What's Cookin'? A Suite of Gas Efficiency Technologies for Commercial Kitchens

Mary Horsey, E Source

ABSTRACT

The U.S. food service industry has the highest energy intensity of any facility type in the commercial sector, with food service facilities using three times more energy per square foot than most other types of commercial buildings. Cooking accounts for one-quarter of energy consumption by the food service industry overall and, at 9 percent, is the third-largest operating expense after labor costs (49 percent) and lease/rental payments (17 percent) for typical food service establishments. Utilities often find food service to be a difficult sector to obtain energy-efficiency savings from because restaurant owners tend to place a higher priority on dealing with other cost issues, such as increasing food prices (Iida, 2009). In addition, manufacturers have been reluctant to redesign equipment to improve efficiency, concerned that food taste and appearance could be negatively affected. However, with baseline full-load equipment efficiencies in the 20 to 30 percent range and part-load efficiencies, where equipment spends much of its time, in the 5 to 10 percent range, this sector is ripe for improvements (Cole, 2011). The inefficiency of the equipment is compounded by the fact that these devices are often turned on as soon as the workday commences and stay on at a high setting until long after the last meal has been prepared.

The purpose of this paper is to raise awareness of some new and emerging energy-efficient commercial kitchen technologies that are likely to appeal to food service owners and operators for their non-energy benefits as well as their efficiency. Program managers may find these characteristics to be helpful in bringing about the uptake of efficient kitchen equipment in an often hard-to-reach sector. We'll look at four innovative technologies—one commercially available and proven, one due to be commercially available at the end of the year and currently undergoing field-testing, and two that are now emerging. These technologies were chosen for their potential to improve efficiency by as much as 63 percent without compromising the quality, flavor, or appearance of prepared food products (Table 1, next page). Some of these technologies offer such high energy savings over the baseline that they are attractive simply for that reason. Others offer more modest energy savings with impressive non-energy benefits such as lower oil costs or higher production rates, as illustrated by names that conjure images of speedy cooking: Turbo Pot and Rocket Fryer. One technology, a water heater, although not strictly considered a cooking end use, does contribute to maintaining a sanitary kitchen environment. In addition, water heating accounts for about 16 percent of kitchen energy end-use with few cost-effective efficiency improvements available. Whether the primary driver for adoption is energy savings or non-energy benefits, we believe these technologies have the potential to transform the market for commercial kitchen equipment, so we also recommend strategies for utilities that are interested in incorporating these products into their energy-efficiency programs to meet increasingly ambitious goals.

Table 1. Benefits and Commercialization Status of Four Key Food Service Technologies

Technology	**Energy benefits (%)** [efficiency increases over standard technology]	Non-energy benefits	Commercialization status
Turbo Pot	51–63	Low cost, boosts efficiency of open-flame gas range, increases food production rates	Commercially available
Advanced Underfired Charbroiler	50	Improves occupant comfort by reducing space heating	Commercially available December 2012
Rocket Fryer	16	Sizable oil cost reduction plus performance improvements	Production-ready, no release date yet
Hybrid optimized tankless (HOT) water heater	15	Plug-and-play replacement for legacy equipment	Emerging, prototyped but no final design

© E Source; data from the Food Service Technology Center and the Gas Technology Institute

Introduction

Recent research efforts, funded primarily by the California Energy Commission's Public Interest Energy Research (CEC PIER) program and conducted by the Gas Technology Institute (GTI) have resulted in the development of commercial kitchen equipment with improvements in energy efficiency and/or performance improvements that make them stand out well above the norm. With energy costs for food service facilities accounting for between 25 and 30 percent of operating expenses and 60 percent of energy consumption driven by cooking (30 percent), refrigeration (19 percent) and sanitation (10 percent), owners of food service establishments are hungry for efficiency opportunities that can improve operating performance and the bottom line (Abadir, et al., 2008).

