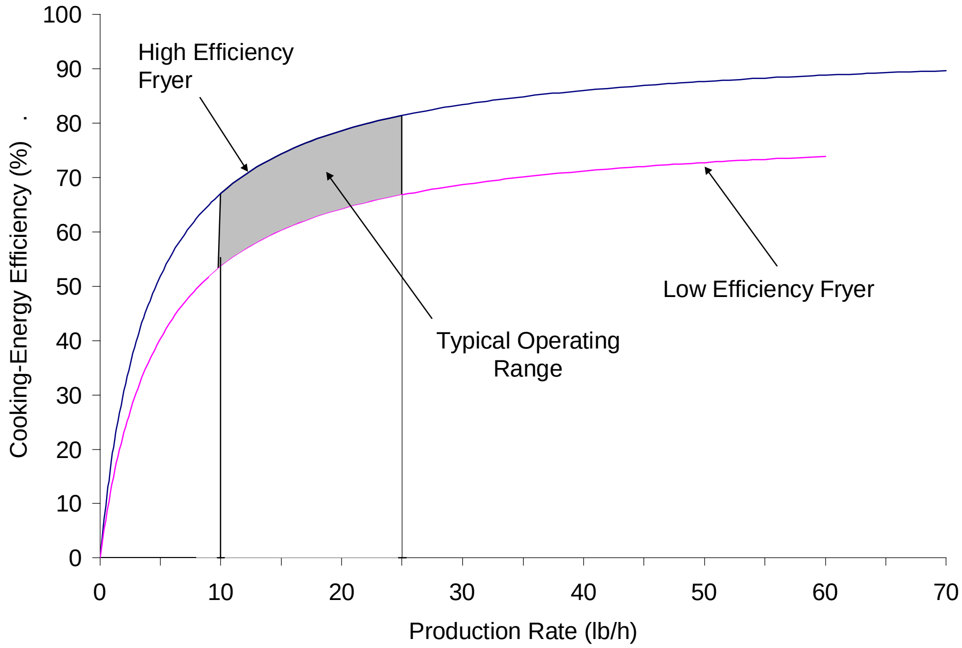

Figure 2-11.
Electric open deep-fat fryer cooking-energy efficiency characteristics.

Pressure fryers require a large vat and typically use a "bottom-fired" design. The benchmark performance of pressure fryers is somewhat lower than that of open deep-fat fryers. In fact, the high-efficiency gas pressure fryers utilize atmospheric burners, as opposed to infrared burners in the open deep-fat fryers. Table 2-2 summarizes the energy performance parameters for gas and electric pressure fryers. Figure 2-12 and 2-13 illustrate the cooking-energy efficiency curves for gas and electric pressure fryers.[15]

Table 2-2. Energy Efficiency for 4-Head Pressure Fryers.

	Electric	Std. Gas	High-Eff Gas
Rated Energy Input (kBtu/h)	30 - 50	55 - 80	40 - 60
Idle Energy Rate (kBtu/h)	1.5 - 4.0	10 - 15	4 - 10
Cooking-energy efficiency (%)	65 - 85	25 - 35	35 - 50
Production Capacity (lb/h)	30 40	25 - 30	30 – 40

