Commercial Gas Cooking Appliances: Current Status and Future Directions

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Commercial cooking is the fourth largest gas end-use in the United States, accounting for 10% of total gas consumed or 0.263 quads annually. A number of high-efficiency cooking technologies have been developed, including infrared fryers, infrared griddles, clamshell griddles, direct-fired convection ovens, and power burner or jet impingement range tops. Energy savings for these options are estimated at 25% to 40%, much greater than untapped opportunities in the residential market.

Despite a high savings potential among available technologies, market penetration is typically 10% or less of current shipments. The primary reason is that first cost is the overriding factor for the end-user and high-efficiency units typically cost 50 to 100% (roughly $800 to $1700) more than conventional units. Another deterrent has been the lack of standardized rating systems which makes it very difficult to compare operating costs among different options, a situation which is being rectified through an unprecedented industry-wide effort. Other market barriers include the lack of dealer motivation to sell high-efficiency equipment, and exaggerated concerns over the reliability of new technologies.

Economic analysis indicates that typical paybacks for these technologies are 4 to 8 years. Unfortunately, paybacks in this range are higher than most commercial customers are willing to accept. As a result, rebates, standards, or more innovative approaches may be necessary to improve current penetration. This represents a significant untapped demand side management potential since only a handful of the 50 largest gas utilities in the United States currently offer any type of incentive for the installation of high-efficiency gas cooking equipment.

Introduction

Gas consumption due to commercial cooking is shown in Figure 1 for the period from 1967 to 1990. These results are based on historic estimates of gas use for the entire commercial sector (AGA Gas Fact 1993) combined with historic end-use share information from commercial gas market surveys (personal communication, 1991 AGA Gas Demand Analysis Division).[1] As indicated in the figure, annual gas use in this sector has historically ranged from about 0.15 quads to 0.30 quads.

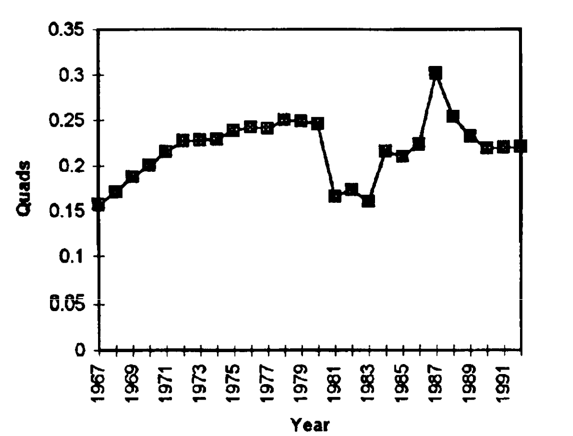

Figure 1. Gas Use for Commercial Cooking (1967-1991)

The American Gas Association (AGA) estimates that replacement equipment accounts for 65% of annual, national, commercial cooking appliance sales and that much of the older equipment replaced has efficiencies below 40% (Himmel 1984 cited in Usibelli et al. 1985). A number of high-efficiency appliances for the commercial cooking market have been developed which are anticipated to save from 20% to 50% over their standard efficiency counterparts (Farnsworth and Himmel 1984). If equipment with these high-efficiency features were consistently specified and installed for the replacement market alone, consumption in this sector would be reduced considerably over the next 20 to 30 years. However, acceptance of these technologies in the market place appears mixed. In addition some technologies, while showing good potential in the laboratory, have never entered the market.

The purpose of this study was to obtain an overview of the commercial cooking appliance market and investigate the availability and relative cost of high-efficiency cooking equipment for commercial kitchens. The report also examines the current market penetration of high-efficiency cooking equipment and the potential for energy savings in this sector. In addition, the role of financial incentives and standards in increasing market penetration is explored and recommendations for follow-up tests or demonstrations are made.

Methodology

Baseline information for the market analysis was obtained from published studies when available. When not available, supplemental data were collected in interviews with industry experts, researchers, trade associations and the commercial cooking equipment manufacturers and suppliers themselves. Types of data gathered included the volume of cooking equipment shipped to market annually and replaced annually by product type, as well as inventory and energy use for categories of commercial gas cooking appliances.

Initially, discussions with industry specialists and a review of published reports identified gas cooking equipment of particular interest as well as known manufacturers of high-efficiency equipment. To supplement this, a list of the manufacturers of gas-fired cooking equipment was obtained from a trade journal and letters of inquiry were sent to 105 manufacturers, including the companies referred by our industry sources. Twenty-six companies responded by sending copies of sales literature. Follow-up phone calls were made to major companies who did not respond to our initial inquiries, and sales literature was subsequently obtained for five additional companies. All literature was thoroughly reviewed and follow-up phone calls were made to as many manufacturers and local dealers as possible to obtain pricing information and penetration rates. List prices were obtained directly from manufacturers' literature and information on standard discounting practices in the industry was gathered in supplemental interviews. Manufacturers and dealers were also queried regarding the importance of energy efficiency as a criterion in the purchasing decision of the end-user. Information on penetration rates and interest in energy efficiency features was also obtained from interviews with industry specialists and utility personnel.