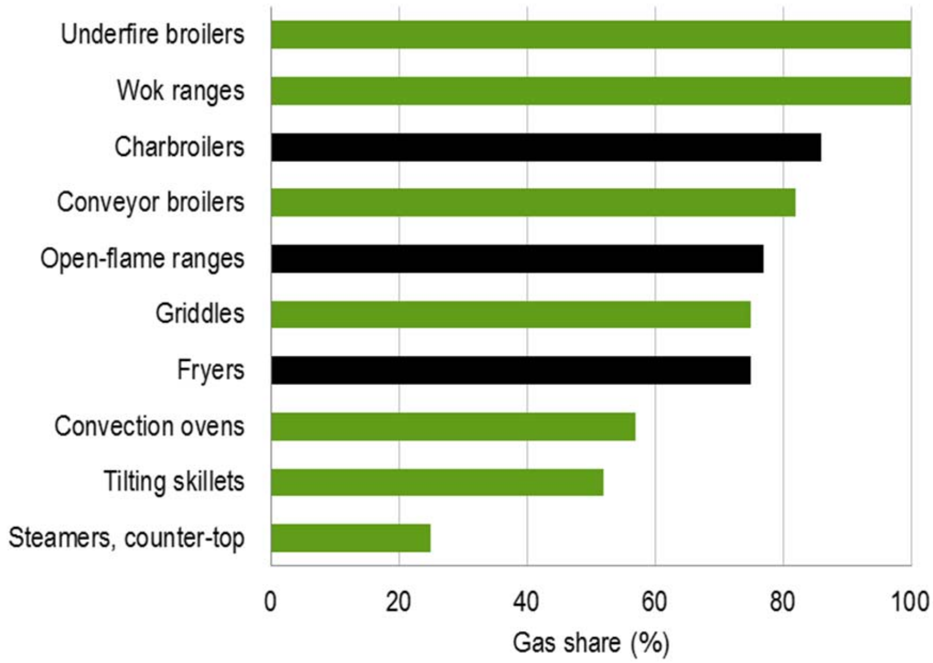
This paper will examine four gas-fired commercial kitchen technologies—the Turbo Pot, the Advanced Underfired Charbroiler, the Rocket Fryer, and the hybrid optimized tankless water heater—that offer either large efficiency improvements or modest efficiency improvements combined with significant non-energy benefits. If we consider the Turbo Pot in combination with an open-flame range, these three kitchen equipment technologies represent the mid- to upper range of relative energy consumption in commercial kitchen equipment (Figure 1, next page).

The technologies range from being commercially available or poised for commercial availability, being production-ready but stalled, and just emerging from prototype phase. For each technology we'll offer as much information as is currently available to assist utility program managers who might be considering creating incentive measures, including, where available, technology overview, efficiency testing, economics, market drivers, potential barriers, market presence, and utility program(s).

Turbo Pot

Of the nearly 300,000 estimated food service establishments in the U.S., nearly all have at least one gas-fired range used to maintain a pot of simmering water as well as other pots for heating up and cooking food (Iida, 2009). Turbo Pots replace the conventional pots used in that environment and are available in a variety of shapes and sizes: stainless steel sauce pans, sauce pots, and stock pots in capacities ranging from 3.5 to 39.0 quarts plus aluminum frying pans, both uncoated and non-stick models, in 8- and 10-inch sizes.

Figure 1. Relative gas share of typical commercial kitchen equipment



Technology Overview

The Turbo Pot design is a remake of standard restaurant-quality cooking pots that incorporates metal fins into the base of the pots to improve convective and conductive heat transfer into the pot, thereby boosting cooking efficiency. Cookware manufacturer Eneron has taken this novel approach to help restaurants achieve significant savings when using their indispensible but notoriously inefficient commercial gas-fired ranges. An upgrade as simple as a new set of stock pots could mean a 50 to 60 percent increase in open-flame gas-range cooking energy efficiency for the food service industry (Sorensen, et al. 2008).

The inspiration for the new design came to Eneron founder Lee Huang when he was shopping around for a range for his newly remodeled kitchen, and discovered that the gas range he preferred to cook on was only 25 to 35 percent efficient at getting energy from the range into the food, compared to 65 to 75 percent for electric ranges and 85 percent for induction ranges (Huang, 2009) (Figure 2, next page). Undaunted, he wondered if there was a way to improve heat transfer from the burner flame to the cooking pot, and he began to tinker.

Standard pots allow the flame to slide ineffectively around the smooth bottom of the pot and up the sides. After a period of trial and error, Huang developed a design with fins that capture and guide the burner flame into channels, creating turbulent flow as the hot gases contact the fins and increasing the surface area for heat transfer. The fins are easy to clean yet sturdy enough for the rigors of commercial food service.

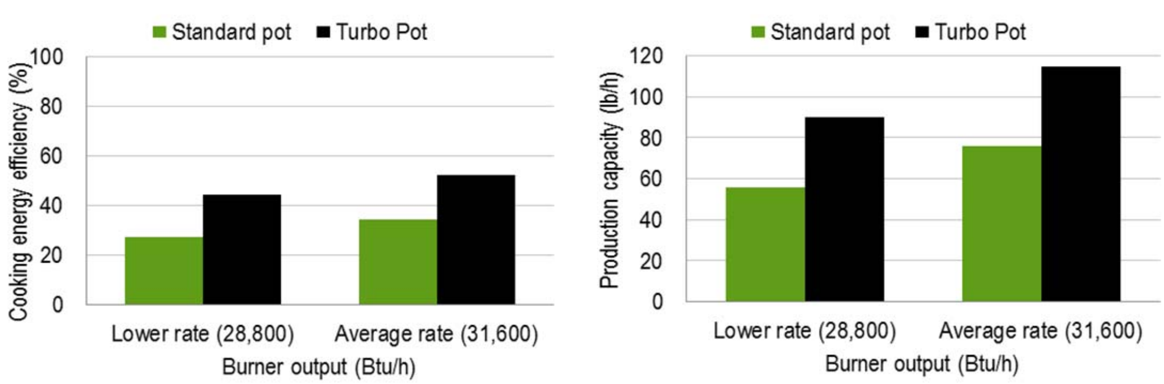
Figure 2. A Turbo Pot's fins capture the flames that would otherwise be lost around the side of the pot