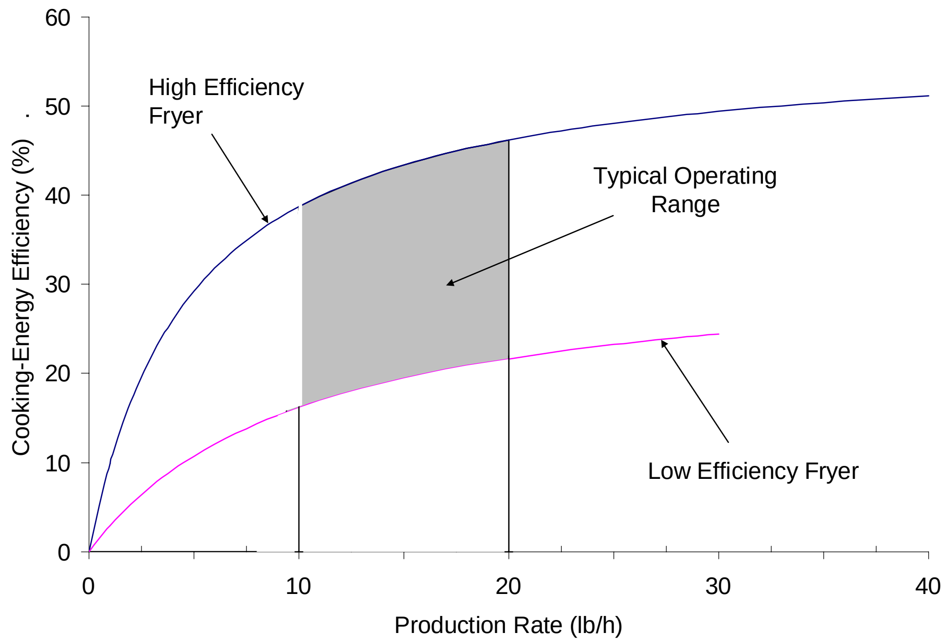

Figure 2-12.
Gas pressure fryer cooking-energy efficiency characteristics.

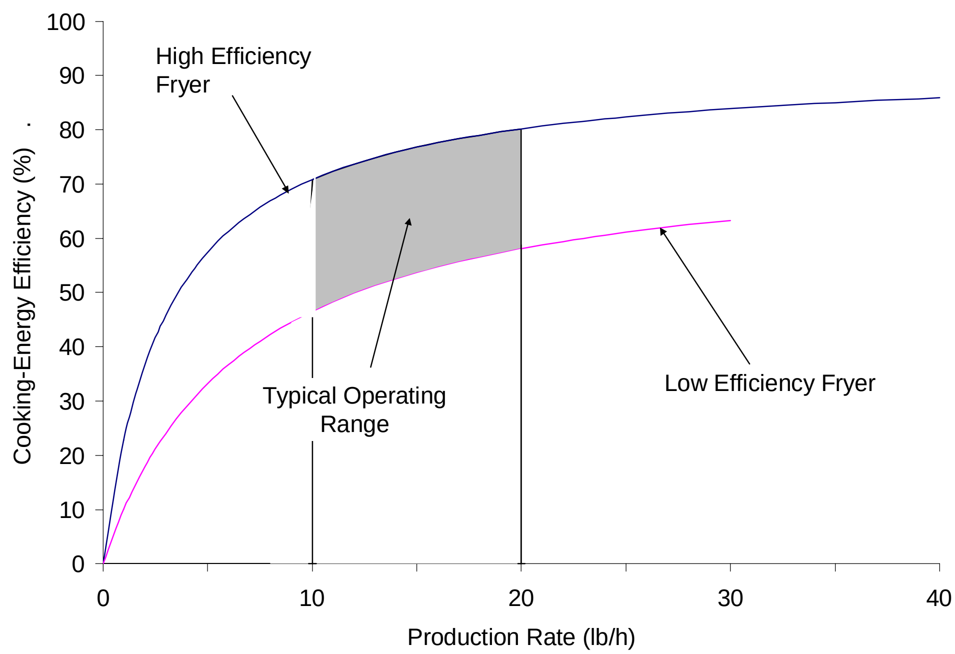

Figure 2-13.
Electric pressure fryer cooking-energy efficiency characteristics.

Gas Versus Electric Fryer Performance

Electric fryers typically use immersed elements to impart heat to the frying medium. This heating technology exhibits higher energy efficiencies due to the absence of the flue losses associated with gas fryers. Figures 2-14 and 2-15 compare the gas and electric efficiency bandwidths for both open deep-fat fryers and pressure fryers.

