Baseline Market Conditions for Efficient Commercial and Industrial Gas Technologies

Martha J. Hewett, Mary Sue Lobenstein, Center for Energy and Environment
Susan K. Nathan, Minnegasco
William Krauss, Krauss and Associates

Baseline data on efficient commercial and industrial gas technologies were gathered for a major Midwestern utility to assist in the planning, design and implementation of customer energy services. The market factors investigated included:

- key trade allies for each product and trade ally roles for each sector
- total annual sales of each type of appliance or equipment in the utility's service territory
- current market share of efficient models
- inventory practices for each type of equipment, inventory levels of efficient models, and other factors that affect availability
- incremental costs of efficient models
- trade ally awareness of and attitudes toward efficient equipment
- trade ally input and feedback on potential elements of the utility's energy services program.

Extensive interviews were conducted with manufacturers, manufacturers' representatives, distributors, heating, ventilating and air conditioning (HVAC) engineers, commercial kitchen designers and contractors/ dealers.

Targeted appliances and equipment were those which account for a large amount of total gas use, have a significant range of efficiency options available, and were thought to have a relatively low current market share of efficient models or features. Commercial equipment investigated included boilers, unit heaters, radiant heaters, year round air conditioners (''rooftop units''), vertical air turnover furnaces, gas cooling equipment, storage water heaters, fryers, griddles, booster heaters, ware-washing equipment, ranges and ovens. Industrial equipment investigated included boilers, grain dryers, industrial ovens, metal processing and metal melting furnaces, thermal oxidizers, air floatation dryers and spray dryers.

The findings are generally transferable to many other areas of the U. S., and provide valuable insights on energy services opportunities for commercial and industrial customers.

INTRODUCTION

The utility has approximately 53,000 commercial and industrial customers, accounting for 61 million dekatherms of gas sales. The company has operated substantial energy efficiency programs since 1980, and in 1993–1994, undertook an ambitious effort to redesign its customer energy services. One aspect of this initiative was a major research project which gathered baseline data on high-efficiency appliances and equipment. In 1994, extensive interviews were conducted with the utility's key trade ally groups: contractors, dealers, distributors, manufacturers' representatives, manufacturers, architectural and engineering (A/E) firms and kitchen design firms.

The baseline data gathered in the surveys included:

- key trade allies for each product and trade ally roles for each sector

- total annual sales of each type of appliance or equipment in the utility's service territory
- current market share of efficient models
- inventory practices for each type of equipment, inventory levels of efficient models, and other factors that affect availability
- incremental costs of efficient models
- trade ally awareness of and attitudes toward efficient equipment
- trade ally input and feedback on potential elements of the company's energy services program.

The project (Hewett et al. 1994) covered residential, commercial and industrial gas technologies, but this paper covers only the commercial and industrial sectors. The information obtained was used in reviewing existing energy services and designing new services to promote efficient gas-fired appliances and equipment.

The equipment and appliances analyzed were selected based on the relative importance of each gas end use to the utility's system sales and load shape objectives, the relative importance of each equipment type within a given end use, the range of efficiency options available, and the estimated current market share of high-efficiency equipment.

METHODOLOGY

In order to assure that data were collected from those sources who are the most knowledgeable and who have the greatest influence on customer decisions, exploratory interviews were conducted with trade associations, with companies at various levels in the distribution system, and, for the industrial sector, with customers to determine which trade ally groups play key roles in each sector. Based on this, the commercial HVAC and service water heating (SWH) interviews focused on manufacturers' representatives, distributors, architectural and engineering (A/E) firms, and contractors/dealers. The commercial cooking interviews focused on manufacturers' representatives, commercial kitchen designers, and contractors/dealers. Manufacturers of commercial HVAC, SWH and cooking equipment were not included because they had been interviewed extensively in a previous project (Krauss, Hewett & Lobenstein 1992; Lobenstein, Hewett & Nathan 1994). The industrial interviews were targeted primarily to manufacturers since the exploratory work determined that much equipment in the industrial sector is sold directly by them. Supplemental interviews of industrial manufacturers' representatives and architectural and engineering firms were also conducted.