Market Overview

Annual Shipments, Current Inventory, Overall Energy Use and Replacement Rates

Table 1 shows data on 1989 shipments, inventories and energy use for six categories of gas cooking appliances (GRI 1992).[2] From these data it is apparent that ranges, ovens, deep fat fryers, and griddles each accounts for at least 18% of total commercial gas cooking energy use, which is estimated at 0.263 quads for 1989. Historic shipments of these same categories of equipment are shown in Figure 2 (two years at a time), and indicate that generally shipments of all equipment were on the increase through 1986-87, but saw a decrease in 1988-89 (ibid). In particular griddles appear to have taken a significant dip in terms of shipments during this two year period. In addition, over this entire twelve year period shipments of fryers have nearly doubled, making them a particularly important equipment category. Shipment data more recent than 1989 are not available in the literature.

Replacement rate is defined as the percent of annual sales used to replace worn out equipment and is shown for various types of commercial cooking equipment in Table 2 (Frost and Sullivan 1975 cited in Hurley et al., 1978). This replacement rate varies from 56% to 75%, but averages 65%, which is the same rate quoted by AGA in another source (Himmel 1984 cited in Usibelli et al. 1985). Based on 1989 shipments, the estimated number of annual units represented by this replacement rate can be calculated for each equipment type (Table 2). Dividing this number into the estimated 1989 inventory for each equipment type yields the expected number of years it would take to totally turn-over the existing inventory with replacement equipment. This number ranges from about 13 to 117 years depending on the particular appliance, and averages approximately 55 years. The three pieces of equipment with expected turnovers of less than 30 years are ranges, deep fat fryers and broilers. Since ranges and fryers are also the two most significant appliances in terms of energy use in this sector (Table 1), interventions to move the market toward more efficient new appliance options in these two equipment categories in particular have a big potential to reduce overall energy consumption in this sector in the next 30 years.

Table 1. 1989 Appliance Inventory and Energy Consumption

Appliance	Size Range Input (1000 Btu/h)	Annual Shipments (1000's)	1989 Inventory (1000's)	Energy Consumption (10^{12} Btu)	% of Total Energy Use
Ranges & Braising Pans	110-170	37.1	606.2	72.5	27.6
Fryers	100-120	62.2	592.7	55.7	21.2
Griddles & Hot Plates	80-120	11.0	582.1	49.7	18.9
Deck & Convection Ovens	80-140	11.8	505.5	47.5	18.1
Steam Equipment	100-180	2.5	176.0	21.0	7.8
Broilers	100-120	13.6	177.8	16.7	6.3
			Total:	**263.1**	**100**

Source: GRI 1992.

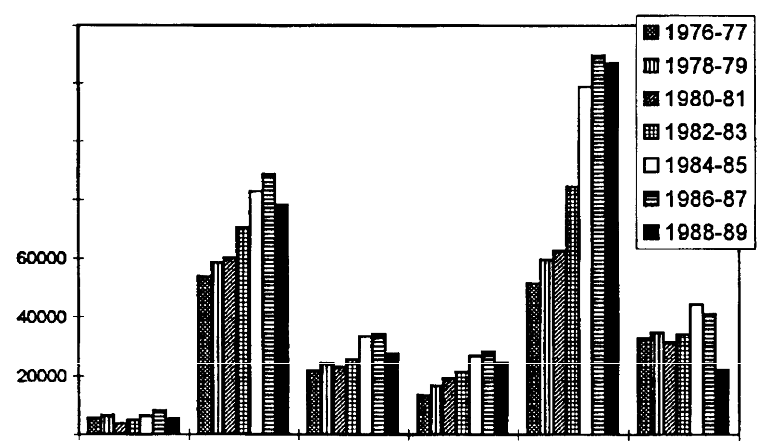

Figure 2. Shipments of Commerical Cooking Equipment

Factors Which Influence Commercial Cooking Equipment Purchases

Results of interviews indicate that energy efficiency is not a key factor in the purchase of new commercial cooking equipment in todays market. Many people stated that a big part of the reason for this is that energy costs are a relatively small part (generally 2% to 3%) of the overall operating budget for the typical restaurant. Another reason for this lack of interest may also be the fact that the industry has only recently begun to develop uniform test procedures for various equipment types and to publish data comparing test results of various appliances using these new procedures.[3] Unfortunately the limited data that are available are often not readily obtainable by end-users who might want to compare operating costs among various options or between different models.