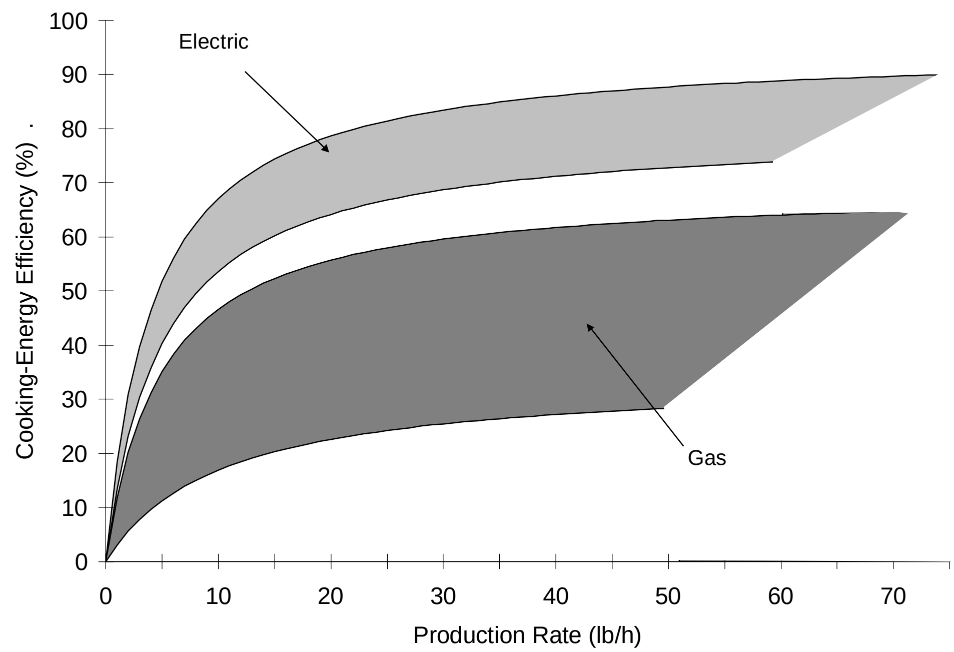

Figure 2-14.
Open deep-fat fryer cooking-energy efficiency bandwidths.

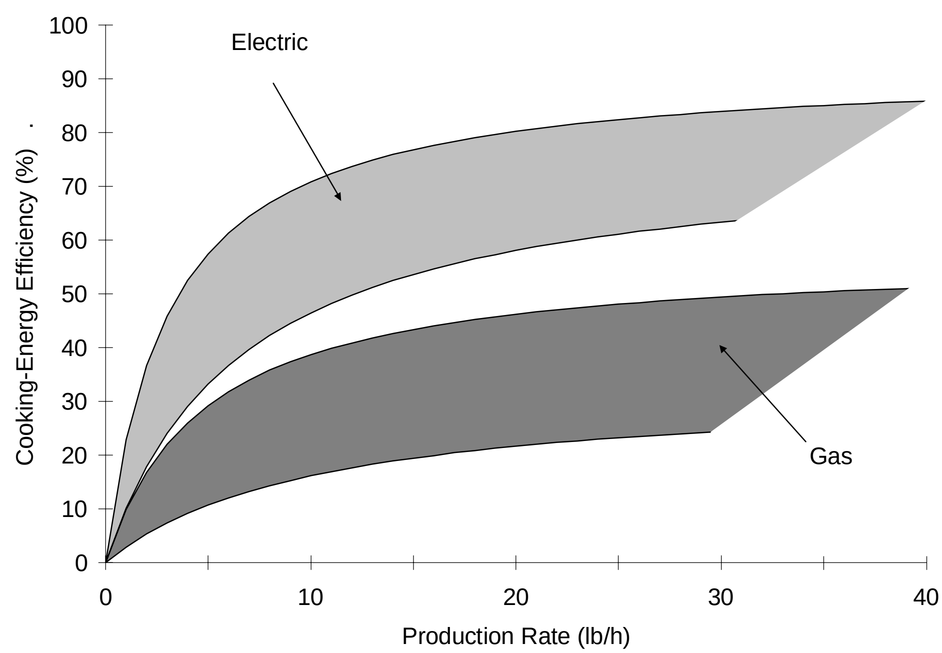

Figure 2-15.
Pressure fryer cooking-energy efficiency bandwidths.