To cost-effectively meet the need for reliable information on a broad range of gas-fired equipment, stratified samples were designed that recognized the structure of the gas appliance industry. Interviews of manufacturers, manufacturers' representatives and distributors focused on those companies that account for at least 80% of total sales, and added those small players known to produce or handle unique high efficiency products. By targeting the key players and working to achieve a high response rate, statistical reliability was achieved much more economically than would be possible through a random sample. Data on manufacturers' market shares came from previous work (Krauss, Hewett & Lobenstein 1992; Lobenstein, Hewett & Nathan 1994) and from the exploratory interviews. The key manufacturers were then contacted to identify all of their representatives for Minnesota and their distributors located in counties the utility serves. The sample of A/E firms came from an association directory considered by the local industry to represent 80% to 90% of the HVAC design work in the state. Screening interviews of 600 HVAC contractors determined the proportion of their work in the commercial and residential sectors, and this was used as a stratification variable in assigning them to the primary interview samples.

Each type of information required was gathered from the most appropriate players in the distribution network. Data were collected through telephone interviews in late 1993 and early 1994. Pre-calls, letters of introduction, repeated contacts, scheduled appointments, incentives (for HVAC engineers and commercial kitchen designers) and other strategies were used to maximize response rates. Response rates of 100% were achieved for many sample groups, and response rates over 77% were achieved for all groups except two very small samples of industrial equipment manufacturers. Data were analyzed using SPSS (SPSS 1993), a comprehensive statistical analysis package.

RESULTS

This section reports the findings of the study regarding trade ally roles for each sector, sales volume of key gas-fired products, the market share of high efficiency features for each of these products, and the incremental costs of equipment with these features. It then describes the findings regarding the path to market and inventory practices for each type of equipment, trade ally awareness and perceptions of efficient products, and feedback from trade allies on utility project design. Finally, it briefly describes the new projects developed on the basis of this research.

Trade ally roles by sector

In the commercial HVAC sector, key trade allies include the manufacturers' representatives, A/E firms, distributors,

and contractors/dealers. Either an A/E firm or a contractor/dealer can have the largest influence on the customer, so utility projects need to work effectively with both of these groups. Both A/E firms and mechanical contractors obtain most of their technical support from local manufacturers' representatives, so the representatives' views of efficient equipment and utility project offerings will have a significant impact on project success.

Distributors are also important in the commercial sector for two reasons. First, a majority of commercial heating equipment is sold from distributor inventory, so stocking practices for efficient equipment will have a major impact on utility projects. Second, smaller contractors/dealers working in the commercial sector rely on the distributor for technical support.

In the commercial cooking sector, the key trade allies are the equipment representatives, the design firms, and the equipment contractors/dealers. There are two types of contractors/dealers. Some only sell and install equipment; others are ''contract'' contractors/dealers who design commercial kitchens as well as sell and install equipment. Inventory, if any, is mostly kept at the contractor/dealer level, although a few pieces may be kept by the manufacturers' representatives.

In the industrial sector, the main trade ally group is the manufacturers, who have far more direct contact with and influence on the industrial end-user than they do in the commercial sector. Some manufacturers also have manufacturers' representatives. Some of these representatives play an extensive role, which includes responsibility for the actual sale of the equipment as well as technical advice and services during and after the sale, while others only serve as the first contact point for an equipment sale. A/E firms were found to play a very minor role in the industrial sector.

Volume of sales of key gas-fired products

Table 1 shows estimated annual sales of key commercial products in the service territory and their typical annual energy use per unit. Sales of industrial equipment could not be estimated because most sales are direct from the manufacturers, who do not track sales by regions as small as a utility service territory. These manufacturers generally sell very few units per year, but each unit uses a large amount of energy annually.

Market share of efficient technologies

The primary objective of the company's regulated energy efficiency services is to increase the market penetration of high-efficiency equipment and appliances. To determine which equipment categories offer the greatest potential for increasing sales of efficient models, the surveys solicited estimates of the current market share of high-efficiency equipment. Estimates obtained from the surveys and previous work are shown in Table 2.