Photos courtesy of Eneron

Efficiency testing. In its laboratory in San Ramon, California, the Food Service Technology Center (FSTC) measured and compared the efficiency and production capacity of open-flame gas range tops using a Turbo Pot and a standard commercial stock pot of the same size. At full burner output, the test measured the time required to heat 20 pounds of water from 70° to 200° Fahrenheit and calculated the cooking energy efficiency—the percentage of energy consumed by the range that ultimately reaches the water (Sorensen, et al. 2008).

The results varied with burner firing rate, but in all cases the Turbo Pot out-performed the standard pot by a wide margin. At an average burner energy rate of 30,000 Btu per hour, Turbo Pot efficiency increased by 49 percent over the standard pot. At 22,000 Btu per hour, efficiency increased by 81 percent. Similar gains were seen in production capacity—the amount of food a burner can cook in a given time. Capacity increased by 49 and 78 percent respectively (Figure 3). The Turbo Pot also consumed 28 percent less energy than a standard pot when holding water at a steady simmer.

Figure 3. Turbo Pot Cooking Energy Efficiency and Production Capacity Improvements over Standard Cooking Pot



Notes: h = hour; lb = pound.

© E Source; data from the Food Service Technology Center

Open-flame gas ranges are approaching their design limit for additional improvements in terms of combustion efficiency and flame distribution. Turbo Pots offer the best opportunity to effectively boost the efficiency of gas range cooking. The FSTC estimates that cooking food in a Turbo Pot on a standard-efficiency gas range (25 to 30 percent efficient) increases the effective efficiency to over 40 percent; on higher-efficiency gas ranges (30 to 35 percent efficient), the Turbo Pot raises effective efficiency to nearly 60 percent (Sorensen, et al., 2008).

Economics. A 24-quart Turbo Pot stockpot costs approximately $190 compared to about $140 for a standard version. The annual energy savings for a pot is $327 at an energy cost of $1.00/therm (this assumes a typical usage pattern of six hours/day, six days/week), yielding a simple payback period of seven months.

Market drivers. The Turbo Pot can significantly boost the efficiency of gas ranges and cut energy costs for very little investment, at a time when commercial kitchen operators are becoming more aware of the impact of energy costs on their bottom line. Chefs appreciate the fact that Turbo Pots do not negatively affect the look and taste of the food product. But because these pots cook food more quickly, chefs will have to adjust their cooking process in one of two ways. They can keep the same production rate by turning down or derating the burners—which will also save energy—or, if there is an opportunity to serve more customers, chefs can maintain the same burner firing rate but experiment with cooking food faster and adjusting their processes as necessary. The second approach can potentially increase profits by increasing the amount of food produced in a given period with little or no impact on energy costs.

Potential barriers. The Turbo Pot's fins make it look quite different from the standard pot, which could be off-putting to food service staff. And because a Turbo Pot cooks food more quickly, chefs will have to learn how to create the desired results in the shorter cooking time.

Market presence. The Turbo Pot is seeing some promising uptake in the commercial market, especially with chain restaurants. Carrabba's Italian Grill cooks pasta to order in open stock pots; it piloted the Turbo Pot in two of its restaurants. The goal was to reduce energy costs while maintaining the same production rate by derating the burners. This retrofit achieved an annual per-burner savings of 240 therms with four hours of continuous daily use. The simple payback period, including the delivered cost of the pot and burner derating cost, is approximately 6.5 to 9.0 months, depending on original burner rating. Carrabba's has begun a chainwide rollout of Turbo Pots (Huang, 2011). Extending Carrabba's energy reductions to the estimated 161,000 full-service restaurants in the U.S. could yield annual energy savings ranging from 39 million therms (derating one burner) to 232 million therms (derating six burners) (Iida, 2009). This is equivalent to the annual household natural gas use of nearly 100,000 to over half a million households in Southern California.[1]

The Cheesecake Factory restaurant chain is taking advantage of the Turbo Pot's ability to cook food more quickly. Notorious for long waiting lines, the restaurant is experimenting to see whether Turbo Pots can be used to increase food production rates, so that more customers can be served in the same amount of time. Since deploying various models and sizes of Turbo Pots in all 11 new restaurants it opened in 2011, the chain has experienced what it terms "significant" reductions in wait times (though it won't publicly announce its exact savings).