Fryer Energy Consumption

Energy Consumption Model

In support of the development of standard test methods for cooking appliances, a model has been reported that simplifies cooking appliance energy analysis.[16] 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 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 fryers. The model can be effectively applied to estimate part-load efficiencies for a fryer installation where only the operating time (e.g., 12h/day) and quantity of food cooked (e.g., 100 lb/day (45 kg/day)) is known. Figures 2-16 through 2-19 show estimated energy consumption rates and typical operating ranges for gas and electric open deep-fat fryers and pressure fryers based on this model.

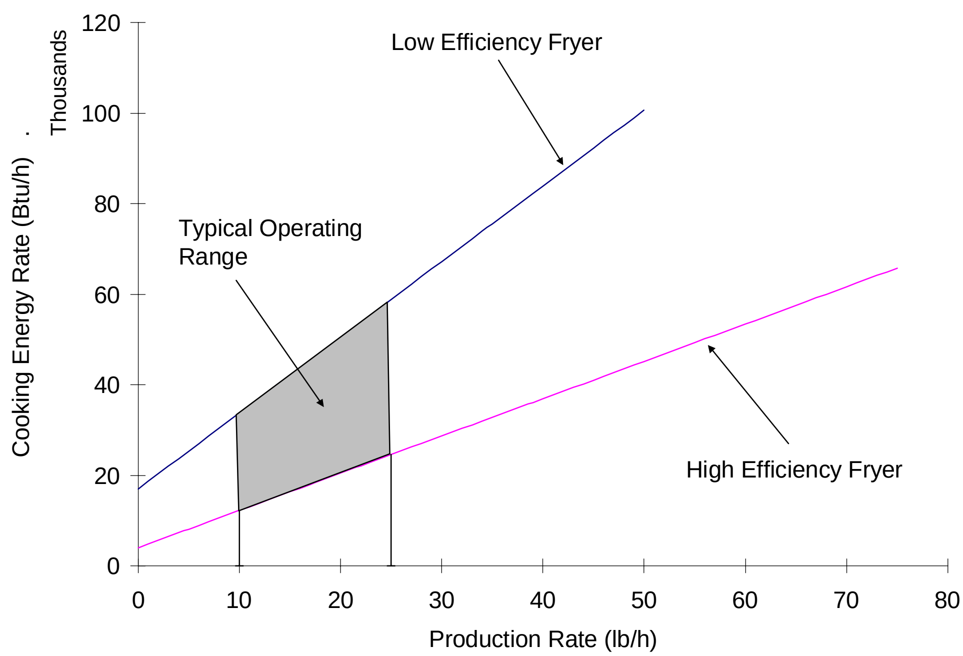

Figure 2-16.
Gas open deep-fat fryer energy consumption based on the two-mode model.