Sources interviewed also agreed that first cost continues to be the overall driving force for this market, with

Table 2. Equipment Replacement Rates

Appliance	Replace Rate[a]	1989 Total Shipments (1000's)	Number Replaced (1000's)	Number Added (1000's)	1989 Inventory (1000's)	Years to Replace Inventory
Ranges & Braising Pans	56%	37.1	20.8	16.3	606.2	29.1
Fryers	71%	62.2	44.2	18.0	592.7	13.4
Griddles & Hot Plates	63%	11.0	6.9	4.1	582.1	84.3
Deck & Convection Ovens	62%	11.8	7.3	4.5	505.5	69.3
Steam Equipment	60%	2.5	1.5	1.0	176.0	117.3
Broilers	75%	13.6	10.2	3.4	177.8	17.4
Average:	65%					**55.1**

(a) Percent of sales used to replace existing equipment (Source: Hurley et al. 1978)

reliability and productivity also important factors for most buyers. However, differences in the market occur depending on the sophistication of the buyer. The least sophisticated purchasers, who appear to make up about 5 to 10% of the overall market, tend to be "one-issue" buyers. For these, purchase price is the only consideration, assuming a certain piece of equipment fulfills the specific cooking job needed.

By contrast, the most sophisticated buyers, who are thought to make up an estimated 20 to 25% of the market, consider reliability and productivity ahead of purchase price. Reliability is a determinant which can be at odds with high-efficiency if it involves new technologies which are less time tested, are likely to break down more frequently, or require a specialized service person for repairs. These are major deterrents in an industry where even a couple of hours of downtime on a piece of equipment can be very costly. Productivity is usually defined as the amount of product divided by the labor cost to produce it (personal communication, 1991 D. Fritzsche, Gas Research Institute), and is often synonymous with the term "high efficient" in the marketing literature for commercial cooking equipment (e.g., if the equipment is high production, it is automatically called high efficient whether or not there is any high-efficiency technology applied to the unit). In addition to considering reliability and productivity, the sophisticated buyer also takes into account actual operating features as well as factors such as ease of maintenance and equipment lifetime. Energy efficiency on its own is still a hard sell even to this buyer group, but is often a consideration, since it is linked to operating costs which are tracked more closely by this group. In terms of cost-effectiveness, this group of buyers is typically unwilling to go beyond a two to three year payback unless other benefits outweigh the additional cost of the particular high efficiency feature. Although not universal, the sophisticated buyer tends to be someone who is a long-time business owner with more than the average amount of experience in this field, and/or a larger owner (like a chain, or an institutional buyer). With less expansion in the chain market over the recent period, the pool of sophisticated buyers appears to be decreasing.

The vast majority of commercial equipment buyers (thought to account for 70% to 75% of the market) make up the middle of the continuum. For this buyer, who could be called the "typical" buyer, first cost is a predominant but not the only consideration. As with the more sophisticated buyer, two other key factors for this group are reliability and productivity. How much influence these other factors bring to bear on the purchase decision depends on how much the particular buyer leans toward the sophisticated end of the scale: the more sophisticated, the more the buyer will weigh reliability and productivity in the purchase decision. However, it is clear that energy efficiency on its own is rarely if ever examined by this group of buyers; if considered at all it is only as it affects reliability or productivity.

Review of Available Technologies

Equipment in this survey includes ovens, ranges, fryers and griddles, the four most important product categories in terms of inventory size and energy use. Broilers and steam equipment were not investigated, since these equipment types do not account for much of the market comparatively.

One of the more difficult tasks in reviewing manufacturers' literature was determining which equipment was indeed "high efficient." As already mentioned, until recently the commercial cooking industry did not have uniform test procedures for any of its equipment. As a result unlike the case for most residential appliances (e.g., furnaces, boilers, air conditioners, water heaters), published efficiency ratings of commercial cooking appliances are unavailable. Many manufacturers do not even test their equipment internally and if they do perform such tests, results are rarely published. Furthermore, the limited efficiency estimates that are found in the sales literature are not comparable among different brands since the method of determining efficiency may be entirely different. As a result, for this survey specific technologies (e.g., infrared, power burner, pulse combustion) were identified and used to determine whether or not a particular piece of equipment was actually high efficient or not. Published data, when available, as well as conversations with independent industry sources and manufacturers were also relied on if further clarification was needed. Of the 31 manufacturers whose literature was reviewed in this project, 16 have equipment that incorporates advanced high-efficiency features.

Ovens

The most common type of oven currently sold appears to be the convection oven, which accounts for about 50 to 60% of total annual oven sales, according to various sources. A convection oven uses fans located in the rear of the oven compartment to circulate heated air over and around the product being cooked, accelerating heat absorption and reducing shrinkage (Jernigan, Ross 1989, p. 47). The burners on all currently available convection ovens are atmospheric. Advantages of convection ovens over standard ovens are increased cooking speed, more even heating, and larger capacity (since racks can be stacked closer together).