---

[1] Assuming average annual household natural gas use of 400 therms for a three-resident household (www.physics.uci.edu/~silverma/actions/HouseholdEnergy.html).

Two Turbo Pot models are also available for the residential market—a pasta cooker/steamer stockpot and a tea kettle—both of which should appeal to busy families who could appreciate both the reduced cooking times and the energy savings.

Utility programs. A small handful of utilities offer rebates and incentives for the Turbo Pot, including Southern California Gas (SoCalGas), San Diego Gas and Electric, Pacific Gas and Electric, and Energy Trust of Oregon. Some offer point-of-sale rebates, while others give away limited numbers as part of their marketing and education programs. The programmatic details and lessons learned from SoCalGas's program are instructive.

SoCalGas has about 35,000 restaurants in its service territory, as well as hotels, prison kitchens, and institutional cafeterias. The utility is encouraged by regulators to create new incentive measures for proven emerging efficiency technologies that can contribute to market transformation. It chose the Turbo Pot to help meet this goal.

The Turbo Pot measure was launched as a point-of-sale program; it rolled out with a large initial incentive of $75 for the first six months, and then reduced the incentive to $50 for the next six months. The incentive will ultimately be reduced to $25 and remain at that level. In addition, SoCalGas's account executives give brochures to their chain restaurant accounts. To engage all the little mom-and-pop restaurants that don't have a dedicated account manager, SoCalGas enlists the help of nearly 100 service technicians who go out on daily service calls to its smaller customers. And Eneron provided small sauté pans that the technicians carry on their trucks so they can give the customer a brochure and show them what a Turbo Pot actually looks like. Rebate applications count toward the technicians' goals, too, so they sign the brochure and get credit for the sale when the application is returned to SoCalGas. Preliminary data shows that the utility's technicians are quite effective in encouraging smaller customers to purchase Turbo Pots, generating about 150 applications in a 10-month period.

Based on the experience, SoCalGas recommends setting the incentive at $75 for the entire program cycle. This would help encourage customers, who might initially be dissuaded by the pot's appearance, to give this new technology a try. In developing its incentive measure, SoCalGas calculated savings of 44 therms per Turbo Pot per year (Dourigan, 2012).

Given the relatively low incremental cost of the Turbo Pot and the fairly generous incentive from SoCal Gas, some might wonder if there were any free-ridership issues. SoCalGas explains that the California investor-owned utilities are mandated to "create market pull" for emerging technologies that help utilities meet the Big Bold Initiatives spelled out in California's Long Term Energy Efficiency Strategy Plan. This landmark document acknowledges that in order to meet the aggressive efficiency targets, some new measures may initially have lower benefit-to-cost ratios, but they still contribute to market transformation (Dourigan, 2012).

Ongoing research. The GTI is working with the FSTC to field-test the Turbo Pot in a California restaurant and plans to add two more test sites by mid-2012. When baseline testing is completed, Turbo Pot equivalents will be substituted for all existing standard cookware. Field-testing of the Turbo Pot will help utilities fine-tune deemed savings values for their incentive programs (Cole, 2012).

Advanced Underfired Charbroiler

The North American Association of Food Equipment Manufacturers estimates that there are about 250,000 underfired charbroilers in the U.S. and Canada. Charbroilers impart a unique look and taste that cannot be achieved with other cooking methods, so they are expected to remain in widespread use throughout the food service industry. But once commercialization of the Advanced Charbroiler has been completed near the end of 2012, this new equipment, which offers efficiency improvements of 50 percent over conventional designs, will be promising both as a replacement for aging equipment and in new construction.

Technology Overview

The underfired charbroiler, primarily used to grill meat, consists of a top metal grate placed over gas burners (Figure 4). The equipment is notoriously inefficient—testing at the FSTC found that at full-load output, charbroilers are only about 30 to 35 percent efficient at heating food to a desired temperature. At part-load, the most common real-world operating condition, efficiency can be as low as 6 percent. To provide the signature grill marks that customers expect, charbroilers are often turned on well in advance of being used and are left full-on even when few customers are present to ensure that the grills will be hot enough when needed. The units also place a sizeable load on a facility's HVAC system (Cole, et al., 2011).