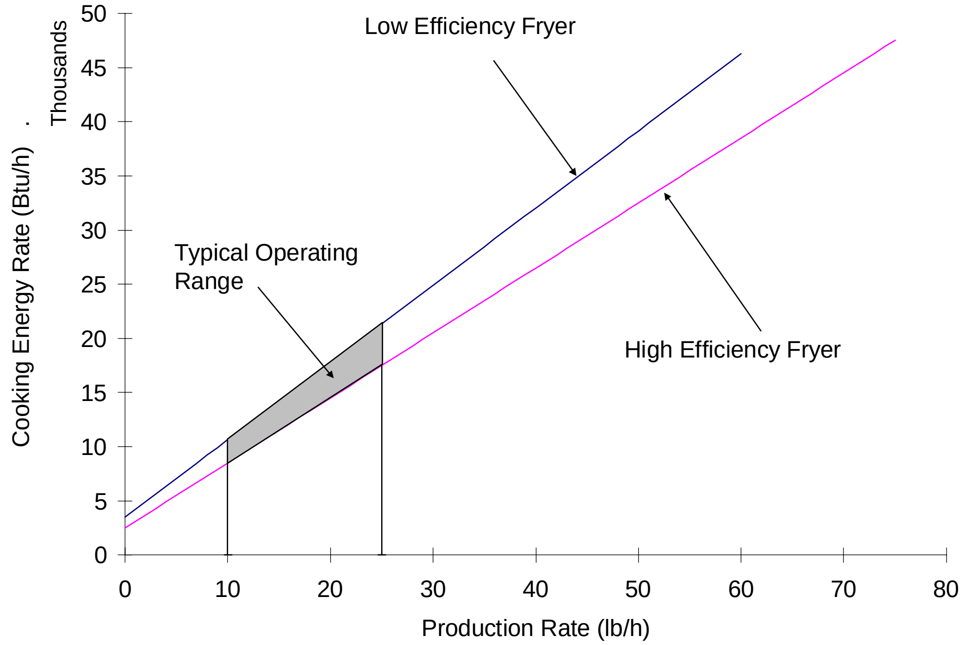

Figure 2-17.

Electric open deep-fat fryer energy consumption based on the two-mode model.

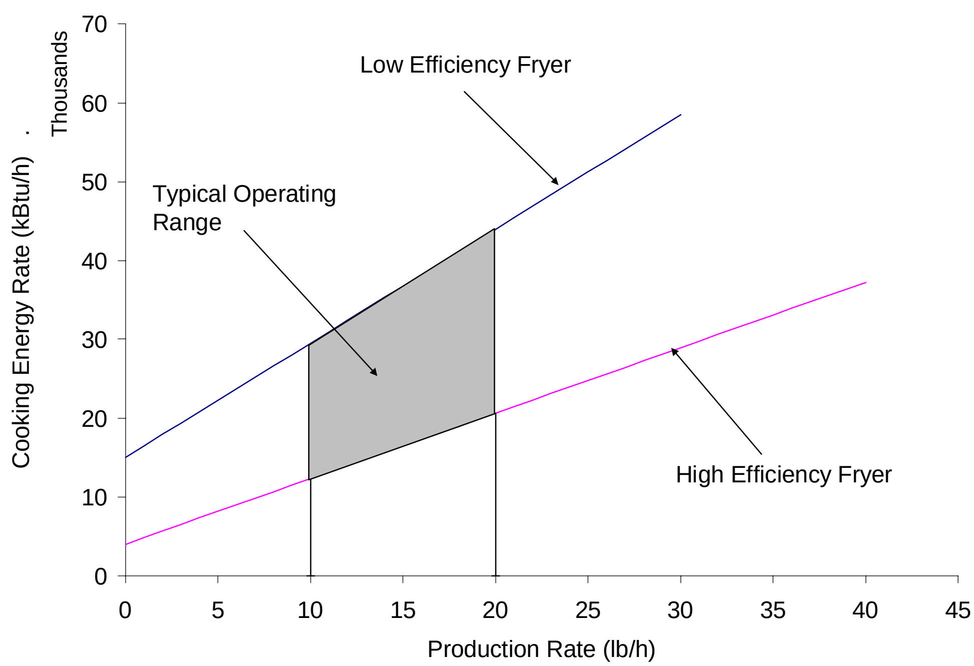

Figure 2-18.

Gas pressure fryer energy consumption based on the two-mode model.