Simple modifications to free-standing forced convection ovens were among the earliest high-efficiency improvements researched and put into effect (Farnsworth, Himmel 1984) and included converting from indirect-fired to direct-fired equipment, utilizing vent dampers and electronic ignition, and reducing motor horsepower. Results from AGA side-by-side laboratory tests indicate that direct-fired convection ovens save from 19% to 39% compared to indirect-fired units depending on the type of product cooked, with an average savings of about 30% (Stack et al. 1989). An added advantage to the direct-fired design is that food cooks more quickly than in an indirect model. Some early problems with food quality, caused by the fans blowing hot air directly on the food product, were solved through the use of diverters. Eight manufacturers were found which produce direct fired units. Two manufacturers still make indirect convection ovens. Current penetration rates for direct-fired units are thought to be less than 20% (Table 3). Costs between the direct- and indirect-fired units appear to be roughly equivalent. On the other hand, list price of a convection oven is generally more than twice as much as comparable conventional ovens ($4 ,000 to $10,500 for the convection, versus $2,000 to $4,000 for the conventional).

Table 3. Estimated Penetration Rates

Ovens	
Direct-Fired Convection Oven	10-20%
Direct-Fired Range Top Oven	5-10%
Combination Oven	5%
Deck Oven	15-20%
Revolving Ovens	<5%
Conveyor Ovens	5%
Ranges	
Power Burner Range Top	<5%
Jet Impingement Range Top	<2%
Deep Fat Fryers	
Infrared Fryer	<10%
Forced Convection Fryer	0%
Pulse Combustion Fryer	0%
Griddles	
Infrared Griddles	<10%
Clamshell Griddle	<5%
Double Sided Gas Griddle	0%
Pulse Combustion Griddle	0%

Source: personal communication with manufacturers, and industry specialists

Other improvements to forced convection ovens include the use of vent dampers and intermittent ignition devices (IID), and reduced hp motors. AGA tests indicate energy savings for using vent dampers varied from 0% during heavy load conditions when the burner was operating continuously, to as much as 30% when the oven was cycling to maintain a preset temperature, a situation typical of light loads (ibid). However, this survey of equipment indicated that no manufacturers are currently incorporating a vent damper in its design, apparently due to lack of market interest. Measured savings data for IIDs on commercial ovens are not available, but have been estimated in the range of 4 to 6% (Lobenstein and Hewett 1991). All manufacturers surveyed offer IIDs on their convection ovens, usually as standard equipment. In addition, all but two of the convection oven manufacturers have reduced the horsepower rating of their motors from 3/4 horsepower to at most 1/2 horsepower and four have reduced the ratings to 1/4 or 1/3 horsepower. Several companies also offer two-speed motors. Costs for the vent damper option were not available since it is no longer produced. The cost for an IID as an option (when it is not standard equipment) typically runs around $200 list. Cost differentials between low and high horsepower motors were not investigated.

A commercial range top oven is an oven with a built in customized "range" on top, similar in style to the typical residential cooking stove. The standard oven in this type of equipment is direct-fired, but circulation of the hot gases is typically accomplished by natural circulation. As a result, one of the main energy efficiency modifications made to this type of equipment is to add forced convection. Gas fuel savings of about 40% have been demonstrated with this modification (Farnsworth, Himmel 1984). Most of these ovens also have IIDs either standard or available as an option, as well as lower horsepower motors. Five manufacturers in this survey produce forced convection range top ovens, although reports of current market penetration were quite low in the range of 5 to 10% (Table 3). List price for a conventional oven runs from $2,000 to $4,000, whereas a range top with a convection oven generally lists at $3,000 to $6,000.

The combination oven and steamer is an innovative new product that replaces two pieces of cooking equipment: the oven and the typical atmospheric pressure steamer. It produces less shrinkage of the food product than a standard oven, is able to re-heat foods without drying, and is particularly suited to baking certain foods like pastries and breads. One U.S. manufacturer has had a gas version of the combination oven in the market for about three years, and two other companies are working on developing one. In side-by-side laboratory performance tests, AGA found that in the convection oven mode the combination oven used an average of 18% less energy per pound compared to a direct-fired convection unit and an average of 42% less than an indirect-fired unit (Stack et al. 1989). Cooking time in the combination oven was less or more than the conventional convection ovens depending on the particular product, but in most cases the browning pattern was uneven with the combination oven. In the steamer mode, the combination oven averaged about 39% less energy per pound of product cooked than a typical steamer, and usually cooked in the same or less time when compared to a conventional steamer. AGA also tested the unit in combined mode and found that it used about 65% more energy per pound of cooked product than the combination oven itself in convection mode. Estimated penetration rates for this product are less than 5% (Table 3) and is mostly limited to institutional buyers (e.g., hospitals, schools, nursing homes). Cost for the combination oven is quite high. A half size unit (accommodates 7 half size pans) lists for about $10,000 and a full size unit (accommodates 9 full size pans) lists for about $16,000. Comparatively, the combined list price of both a convection oven and a steamer would be in the range of $10,000 to $12,000.