Figure 4. Standard and Advanced Charbroilers

Standard underfired charbroiler

Advanced underfired charbroiler

Photos courtesy of the Gas Technology Institute

GTI, with funding from the CEC PIER program, developed the Advanced Underfired Charbroiler. The goal was to create a prototype that would improve real-world cooking efficiency well above the 6 percent part-load level, reduce heat gain to the space, and maintain the signature look and flavor of the cooked product. GTI's prototype included a retractable hood to lower cooking heat loss and reduce the HVAC burden as well as a temperature probe and thermostat control to modulate the burners, maintain cooking setpoint, and reduce idle energy usage. When the operator lowers the hood, the temperature under the hood rises quickly until the thermostat shuts the burners off at the cooking setpoint. Energy efficiency is achieved by lowering the hood and cycling the burners off during idle periods, while maintaining the grill surface temperature required to impart grill marks and charbroiled flavor (Cole, et al., 2011).

Based on GTI's design, two prototype Advanced Underfired Charbroilers were built by Royal Range, a broiler manufacturer. Typical charbroilers have either ceramic or metal fiber burners so one prototype contained ceramic burners and the other metal fiber burners.

Efficiency testing. Test results were similar for the two burner types. Both types achieved performance improvements in preheat efficiency (the grills reached their setpoint temperatures more quickly with less heat when the hood was down) and in idle energy use (they used less energy to maintain grill setpoint with burner modulation while the hood was down). Testers measured cooking energy efficiencies of 45 percent with the hood opened and 52 percent with the hood closed—and both showed improvements of 50 percent over standard charbroiler efficiency (Cole, et al., 2011). The high-efficiency rating achieved even with the hood open demonstrates the benefit of applying thermostatic controls. When few customers are present and the grill is lightly loaded or not loaded at all, the thermostatic control modulates the burners to maintain the grill temperature setpoint instead of leaving the burners on full, as standard charbroilers must.

Economics. The manufacturer intends to begin selling these charbroilers by the end of 2012 and information on pricing is expected soon. A standard charbroiler operating 12 hours per day uses about 250,000 kBtu per year. A 50 percent efficiency improvement would save about 1,225 therms per charbroiler per year—about $1,225 at $1.00 per therm.

Market drivers and non-energy benefits. The Advanced Underfired Charbroiler offers sizeable energy savings potential at a time when food service operators are highly motivated to reduce energy costs and improve the bottom line. And there are non-energy benefits as well. This was evident in tests that confirmed that an acceptable level of cooking quality and cooking experience had been preserved in the new design. The two charbroiler prototypes were evaluated by experienced operators: The head chef at the GTI café and the chefs at the San Ramon Valley Conference Center Cafeteria in San Ramon, California. The GTI chef gave positive feedback on the look and taste of food cooked on the charbroiler and appreciated the ability to close the hood and reduce the amount of heat radiating toward the user and nearby workers.

The San Ramon unit was used by a number of chefs to prepare between 100 and 300 meals per day for at least two weeks. The chefs commented that some time was required to "learn" the cooking characteristics of the broiler compared to their existing unit, but they preferred to cook with the hood down, except at busy times. In addition, they noted that the initial preheat time was reduced from 30 minutes for the old broiler to less than 10 minutes with the hood down (Cole, et al., 2011).

Potential barriers. The main barrier to market penetration of the Advanced Underfired Charbroiler is concern about its ability to maintain the same charbroiled look and flavor and to mimic the cooking qualities that experienced chefs have come to expect from standard charbroilers. The responses of the chefs who tested the prototypes indicate that this is not likely to be a problem, but the survey sample size was small (Cole, et al., 2011).

Market presence. The GTI and the FSTC are currently field-testing a production version of Royal Range's Advanced Charbroiler in two California restaurants. After establishing the baseline energy use of a standard charbroiler in each location, Advanced Underfired Charbroilers will be installed and monitored for performance. Nicor Gas Co. also plans to field-test a production unit at its headquarters building near Chicago. The GTI expects to have a final report on field-tested performance by mid-year 2012 and Royal Range expects to begin offering these charbroilers for sale by the end of 2012 (Cole, 2012).

Utility program. Currently, there are no incentive programs for this technology. However, the GTI/FSTC performance field-testing currently underway should provide sufficient savings data for utilities to build a program around. Nicor Gas Co. plans to use its field-test data to develop an incentive measure (Cole, 2012).

Rocket Fryer

Standard fryers are heavy consumers of energy, but the technology has seen some progress toward energy efficiency. Energy Star standards for commercial fryers have been in place since 2003, requiring a minimum full-load cooking energy-efficiency rating of at least 50 percent and a maximum idle energy rate of 9,000 Btu/hour. By 2009, Energy Star–rated units made up about 12 percent of all tracked shipments (Scott, 2011). The fryer technology discussed in this paper is about 16 percent more efficient than the Energy Star minimum, and it offers several non-energy benefits—low oil use, fewer hot spots, and continuous filtering—which are likely to be the drivers for market adoption.