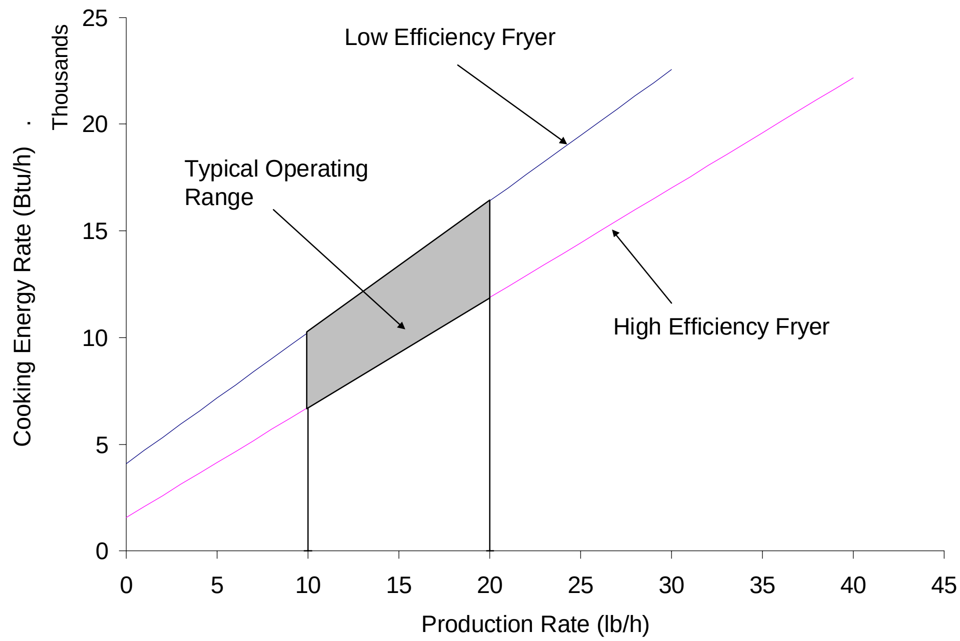

Figure 2-19.
Electric pressure fryer energy consumption based on the two-mode model.

A more robust energy model has been included in subsequent revisions of the ASTM Test Method for the Performance of Open Deep Fat Fryers. 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 F1361-99. 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 fryer.

Projected annual energy consumption for gas and electric fryers are presented in Tables 2-3 and 2-4 based on the assumptions documented by the table footnotes. The information is based on test method development work for fryers at the Food Service Technology Center and proprietary end-use monitoring reports. The duty cycle is defined as the average rate of energy consumed expressed as a percentage of the rated energy input or the peak rate at which an appliance can use energy.

Typical fryer usage involves one or two preheats over an 8- to 12-hour operating day. Figures 2-16 through 2-19 can be used to determine the average energy rate during operating hours for each type of fryer. Annual energy consumption ranges for gas and electric open deep-fat fryers and pressure fryers are summarized in Tables 2-3 and 2-4. These ranges can be applied to demographic information to estimate the total annual fryer energy consumption for typical use in North America.

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

	Oil Capacity (lb)	Rated Energy Input (kBtu/h)	Duty Cycle (%)	Avg. Energy Consumption (kBtu/h)	Typical Operating Hours (h/d)[a]	Annual Energy Consumption (kBtu)[b]
OPEN DEEP FAT:						
Open Deep Fat	35 - 50	80 - 120				
(Median)		100	20	20[c]	12	74,900
PRESSURE/KETTLE:						
Pressure/Kettle	30 - 50	40 - 80				
(Median)		60	30	18[d]	10	56,600
FLAT BOTTOM:						
Chicken/Fish	125	180				
(Median)		180	30[e]	54	10	168,000
Donut	80	60 - 76				
(Median)		68	20[f]	14	8	34,900

[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.[16] An associated duty cycle of 22% was calculated.
[d] The average energy consumption rate is based on a median-production rate of 10 lb/h generated from the two-mode energy model.[16]
An associated duty cycle of 30% was calculated for a pressure/kettle fryer.
[e] A 30% duty cycle has been assumed for flat-bottom chicken/fish fryers based on the assumption that the usage pattern is similar to pressure/ kettle operations. Based on the duty cycle and the median energy input rate, an average energy consumption rate of 54 kBtu/h was calculated.
[f] A 20% duty cycle has been assumed for flat- bottom donut fryers based on the assumption that the usage pattern would be somewhat less than open deep-fat fryer operations. Based on the duty cycle and the median energy input rate, an average energy consumption rate of 14 kBtu/h was calculated.