Other types of ovens include deck ovens (with an estimated 15 to 20% of the market), and revolving and conveyor ovens (each with an estimated 5% of the market) (Table 3). In general, very few innovations appear to have been made over the recent period for this type of equipment. Most deck ovens are typically direct-fired, but not convection. Furthermore, it is unlikely that convection style deck ovens will be developed since many people in the industry see deck ovens as fulfilling a specific niche (e.g., pizza preparation) where it is believed that a convection oven would result in an inferior product. One manufacturer has developed an air curtain version of the deck oven, which is designed to prevent heat from escaping during baking. In PG&E comparison tests the oven did consume considerably less energy for preheating and idling (about 30% to 40% less) than a comparable deck oven of standard design but cooking time and energy use was about the same as a standard deck oven (Ferlin, Cushman 1983). The revolving oven is more of a marketing tool, in that it typically has clear sides and/or windows through which the product can be viewed by customers while baking. This oven style has no particular energy saving features. In comparison tests conducted by PG&E the revolving oven took twice as long to cook the product as a conveyor oven and 20% longer than a deck oven (Ferlin, Cushman 1983). In a conveyor oven, heated air is directed to impellers that then push the air through rows of fingers extending across the conveyor, transferring heat to the food product (Jemigan, Ross, 1989, p. 48). The advantage of this oven style is that it provides uniform, rapid baking from the top and bottom. In PG&E comparison tests, conveyor ovens cooked pizzas about 50% to 60% faster than either a revolving oven or a deck oven (Ferlin, Cushman 1983). Among manufacturers surveyed, two produce conveyor ovens, none with IID. Conveyor ovens cost three to four times as much as conventional decks.

Range Tops

Designing the burners of a commercial range with a power system that fully mixes air and gas in the burner (as opposed to drawing secondary combustion air from around the burner itself) has been shown to increase burner efficiency to about 60% (GRI, December 1986). Other advantages include a wider control range, more even heat distribution and decreased cooking time. Performance tests conducted by the AGA showed that the power burners used an average of 24% less energy to boil water than an atmospheric burner, and had an average measured thermal efficiency of 45% compared to 34% for the atmospheric unit (Parobechek et al. 1987). The power burner range is currently only produced by one manufacturer and comes standard with an IID. Penetration rates of this product are estimated at less than 5% (Table 3). Other manufacturers interviewed have no plans to develop a similar technology. The power burner range lists for $4,800 versus $1,600 to $3,300 for a conventional range top with a standard oven.

The infrared jet impingement gas burner uses both radiant and convective heat transfer. Combustion occurs within or at the surface of a flat ceramic tile which glows and emits radiant heat. In addition, jets of air propel these combustion products through a porous glass plate located above the ceramic tile to deliver convective heat. IID is standard on the unit. The jet impingement burner is expected to save 20% to 30% over conventional range technology and has an efficiency of about 66% (GRI 1989). Currently, no manufacturer produces a commercially available range top with this technology, although one manufacturer is tooling up for this design. List price is expected to range from $2,400 ($2,700 with IID) to $3,700 ($4,000 with IID), depending on exact features. By comparison, list price for conventional range ovens generally range from $1,600 to $3,300.

Deep Fat Fryers

From various industry sources, it appears that floor model deep fat fryers account for 60 to 70% of the fryer market. Counter top models and pressure fryers account for the remaining market. Typical deep fat fryers in the early 1980s had efficiencies of 45 to 50% (Usibelli et al. 1985). Since then, several innovative technologies have been developed which have improved the efficiency of new deep fat fryers to 70% or greater. These technologies include infrared, forced convection and pulse combustion. Of these, infrared technology is the only one that is currently being produced and marketed.

Infrared technology was among the first improvements to deep fat fryers, with the initial units marketed as early as 1980 (Farnsworth, Himmel 1984), but are estimated to have less than 10% of the current market (Table 3). Compared to typical atmospheric tube burner fryers, infrared models are expected to have efficiencies of 75% to 80% (Striven, Stevens 1989, p, 76). Three manufacturers of infrared fryers were found, all of which come standard with IID. AGA laboratory comparison tests indicate that a typical infrared fryer used about 35% less total energy and 33% less energy per pound than a typical high input fryer when cooking 3/8” french fries (Diggins et al. 1987). In addition, the infrared burner allows deep fat fryers to be configured with separate (or split) tanks, which should save additional energy since only one side of the fryer needs to be used during non-peak times. It is also more versatile because two different products can be fried at the same time. List price on the infrared fryers ranges from $3,600 to $5,000, depending on whether it is a split vat or single unit. Generally, this is about twice as much as the list price for standard fryers.