Table 1. *Annual Sales and Energy Use of Key Gas-Fired Commercial Products in the Utility's Service Territory*

Product	Sales, Units/Yr	Energy Use, Therms/Yr per Unit
HVAC, SHW Equipment		
Boilers (input, Btu/h)		
$>$ 150,000 to $<$ 300,000	235	
$\geq$ 300,000 to $<$ 2,500,000	564	
$>$ 2,500,000 and up	91	
TOTAL	890	7,670
Unit heaters	3,222	1,724
Radiant heaters	1,070	Not avail.
Storage water heaters	Not avail.	5,346
Gas cooling	20	Not avail.
Cooking Equipment		
Fryers	442	940
Griddles	329	854

Commercial heating equipment. All commercial heating equipment is rated only in terms of steady-state combustion efficiency. Steady-state efficiency alone does not capture the relative performance of heating equipment under the annual load conditions typical in commercial facilities, so any rebate project designed to increase annual efficiency must be based on both steady-state efficiency and the presence of features which improve seasonal efficiency. These include such features as power venting (forced or induced draft), power burner design, condensing design, and step or full modulation of fuel and air inputs.

The current market shares of power-vented unit heaters, duct furnaces and radiant heaters are relatively low (25% or less), making these promising program targets. The market share

Table 2. *Market Share of Selected Efficient Technologies in the Utility's Service Territory*

Product	Efficiency Level or Feature	Pct. Market Share (Sales-Weighted)
Commercial HVAC and SHW Equipment		
Boilers ≥ 150,000 to < 300,000 Btu/h input	AFUE ≥ 83%	19.1%[a]
Boilers 300,000 to < 1,000,000 Btu/h input:	Power vented/power burner, CE < 85%	17.5–42.8%[b]
	Near-condensing/condensing, CE ≥ 85%	6.0–6.3%[c]
Boilers 1,000,000 to 2,500,000 Btu/h input	Power vented/power burner, CE < 85%	28.9–58.4%[b]
	Near-condensing/condensing, CE ≥ 85%	2.3–3.5%[c]
Boilers 2,500,000 Btu/h input and up	Power vented/power burner, CE < 85%	64.3%[d]
	Near-condensing/condensing, CE ≥ 85%	0.6%[d]
Boilers 300,000 to 2,500,000 Btu/h input	Modular boiler systems	43.8%–52.6%[e]
Unit heaters	Power vented	16.6–25.5%[b]
	Condensing	0.0–6.2%[b]
Duct heaters	Power vented	15.0%[f]
Radiant heaters	Pct of unit heater plus radiant heater mkt	25.0%[g]
Year-round air conditioners (''rooftop units'')	Power vented	100.0%[f]
Vertical air turnover furnaces	Power vented	95.0%[f]
	Intermittent ignition	90.0%[f]
Cooling	Gas-fired cooling	1.0%[h]
Storage water heaters	Integral flue damper or power vent	near 100.0%[i]
	Condensing	< 1.0%[i]
Commercial Cooking Equipment		
Fryers	Infrared	2.5%[d]
	Infrared with built-in filter	0.0%[d]
	Standard with built-in filter	25.3%[d]
Griddles	Infrared	1.0%[d]
	Double-sided	0.3%[d]
Booster heaters	Gas-fired	6.5%[j]
Dish machines	Gas-fired	4.6%[j]
Ranges	Power burner	< 10%[f]
Ovens	Convection	40 to 60%[f]
Industrial Equipment		
Boilers 60 to < 800 hp output	Oxygen trim	17.9%[k]
(2.5 to 33.5 million Btu/h input)	Economizer (feedwater preheat)	2.0%[k]
	Near-condensing/condensing	21.9%[k]
	Modulating burners (both gas and air)	33.2%[k]
Boilers ≥ 800 hp	Oxygen trim	55.6%[k]
	Economizer (feedwater preheat)	73.1%[k]
	Near-condensing/condensing	0.0%[k]
	Modulating burners (both gas and air)	100%[k]

Notes: All results are sales-weighted or project-weighted as appropriate. [a]Distributor survey. [b]Low from distributor survey, high from contractor/dealer survey. [c]Low from contractor/dealer survey, high from distributor survey. [d]Contractor/dealer survey. [e]Low from distributor survey, high from A/E survey. The percentage of modular boilers with optimized design is substantially smaller. [f]National estimate from Krauss, Hewett & Lobenstein 1992 (HVAC) or Lobenstein, Hewett & Nathan 1994 (cooking). Local data were not obtained. [g]Estimate based on several sources. Hewett et al. 1994. [h]A/E survey. [i]Exploratory manufacturer interviews. [j]Commercial kitchen designer survey. [k]Manufacturer interviews.

of power-vented and power-burner boilers increases steadily as boiler size increases, so it could be justifiable to design incentives which decrease in relative terms (i.e., per kBtu of input) with increasing burner size. Power burner incentives for boilers should not be offered for inputs over 4,000,000 Btu/h, a range in which very few manufacturers make natural draft units, and perhaps should not be offered for inputs over 2,500,000 Btu/h, where the power burner market share approaches 65%. Market shares of modulating burner designs were not determined for commercial boilers under 2,500,000 Btu/h, but their market shares are certainly substantially lower than for the larger industrial boilers discussed below, making them a promising program target as well.