Technology Overview

Deep-fat fryers are one of the most common equipment types in commercial food service kitchens due to their ability to cook food quickly. They typically feature two side-by-side baskets and a deep well for oil. Each basket can cook 1.5 pounds of french fries in about 3.5 minutes. The oil is typically heated from beneath the well with an atmospheric burner or via fire tubes in the well walls. The well is designed with a remote volume of cool oil (the “cold zone”), where crumbs and sediment can collect before being filtered out. Lower oil temperatures lessen the carbonization of sediment in hot spots, a process that can create harmful breakdown products that limit oil life. Because the fryer must be shut down during the filtering process, restaurants are sometimes reluctant to filter as often as recommended.

Recently, food service providers’ concerns about rising energy costs coincided with increasing public awareness of the potential health hazards of fried foods in general and of trans-fat oils in particular. They are seeing a rising cost for trans-fat-free oils and are worried about the negative effects of “hot spots” on oil quality. This confluence of trends has encouraged research into higher-efficiency fryers that use a lower volume of oil.

With funding from the CEC PIER program, the GTI set out to develop a gas fryer that reduced energy costs, improved performance, and reduced oil consumption. The new model, called the Rocket Fryer, incorporates an innovative heat exchanger and oil-pumping system that uses recovered heat from the flue gas to heat the oil as it is circulated through the system. This technique improves energy efficiency, provides a lower average frying oil temperature, and eliminates hot spots (Cole, 2008). The Rocket Fryer uses one-third less oil than standard fryers but maintains typical fryer production capacity without changing the look or flavor of the cooked food. The GTI team also devised an improved filtering system that continuously removes sediment from the oil and can be emptied without having to interrupt the frying process. The Rocket Fryer can be used in any food service facility that cooks fried food.

Efficiency testing. In laboratory testing, the GTI found the Rocket Fryer to have a cooking energy efficiency of about 60 percent. Field-testing of the fryer was conducted by the GTI and the manufacturer, but those results are not publicly available.

Economics. Operating 12 hours per day, 365 days per year, the Rocket Fryer will consume about 887 therms—yielding an annual energy and cost savings of about 536 therms and $536 (at $1.00/therm) compared to a standard unit. Over the course of a typical 12-year expected lifetime, one Rocket Fryer will save nearly 6,500 therms, or about $6,500. Even better news for consumers, however, is the cost savings from reduced oil volume in the fryer. Using 35 pounds of oil instead of the standard 50 pounds should result in an annual costs savings of about $1,000 per year in units that use trans-fat-free oils (Cole, et al., 2011). Because a production date has not yet been set by the manufacturer, no price point is available at this time, so it isn't possible to calculate a simple payback period or ROI.

Market drivers and non-energy benefits. The Rocket Fryer is about 16 percent more efficient than a fryer that meets the minimum Energy Star rating, but non-energy benefits may play an equally important role in market transformation. Potential annual cost savings of nearly $1,500 from the Rocket Fryer's energy-efficiency improvements and oil cost savings alone should catch the attention of the food service industry. Performance improvements such as maintaining a consistent oil temperature, the elimination of hot spots that cause oil degradation, continuous filtering, and the ability to remove sediment without shutting down the frying process are also likely to contribute to a successful rollout of this technology (Cole, 2008).

In addition, the GTI reports that some quick-service restaurant chains, responding to their customer's concerns, are trying to become more energy efficient, reduce their carbon footprint, and provide healthier food products. One aspect of "greening" their facilities is pushing efficiency down the supply chain by asking manufacturers to produce new equipment that is more energy efficient and that produces a healthier food product (Cole, 2012).

Potential barriers. Neither the potential for negatively affecting the look and taste of the food product nor expected cooking qualities are a major concern for commercial fryer technology. However, buyers will want to be sure that they can maintain the same production capacity as a standard fryer. Prototype testing has demonstrated that capacity.

Market presence. Though the manufacturer developed and successfully field-tested production models of the Rocket Fryer, the company recently suffered successive changes in top management, and final production is currently on hold.