In a forced convection fryer, hot oil is continuously pumped through a heat exchanger with a built in filter. The burner itself is forced combustion and it has an IID. In comparison tests a convection fryer was found to use about the same total energy as an infrared fryer to cook 3/8” french fries, but about 20% less energy per pound for the task (Sobieski et al. 1985). In addition, in comparison to a typical high input fryer, the convection unit used 37% less total energy and 46% less energy per pound. for cooking 3/8” fries (ibid). Efficiency for the convection fryer is estimated to be around 72% to 73% (Fritzsche 1991). One manufacturer produced the convection fryer for a short time and then took it off the market because of problems with clogging filters (apparently due to poor maintenance and misapplication of the product, at least according to the developer). It is not currently known whether this item will be marketed again in the near future so it has a market penetration of 0% (Table 3).

Applying pulse combustion technology to a commercial fryer was investigated by GRI and showed substantial promise to decrease energy consumption. In fact, preliminary tests showed energy savings of 54% over a standard fryer (Farnsworth, Himmel 1984). Although promising, the technology was never produced for market. Apparently this was both because the cost of the unit to the end-user was expected to be too high (evidently even higher than infrared fryers) and because there were concerns about the reliability of operating this type of equipment (which is fairly complicated and a bit touchy) in the hostile environment of a commercial kitchen. It is possible that a manufacturer will put a pulse combustion unit into production at some future point if gas prices increase enough to justify the high first cost of the appliance.

Griddles

High-efficiency technologies that have made inroads into this cooking appliance include infrared and pulse combustion. In addition, a recently introduced all gas clamshell griddle shows promise to cook foods faster and more energy efficiently as does a soon to be introduced double sided griddle intended for the fast food market.

Commercial gas griddles are another application for infrared technology, but current market penetration is thought to be less than 10% (Table 3). Whereas a typical griddle might have an efficiency of around 45% to 50%, an infrared unit is expected to have efficiencies in the neighborhood of 60% to 64% (GRI 1987). Two manufacturers currently produce infrared griddles, both with IID. Two other manufacturer expect to market an infrared griddle in the next one to two years. In comparison tests with standard griddles, researchers found that infrared griddles used from 17 to 22% less gas for cooking frozen hamburgers (Sobieski et al. 1985). List price for the infrared griddle ranges from about $4,000 to $8,000. For one manufacturer this is 35% more than its standard griddles; for the other manufacturer it is about twice as much.

Pulse combustion technology can also by applied to commercial griddles, with expected efficiencies of over 70% and fuel savings of about 27% (GRI 1987). The griddle has other benefits of good temperature control and consistency of product. In addition, the design allows flexibility in that individual portions of the griddle can be operated or not as required. In spite of its advantages, the pulse combustion griddle has not been marketed to date, apparently for the same concerns as the pulse combustion fryer: cost and reliability.

The clamshell griddle is a new gas item (there has been an electric equivalent for several years) which shows promise to considerably reduce the energy costs and cooking time associated with griddle foods. The unit has a conventional griddle bottom and an infrared broiler top that can be lowered down on top of the food product to cook both sides at once.[4] The advantages of the clamshell include speed (according to the manufacturer it cooks twice as fast as a typical griddle), versatility (more than one type of product can be cooked at the same time) and high-efficiency (according to the manufacturer, it approaches 74% efficient.) The unit can be used instead of an electric clamshell, conventional gas or infrared gas griddle. No performance tests have yet been completed on this unit. Only one manufacturer currently makes this product (with IID) and its current market penetration is less than 5% (Table 3). The clamshell costs roughly twice as much as a conventional griddle, and about the same as an infrared griddle. However, production is also expected to be much greater than a standard griddle.

Another innovation is the double sided all-gas griddle or "duplex" cooker as it is sometimes called since food can be griddled from both sides simultaneously. It has a conventional griddle on the bottom and a griddle heated by circulating hot oil on the top. A version of a duplex cooker with a gas griddle base and an electric platen top has been available from at least one manufacturer for several years, but this is the first development of an all gas version of the same idea. This appliance is intended for application in high-production food service where large quantities of the same product need to be made at the same time, or in restaurants where time is crucial (e.g., fast food market). This unit is currently in development stages and is not on the market yet.

Conservation Potential for High-Efficiency Cooking Appliances

Typical annual consumption for various appliances were calculated based on engineering estimates of the average operating hours, average input of the equipment in question, and the average operating days per year (Table 4). Based on these typical annual consumption, and estimates of savings for specific high-efficiency upgrades already discussed, savings potential and payback were calculated for each appliance type of interest (Table 5). In cases where data from AGA market introduction studies were available, an average of the energy savings per pound over all product types cooked was used as the savings estimate. (To avoid the necessity of arbitrary assumptions about typical idling hours, savings from preheat and idling, which in most cases were considerable, were not figured into the calculations.) Equipment costs were estimated by a two step process. First, a rough average of all manufacturers list prices for a specific product was calculated. This average was then discounted by 40%, which from conversations with various sources appears to be a typical discount for this type of equipment.