The market shares of near-condensing and condensing equipment are quite low for all commercial HVAC equipment, which may justify a second-tier rebate for them. We would not recommend rebating only near-condensing and condensing commercial boilers, because of the greater market barriers for condensing equipment, problems with consistent ratings of combustion efficiency, and the application-specific nature of combustion efficiencies realized in the field.

Past research (Krauss, Hewett & Lobenstein 1992) found that nearly all year-round air conditioners (''rooftop units'') and vertical air turnover (VATO) furnaces that are sold are power vented. Only one manufacturer makes a condensing year-round air conditioner (YAC), and no one produces a condensing VATO furnace. These products were therefore not considered to be good candidates for efficiency programs and were not extensively analyzed in this project.

In addition to equipment selection, system design can play an important role in the overall energy efficiency of commercial buildings, but system design features were examined only briefly in this project and are not discussed here.

Commercial water heaters. Exploratory interviews with commercial water heater manufacturers indicated that, due to the lower standby losses required by the Energy Policy Act of 1992, virtually all commercial storage water heaters manufactured after January 1, 1994 would have either power venting or integral flue dampers, features which provide similar efficiencies. This change eliminated the less efficient units that had dominated the market. Only one manufacturer makes condensing commercial storage water heaters; these currently have a market share of less than 1%. (Condensing commercial water heating systems can also be designed using condensing boilers and insulated storage tanks.)

Commercial cooking equipment. All of the commercial cooking equipment features of interest to the utility had current market shares below 10% except for convection ovens and standard fryers with built-in filtration systems. In previous work (Lobenstein, Hewett & Nathan 1994), independent documentation of energy savings from infrared fryers and griddles was obtained, but no similar documentation was found for double-sided griddles or filtration fryers. To gain some insight, manufacturers' representatives were asked about the performance of these products. While all manufacturers' representatives considered infrared fryers and griddles to be more energy-efficient than standard units, only two-thirds felt that double-sided griddles were more energy-efficient than standard units, and only half felt that filtration fryers were more energy-efficient. Increased productivity may result in lower total energy input, thereby accomplishing the objectives of energy-efficiency projects, but while double-sided griddles can increase productivity, filtration fryers do not. Given the comparatively high existing market share of filtration fryers and the uncertainty about their savings, filtration fryers may not be a high priority efficiency target relative to other options.

Industrial equipment. For industrial boilers under 800 hp, all energy-efficiency features analyzed have market shares of less than 25% except modulating burners. Modulating burners may still prove to be a cost-effective target, especially at the lower end of the size range where the penetration would be the least. Another option would be to promote only modulating burners with very high turn down ratios (10:1), which are believed to have a low penetration among boilers of less than 800 hp. For boilers over 800 hp, the market penetrations of all available efficiency features are already high.

Industrial equipment examined in less detail included grain dryers, industrial ovens, metal processing and metal melting furnaces, thermal oxidizers, air floatation dryers and spray dryers. The patterns found were similar to those for the larger industrial boilers. Large industrial equipment consumes so much energy that efficiency is a primary consideration, and it appears that this has already moved the market toward the higher efficiency options.

Incremental costs of high-efficiency equipment

The incremental costs of high-efficiency appliances and equipment provide a perspective for establishing incentive amounts and must be known to calculate the cost-effectiveness of energy efficiency projects from different perspectives. The trade price premiums to the contractor/dealer and incremental end-user costs for the key products analyzed are shown in Table 3.