Table 2-4. Projected Energy Consumption for Electric Fryers.

	Oil Capacity (lb)	Rated Energy Input (kW)	Duty Cycle (%)	Avg. Energy Consumption (kW)	Typical Operating Hours (h/d)[a]	Annual Energy Consumption (kWh)[b]	(kBtu)[c]
OPEN DEEP FAT:							
Open Deep Fat	35-50	12 - 17					
(Median)		15	20	3[d]	12	11,200	38,300
PRESSURE/KETTLE:							
Pressure/Kettle	30 - 50	9 -14					
(Median)		12	33	2[e]	10	6,200	21,300
FLAT BOTTOM:							
Chicken/Fish	125	20 - 28					
(Median)		24	20	5	10	15,600	53,200
Donut	80	10 - 18					
(Median)		14	14 [f]	2	8	4,990	17,000

[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.[16] An associated duty cycle of 20% was calculated.
[e] The average energy consumption rate is based on a median-production rate of 10 lb/h generated from the two-mode energy model.[16] An associated duty cycle of 12% was calculated for a pressure/kettle fryer.
[f] A 14% duty cycle has been assumed for flat-bottom donut fryers based on the assumption that the usage pattern would be somewhat less than open deep-fat fryer operations. Based on the duty cycle and the median-energy input rate, an average energy consumption rate of 2 kW was calculated.

Impact of Fryer Design on Oil Life

The type of energy and its method of delivery to the frying oil has some effect on oil degradation; however, documented studies indicate that the effect is overshadowed by the degradation caused by the cooking process itstelf.[17,18]

Ventilation Requirements

Fryers generate moderate levels of effluent and, therefore, require moderate ventilation rates (200 to 300 cfm (95 to 140 L/s) per linear foot). Due to their relatively low idle energy rates and associated low surface temperatures, fryers introduce little radiant heat gain to the space.

Research and Development

Gas fryers have a large energy performance bandwidth, due in part to the prevalence of inexpensive, low-efficiency burner designs. Additionally, a fryer exhibiting high heavy-load cooking-energy efficiency may still have significant idle losses. Since most fryers are operated in the 10 to 20 lb (4½ to 9 kg) per-hour range, improving the part-load efficiency of fryers will have the largest impact on reducing overall fryer energy usage. Fryer part-load performance is primarily affected by the fryer's standby losses. Reducing these losses with a minimal additional first cost will make a significant impact on total annual energy consumption.

Potential technologies or strategies that could be applied include: enhanced temperature control, frypot insulation, advanced atmospheric burners, pulse combustion, modulating burners, recirculation tubes, and/or flue dampers.

Industry Market Focus

First cost is a major factor in food service equipment purchases. Many energy efficient technologies (e.g., powered IR burners) have a high premium associated with them that deters many food service operators from purchasing the higher efficiency model. An attractive strategy for the gas industry involves the development of a lower first-cost, atmospheric-burner fryer with reduced standby losses and advanced performance by applying better heat transfer, control and insulation.

The performance and diversity advantages of split-vat fryers should be better documented and promoted, particularly to the independent operator. Interestingly, split-vat fryers typically are listed by fryer manufacturers.

Developing a higher efficiency donut fryer is another opportunity that, to date, has not experienced any end-user pull. A similar situation exists for many of the flat-bottom and kettle/pressure fryers. These specialty fryers tend to incorporate very low-cost burner components and controls.

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