A small market potential may exist (in cases where a standard deck is not required for a specialty product like pizza) to encourage a commercial buyer to purchase a free-standing convection oven rather than a standard deck or roast and hold oven. Average estimated paybacks for installation of a direct-fired convection oven instead of a conventional deck is about 3.7 years (Table 5). Otherwise utility programs should focus on encouraging the purchase of direct fired rather than indirect fired ovens. Since free-standing convection ovens generally have good penetration already, more potential to influence purchasing decisions toward high-efficiency options probably exists in

Table 4. Average Energy Use for Commercial Cooking Equipment

Appliance	Input Btu/hr	MBtu/Yr	CCF/Yr	$ Per Year
Range	130,000	184	1838	$780
Indirect Fired Conv Oven	80,000	113	1131	$480
Deck Oven	120,000	170	1697	$720
Fryer	110,000	156	1555	$660
Griddle	90,000	127	1273	$540

Assumptions: approximately 3.9 hours of operation per day at full input, 360 days per year; gas price $0.42 per CCF

the category of range ovens, where convection ovens are not as readily purchased. Estimated payback is about 8 years (Table 5).

Combination ovens appear to be more efficient than using both a steamer and a convection oven independently, and in cases where a facility does not need to use a steamer and convection oven at the same time, it is an excellent option. The merit of a combination oven as a direct replacement for a convection oven is yet to be determined, but seems unlikely given the high cost. In addition, there is probably some concern that energy use could increase in comparison to a direct-fired convection oven if an end-user is likely to use the combination mode a lot.

A large potential appears to exist to move the marketplace towards the purchase of more efficient ranges. As mentioned under ovens, one option is to upgrade a conventional range oven to a convection style oven. In terms of the range burner itself, the only high-efficiency technology currently on the market is a power burner range, but savings are substantial for this upgrade. In addition, it looks like the jet impingement range could be available soon, with a similar savings potential. Estimated paybacks for installing a power burner range top, with or without an oven, are roughly 7 to 8 years (Table 5).

The infrared deep fat fryer is another promising technology which does not appear to have widespread market penetration. Based on estimates of savings in the range of 33% to 43%, a typical infrared fryer could save an end-user about $220 annually, with a payback of about 6 years (Table 5). Infrared technology is also available for commercial cooking griddles. Potential savings for the upgrade are expected to be about $145 for the typical case (Table 5), translating into an estimated payback of about 7 years.

Intermittent ignition devices (IID) are standard equipment on infrared griddles and fryers, and on ranges with power burner or jet impingement technology. While also standard on many convection ovens, there are some convection ovens on which an IID does not come standard, but is an option. While specific savings for an IID on commercial ovens were not available, we estimate savings to be in the range of 50 to 60 CCF ($20 to $25) per year for a 500 Btu per hour pilot and using computations derived from research on residential heating equipment (Bonne, Patani 1982). At a list price of $300 as an option, payback is about 10 years.

Utility Programs for Commercial Cooking Equipment

In order to review what gas utilities are currently doing to encourage the purchase of high-efficiency commercial cooking appliances, the 50 largest U.S. gas utilities (based on customers) were interviewed. Of these, seven offer rebates. The equipment most commonly included are convection ovens, fryers and griddles. Most utilities said that few customers are taking advantage of the incentives (1 to 2 per month on average). Part of this may be marketing, since several utilities stated that they did not market the programs vigorously. The utility with the most aggressive marketing strategies reported yearly rebates in the range of 100 to 120.

Rebates are most often tied to certain recognizable high-efficiency features (e.g., infrared technology). However, there were a number of rebate criteria which were of questionable value. For instance, one utility offers rebates for "heavy duty" ranges, which is likely to include a large variety of equipment since most manufacturers offer both a heavy duty and light duty line. Another

Table 5. Savings and Payback Estimates for Commercial Cooking Options

	First Cost[(a)]	Operating Costs[(b)]	Estimated Savings[(c)]	Estimated Payback
Standard Deck Oven	$1,650	$720		
Direct Fired Convection Oven	$2,988	$360	50%	3.7 years
Differential	$1,338	$360		
Indirect Fired Convection Oven	$2,988	$480		
Direct Fired Convection Oven	$2,988	$350	28%	0.0 years
Differential	$0	$130		
Standard Range Oven	$1,875	$260		
Direct Convection Range Oven	$2,718	$155	40%	8.0 years
Differential	$843	$105		
Atmospheric Range (no oven)	$1,701	$520		
Power Range (no oven)	$2,571	$395	24%	7.0 years
Differential	$870	$125		
Atmospheric Range & Std Oven	$1,875	$780		
Power Range & Direct Conv Oven	$3,633	$555	29%	7.8 years
Differential	$1,758	$225		
Standard Fryer	$1,165	$660		
Infrared Fryer	$2,538	$440	33%	6.2 years
Differential	$1,373	$220		
Standard Griddle	$1,832	$540		
Infrared Griddle	$2,880	$395	27%	7.2 years
Differential	$1,048	$145		

(a) Average list price for item less typical discount of 40%
(b) For standard equipment based on engineering calculations (Table 4); for high efficiency equipment based on estimated savings
(c) Based on results of available laboratory tests (see text).

example is fryers with thermostatic controls. This criteria qualifies most fryers sold today because all but the very bottom of the line have thermostatic controls. Undoubtedly establishing criterion for rebates will become less arbitrary as standardized test procedures and efficiency ratings for commercial cooking equipment are instituted and applied systematically throughout the industry.