Two general points of interest can be noted from review of Table 3. First, the price premium on condensing/near-condensing equipment is considerably higher than the price

Table 3. *Average Incremental Cost of Selected Efficient Technologies in the Utility's Service Territory, Sales-Weighted*

	Efficiency Level or Feature	Size Range	Average Incremental Cost[a] Contractor/ Dealer	End User
Commercial HVAC and SHW Equipment				
Boilers	AFUE ≥ 83% vs. AFUE < 83%	> 150–< 300,000 Btu/h	$508	Not asked
Boilers	Power vented/power burner	≥ 300–< 1,000,000 Btu/h	$802	$1318
	vs. atmospheric burner	≥ 1,000–2,500,000 Btu/h	$1323	$2813
Boilers	Near-condensing/condensing	≥ 300–< 1,000,000 Btu/h	$1584	$1313
	vs. power vented/power burner	≥ 1,000–< 2,500,000 Btu/h	$2364	Not asked
Boilers	Step modulation of fuel and air (high/low) vs. fixed fuel and air	≥ 300,000 Btu/h	$500[b]	Not asked
Boilers	Continuous modulation of fuel and air vs. fixed fuel and air	≥ 300,000 Btu/h	$950[b]	Not asked
Boilers systems	Modular boiler system	1,000,000 Btu/h	8.4%	Not asked
	vs. single large boiler	5,000,000 Btu/h	12.0%	
Unit heaters	Power vented vs. atmospheric unit	60–125,000 Btu/h	$143	$306
		126 187,000 Btu/h	$220	$393
		188–250,000 Btu/h	$235	$525
Unit heaters	Condensing vs. power vented	100,000 Btu/h	$700[b]	Not asked
Radiant heaters	vs. natural draft unit heater	75,000 Btu/h	$840[b]	
		100,000 Btu/h	$980[b]	Not asked
		125,000 Btu/h	$1000[b]	
		150,000 Btu/h	$1325[b]	
Storage water heaters	Condensing vs. atmospheric unit	34 gal, 100,000 Btu/h	$300	Not asked
Commercial Cooking Equipment				
Fryers	Infrared vs. standard	Average	$1036	$550
Fryers	With filter vs. without	Average	$2271	$909
Griddles	Infrared vs. standard	Average	$902	$448
Griddles	Double-sided vs. standard	Average	$2046	$1080
Ranges	Power burner with std oven vs. atmospheric burners with std oven	Four burner	Not asked	$1053[b]
Ovens	Convection vs. deck	Average	Not asked	$1338[b]
Industrial Equipment				
Boilers	Oxygen trim	≥ 60–< 800 hp	13.1%	Not asked
		≥ 800 hp	2.2%	
	Economizer	≥ 60–< 800 hp	10.0%	Not asked
		≥ 800 hp	11.2%	
	Modulation of fuel and air	≥ 60–< 800 hp	6.0%	Not asked
		≥ 800 hp	Std feature	
	Near-condensing	≥ 60–< 800 hp	3.5%	Not asked
		≥ 800 hp	Not available	
	Condensing	≥ 60–< 800 hp	225.0%	Not asked
		≥ 800 hp	Not available	
	Combustion air preheat	60–< 800 hp	Not available	Not asked
		≥ 800 hp	8.5%	

Notes: [a]Trade allies were unwilling to provide incremental costs in dollars for certain products, and gave information only as a percentage. Incremental costs for end-users are for equipment only and do not include incremental installation costs. End user costs were not obtained for some features due to constraints on the length of interviews. [b]From Krauss, Hewett & Lobenstein 1992.

premium on efficient non-condensing equipment. This, together with the greater energy savings and the markedly better savings at the time of the utility system peak, may justify a second-tier rebate for condensing equipment.

Second, when the incremental costs are compared with the typical energy use per unit for various equipment, there is a gross correlation for all equipment categories except for cooking equipment, which has a substantially higher incre-

mental cost relative to its energy use. Though energy-efficient cooking equipment has other advantages which may help to promote sales, it may be difficult to move this market without substantial incentives.

Path to market and inventory practices

The success of a utility conservation project depends in part on the ready availability of qualifying products. The project assessed the following conditions related to market and inventory processes:

- the paths by which various gas-fired products get to market
- the percentage of various products sold from inventory as opposed to special order
- the inventory levels of high-efficiency products
- the lead time for standard and high-efficiency equipment
- the perceived relative availability of standard and high-efficiency equipment

Equipment paths to market. The vast majority of commercial HVAC and SWH equipment goes to market through distributors, so they are key trade allies for these equipment categories. Manufacturers' representatives, including ''stocking'' representatives handle about 23% of commercial boiler sales.

Commercial cooking equipment goes to market through more diverse routes (Table 4), which requires involving more trade allies in utility projects for cooking equipment.