Hybrid Optimized Tankless (HOT) Water Heater

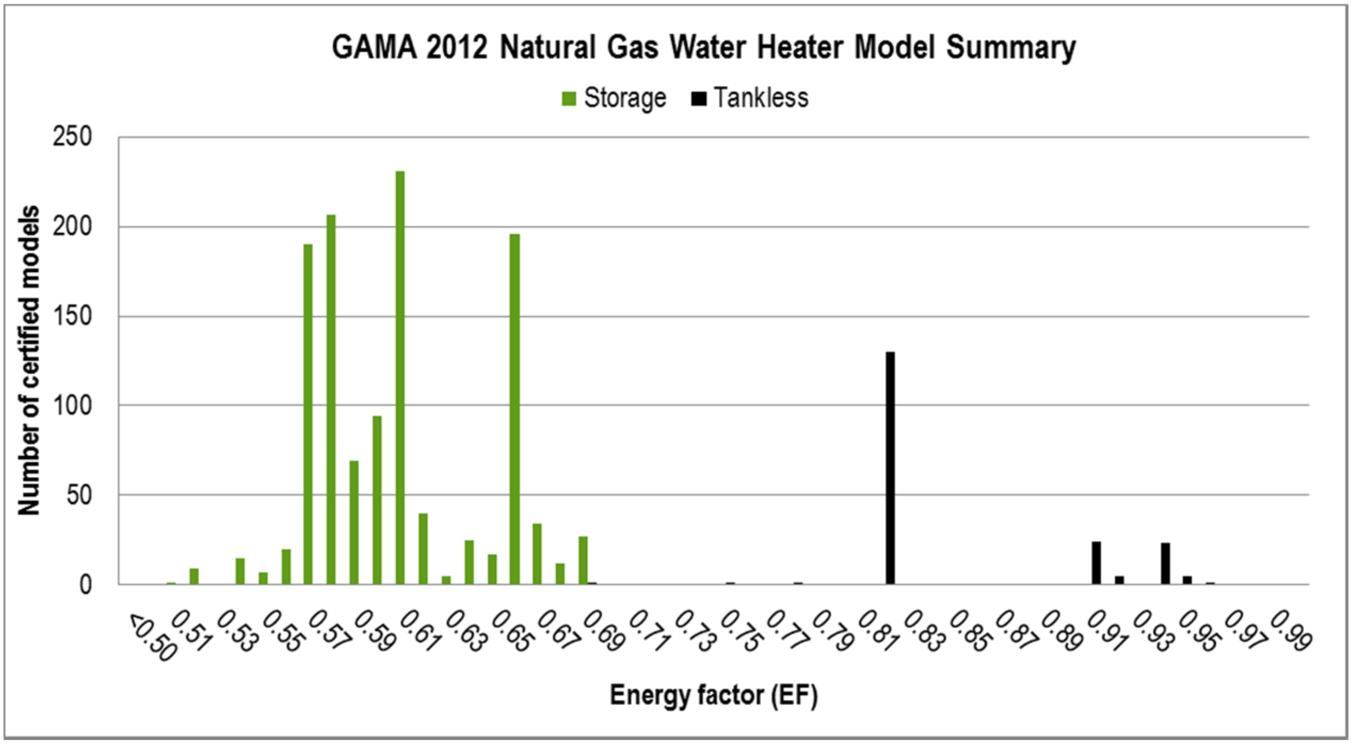
Though water heaters are not considered cooking appliances, per se, we have included them because they make up 16 percent of energy consumption by end use for U.S. full-service and quick-service restaurants, and the water they heat is used directly for cooking, among other things. When combined with cooking energy consumption, water heating and cooking end-uses account for over 40 percent of all energy use in food service facilities (Iida, 2009). Despite long-term energy-savings potential, restaurant owners typically purchase the least expensive residential storage-type water heater available, with energy factors (EF, a measure of a water heater's overall energy efficiency with a maximum of 1.0) in the range of 0.59 to 0.62. The water heater market is currently being flooded with new high-efficiency tankless models as well as condensing equipment in both tank and tankless models. With energy factors of 0.8 and above, these new models are getting a lot of attention. However, their high cost is preventing them from helping to move the replacement water heater market beyond the current federally mandated minimum levels. The emerging HOT water heater seeks to improve efficiency using a cost-effective combination of off-the-shelf tank and tankless parts along with some advanced controls to offer an affordable, plug-and-play water heater for the replacement market.

Technology Overview

The HOT water heater prototype combines a 20-gallon storage tank with a 75,000 Btu/hour tankless-type gas burner to create a midrange-efficiency, cost-effective unit that delivers plentiful hot water at a consistent temperature and fills an efficiency gap in available water heaters (Figure 5, next page). Water heaters tend to fail catastrophically at their end-of-life and the opportunity to increase the efficiency of existing stock is lost when there are no midrange-efficiency models available for replacement at a modest cost increase. Most of the more than 100,000 food service establishments in California, for example, use residential tank-type water heaters that just meet minimum Energy Star efficiency standards. The widespread use of tankless water heaters that offer 0.8 EF or higher could lead to statewide energy savings of close to 100 million therms per year, but they have been significantly limited in their market penetration by high first costs and high installation costs due to required gas piping and venting upgrades in retrofit applications.