The rebate structure varied somewhat among utilities surveyed. A number of utilities offer rebates based on a fixed percentage of the equipment cost. Most rebates are based on the cost of the equipment itself, not including installation, freight or taxes. Some utility programs linked rebate amounts to estimated energy savings. In several cases the rebates are individually tailored. Six of the seven utilities also offer technical assistance to the end-user and/or equipment dealer, including such things as free site surveys and payback analysis. It did not appear as though any of the utilities offered incentives to equipment dealers in addition to or instead of the end-user, although the question was not directly asked. This may be an issue to explore further, since marketing of any rebate program in the commercial sector is likely to improve if the equipment specifier has an incentive to select high-efficiency options.

Summary and Recommendations

Commercial cooking accounts for a substantial amount of national annual gas use. Of the six major appliance types identified in the study, ranges/braisers, ovens, griddles and deep fat fryers each account for 18% to 27% of the total gas energy used for commercial cooking. A number of high-efficiency cooking technologies are currently available which have good potential to decrease energy use in the sector overall. Chief among these are infrared fryers, infrared griddles, direct-fired convection ovens (free-standing and range top), power burner range tops, jet impingement range tops and possibly clamshell griddles. Significant efficiency advances are also available in specific market niches through the combination oven and the forthcoming double sided griddle. Savings potential from these measures is quite high, generally in the 25% to 40% range. However, despite the availability of these high-efficiency options, the market penetration of most of these technologies is still comparatively low, in most cases 10% or less of current shipments.

A significant reason for the low penetration rates of high-efficiency cooking equipment is that in a market which is highly driven by first-cost, the substantial price differential between cooking appliances with high-efficiency features and those with standard features is difficult to overcome. On average, most high-efficiency options cost the end-user $800 to $1,700 more than comparable conventional equipment. Typically, this is about one-half to two times the cost of the standard efficiency alternative. However, not all of this price tag can be attributed solely to the cost of high-efficiency technology, since most high-efficiency equipment has other premium features (e. g., deluxe controls) which contribute to the price disparity.

The lack of a standardized rating system has been another formidable barrier. Fortunately, this difficulty is in the process of being rectified through an industry-wide effort to establish and utilize uniform test procedures. In addition to making it possible to compare the efficiencies of different equipment options, this enterprise will undoubtedly promote interest in high-efficiency equipment in general and is a significant trend.

A further deterrent to the purchase of high-efficiency equipment is the fact that equipment dealers may lack the information or motivation to sell high-efficiency equipment. Since high-efficiency equipment tends to cost more than standard equipment for the same function, there is little incentive for a dealer to push high-efficiency equipment when a competitor can easily undercut the price, often without the customer really understanding the difference between the units being specified.

Some buyers may also hesitate to purchase high-efficiency equipment for fear that it will break down more often or cost more to repair and maintain, understandable concerns since equipment breakdowns translate directly into lost revenue. While high-efficiency equipment tends to use more complicated components, reliability has generally been good and most difficulties that have arisen have been addressed and resolved. In addition, high-efficiency equipment tends to have additional features which can add to reliability and ease of use (e.g. solid state controls).

Results of a simplified economic analysis indicate that typical paybacks for high-efficiency equipment range from 4 to 8 years, which is longer than most commercial customers are willing to accept without some other incentive. As a result, rebates, standards, or more innovative approaches may be necessary to improve current penetration. This represents a significant untapped demand side management potential since only a handful of the 50 largest gas utilities in the United States currently offer any type of incentive for the installation of high-efficiency gas cooking equipment.

Endnotes

1. Historically, commercial cooking accounts for 7 to 14% of total gas commercial gas consumption, depending on the exact year analyzed, and averages about 10% of total use.

2. It is not clear from this report whether the inventory and energy use numbers given for ovens include ovens used as the base of a range top, or only cover free-standing ovens.

3. Pacific Gas and Electric has been working with a coalition of industry representatives to develop such test procedures as well as to subject various appliances to testing using them. Standardized procedures are currently available for griddles, combination ovens, range tops and deep fat fryers; procedures for steamers and ware washers are under review. Results of testing that has been completed to date using these procedures is available in the Kitchen Monitor, published by Cahners.

4. A predecessor to this all gas clamshell was a gas bottomed griddle with a quartz electric top. These were manufactured by two companies both of which have discontinued the product because the quartz lamp tops were difficult and expensive to replace, causing customer dissatisfaction. In addition, there was some concern over contamination of the food product with glass if the quartz lamp ever burst.

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