Industrial boilers under 800 hp are sold primarily through distributors and ''stocking'' manufacturers' representatives, though a significant minority are sold directly by the manufacturer (Table 5). The largest proportion of industrial boilers of 800 hp or more are sold directly by the manufacturer or through ''stocking'' manufacturers' representatives (though they are not actually stocked). Other industrial equipment is sold directly by manufacturers to end-users, sometimes with the assistance of a regional representative.

Inventory practices. Since almost all commercial HVAC and SWH equipment is sold through distributors, their inventory practices were investigated in some detail. The vast majority (87%) of commercial unit heaters and a significant majority (63%) of commercial boilers are sold from distributor inventory. A majority of distributors in the service territory reported stocking power-vented unit heaters, but the proportion of high efficiency stock maintained was very low, and probably not adequate to satisfy the demand that would be generated by a rebate project. Only a minority of distributors claimed to stock commercial power boilers, condensing boilers and condensing unit heaters, and the actual inventory levels for these products were near zero.

Commercial cooking equipment contractors/dealers maintain inventories of commercial cooking equipment. Contrary to the utility's expectation, these respondents indicated that 48% of fryers and 70% of griddles are sold from inventory as opposed to special order. The stock of high-efficiency griddles and fryers actually maintained in this area was reported to be nearly zero.

Inventory of small industrial boilers in a wide range of sizes is fairly common, but this inventory is kept at the factory level, not locally. Large industrial boilers (800 hp and larger) and other types of industrial equipment are almost always made to order, rather than inventoried. In those cases where

Table 4. *Commercial Cooking Equipment Path to Market (Sales-Weighted)*

Pct through	Fryers	Griddles
Equipment Dealers	28.2%	70.8%
Contract Dealers	38.9%	20.0%
Manufacturers (Direct)	15.0%	4.2%
Chain Accounts	17.9%	5.0%

Table 5. *Industrial Equipment Path to Market (Sales-Weighted)*

Pct Through	Boilers 60 to < 800 hp	Boilers ≥ 800 hp	Other Equipment
Distributors	46.3%	0.0%	none
Stocking Reps	27.4%	34.1%	none
Other Reps	2.7%	8.9%	major
Manufacturer	17.1%	46.1%	major
Contractor	6.6%	10.9%	minor

some stock of large industrial equipment is maintained, it is kept at the factory and only in very limited sizes.

Lead time. Generally, distributors indicate little difference in lead time (from the date an order is placed to the date of receipt) for standard and high-efficiency commercial HVAC and SWH equipment. On average, the standard equipment is received in about four weeks, and the high efficiency equipment is obtained in 5.5 weeks or less. Commercial cooking contractors/dealers report lead times for commercial cooking equipment that generally range from 3 to 5 weeks, with only slightly longer lead times for high-efficiency equipment. A significant fraction of A/E firms and commercial kitchen designers, however, had the perception that high-efficiency equipment was less readily available than standard equipment within the time constraints of a typical project.

Lead times for industrial boilers range from 1 to 18 weeks (mean of 6 weeks) for units with outputs less than 800 hp, and from 2 to 24 months (mean of 8 months) for units of 800 hp and larger. Lead times for other industrial equipment vary depending on the type of product, but generally range from about 15 to 30 weeks. Selection of high efficiency options does not affect lead time.

Information on relative turnover times of standard and high-efficiency equipment in inventory was also collected, since it is a key factor in profitability. For HVAC equipment, there was little difference in reported turnover time as a function of efficiency. Turnover time for high-efficiency cooking equipment was not available because contractors/dealers only stock standard efficiency options.

For commercial boilers and unit heaters, an average of 67% to 91% of units ordered for inventory were ordered in distributors' top three ordering months, which has implications for the timing of new utility projects.

Trade ally awareness and perceptions of efficient products

A key factor in the success of a utility efficiency project is trade ally familiarity with the equipment that is being promoted. The majority of trade allies consider themselves very familiar with power burner boilers, but only a minority consider themselves very familiar with power vented unit heaters, condensing boilers, condensing unit heaters, or radiant heaters. Engineers' familiarity with gas cooling equipment is lower than with efficient heating equipment, but higher than expected given the low market share of this equipment in the area. All kitchen designers were very familiar with filtration fryers, but half or less considered themselves to be very familiar with infrared fryers and griddles, double-sided griddles, and gas ware-washing equipment.