With funding from the CEC PIER program, a project team from the GTI, working in partnership with a major manufacturer, designed and tested laboratory prototypes of a replacement hybrid water heater to meet midrange efficiency needs at a reasonable cost. These new HOT water heaters have an efficiency range of 0.71 to 0.73 EF, about 15 percent better than conventional water heaters, and they can be installed using existing gas piping and venting. By directly heating water for consumption while providing a minimum storage volume, the HOT water heater minimizes the performance problems of tankless units by reducing cold draws and water waste while providing a stable water temperature on demand for dynamic loads and flow rates—all at a cost-effective price point.

Figure 5. Distribution of Residential Gas-Fired Water Heater Models by Energy Factor



© E Source; 2012 data from AHRI

Market drivers and non-energy benefits. Though the HOT water heater offers a 15 percent efficiency improvement over standard units, non-energy benefits are likely to play a large role in market transformation. Its affordable cost and plug-and-play design are likely to encourage trade allies to stock these units, carry them on their trucks, and offer them as cost-effective replacements for standard units when responding to water heater failure calls. Code changes may also help to drive the market. Several industry groups—including the American National Standards Institute (ANSI) and the Air-Conditioning, Heating, and Refrigeration Institute (AHRI)—are collaborating on the development of water heater venting categorization standards, similar to those established for warm-air furnaces in the National Fuel Gas Code. This standardization would work to the advantage of the HOT water heater design because it would be able to use Category I, or existing, venting while other high-efficiency water heaters will likely be required to use the more costly Category II venting.

Market presence. Details concerning the release of a hybrid gas water heater compatible with Category I venting have not been disclosed. Currently there are several hybrid gas water heater products on the market but none meet the specifications of the HOT unit.

Conclusion

In aggregate, these four technologies have the potential to reduce energy consumption in a typical food service establishment by about 3,600 therms/year, enough to supply the average annual gas use for (9) three-resident households in Southern California. When expanded to the estimated 161,000 full-service restaurants in the US, the savings would meet the gas use of nearly 1.5 million households[2] -- demonstrating the potential power of emerging technologies to transform a hard-to-reach market that is dominated by notoriously inefficient equipment and a business model that favors flavor and throughput over energy costs. Although food service operators are increasingly concerned with energy costs, they must weigh other factors, such as maintaining the look and taste of their food products, even when considering energy-efficiency improvements that could yield large cost savings. In many cases, food service operators will be more motivated by non-energy benefits, like oil cost savings or plug-and-play equipment replacement, than simply by reduced energy costs. This mix of technologies offers program managers multiple avenues to pursue in marketing a suite of efficient food service measures while still offering impressive efficiency improvements. In all four cases, these existing and emerging technologies offer utility program managers and implementers an opportunity to use their incentive programs to move commercial kitchen energy efficiency forward.

References

Abadir, E., M. Dare, A. Dietemann, A. Doeschot, K. Erickson, M. Guilfoyle, A. Khan, and K. Lewis. 2008. *Cooking Up a New Approach for Program Design II: A Recipe for Success.* Paper presented at the American Council for an Energy-Efficient Economy Summer Study, Pacific Grove, CA, August 17–22.

Cole, Tim (Gas Technology Institute). 2012. Personal communication. February 14.

Cole, Tim, Paul Glanville, Frank Johnson, Dave Kalensky, and Douglas Kosar. 2011. *Advanced Gas Appliance Development.* PIER Final Project Report CEC-500-2010-034, Des Plaines, IL.: Gas Technology Institute.

Cole, Tim, Steve Savage. 2008. *Advanced Design Commercial Foodservice Fryer*. Slide presentation at the International Gas Union Research Conference, Paris, France. Oct 7–10.

Dourigan, Allison (Southern California Gas Co.). 2012. Personal communication. February 29.

Huang, Lee. 2011. *National Account Case Study: The Turbo Pot.* Slide presentation at the Energy Solution Center's Technology & Market Assessment Forum. Oct 25–27, 2011.

Huang, Lee (Eneron). 2009. Personal communication. April 16.

Iida, Yuki. 2009. *Restaurants Sector Snapshot.* MAS-S-22. Boulder, CO: E Source.

Scott, Shawn, Frank Johnson, and Tim Cole. 2011. *Cooking for Profit Magazine*. August 15.

Sorensen, Greg, and Dave Zabrowski. 2008. *Eneron, Inc. Prototype Commercial Stock Pot Testing.* FSTC Report 5011.08.12. San Ramon, CA: Food Service Technology Center.

[2] Assuming annual savings on a per facility basis of: (2) Turbo Pots at 240 therms each, Charbroiler at 2,500 therms, Fryer at 536 therms, and HOT water heater at 50 therms. Annual household gas use of 400 therms.