The majority of representatives and contractors/dealers promote or recommend high efficiency products less than they do standard models. The only high efficiency products that are promoted more heavily than the standard models by any trade ally group are modular boiler systems and filtration fryers.

The relative profitability of high-efficiency equipment is apparently not a disincentive to trade allies. With few exceptions, the profitability of energy-efficient equipment is perceived to be the same as or greater than that for less efficient equipment.

Trade allies were asked for input on the barriers to increased use of efficient products. First cost was overwhelmingly the most often mentioned, and the barrier considered most serious. Lack of familiarity among end users, contractors/dealers and designers was also frequently cited by survey respondents. Technical problems with high-efficiency equipment were mentioned less often and considered to be less serious by trade allies than anticipated, even by contractors/dealers who install the systems and are accountable for their performance to the end users. In general, technical problems were mentioned most often or considered more serious for condensing equipment.

Feedback from trade allies on utility project design

Trade allies were asked about a wide range of potential utility activities, and whether they thought these activities would make a lot of difference, some difference, a little difference, or no difference in the sales and installation of efficient technologies.

HVAC contractors/dealers gave their highest ratings to customer rebates. Cooperative advertising, rebates to contractors, third-party financing (with zero down-payment and positive cash flow), demonstration projects, energy audits, and educational seminars also received strong ratings, while technical assistance from utility staff and funding of engineering studies were not as highly rated. Manufacturers' representatives for commercial HVAC and A/E firms gave the highest ratings to standardized rebates, custom rebates which achieve desired paybacks, and carefully structured third party financing (zero down-payment, positive cash flow). They also rated education projects, demonstration projects and cooperative advertising as making some difference. They did not consider rebates to contractors/dealers, equipment leasing offers, engineering studies, and technical assistance from utility staff to be as effective.

Commercial cooking contractors/dealers thought demonstration projects, rebates to dealers, technical assistance from utility staff, educational seminars and equipment leasing

would be most effective, with lower ratings for customer rebates and energy audits, and the lowest ratings for third party financing and cooperative advertising. Commercial cooking representatives and designers thought rebates to contractors/dealers and designers, third-party financing, educational projects, demonstration projects and cooperative advertising would make the most difference. They gave lower scores to customer rebates than did the HVAC trade allies. Kitchen designers thought design assistance would be quite helpful. They also thought that equipment leasing projects would be effective, but the manufacturers' representatives did not.

Trade allies involved with industrial equipment tended to rate activities similarly to commercial HVAC trade allies, except that they rated cooperative advertising and educational projects as somewhat less effective. These trade allies also indicated that they believe energy audits performed by utility staff would be more effective than audits simply subsidized by the utility.

Trade allies were also given an opportunity to provide open-ended input on their concerns and advice about the utility's regulated energy efficiency services. The major themes expressed by trade allies included fairness of qualifying criteria (meaning primarily that the criteria truly reflect improved efficiency and that most trade allies have units that qualify), adequate advance notification, project promotion/marketing, customer education, project simplicity, and concerns about competition from the utility in appliance sales and service.

New energy services

Several new energy services were initiated for the commercial and industrial sectors as a result of this and other research.

The Commercial/Industrial (C/I) Heating System Rebate project provides rebates to C/I customers to overcome the first cost barriers for high efficiency heating equipment replacements and retrofits. The comprehensive C/I Food Services Project provides equipment design assistance, rebates, and a training facility used to demonstrate efficient food service technologies. The C/I Custom Rebate project provides large volume C/I customers with design assistance and site-specific equipment rebates for energy-efficient process improvements.

CONCLUSIONS

This project identified a substantial number of efficient commercial and industrial gas technologies that currently had low market penetrations. First cost was identified as the most important barrier to increased use of these technologies, and incremental cost figures were generated to assist in the establishment of rebate levels. Information on trade ally roles, inventory practices, trade ally perceptions and other market characteristics provided the basis for effective program design and implementation.

The market share and incremental cost results from this project are in good agreement with our previous work (Krauss, Hewett & Lobenstein 1992; Lobenstein, Hewett & Nathan 1994). The results of the study as a whole should be generally applicable to many other areas of the U.S., and provide valuable insights on energy services opportunities for commercial and industrial customers.

REFERENCES

Hewett, M.J., M.S. Lobenstein, T.S. Dunsworth, W.E. Krauss, M. Niebuhr, J. Melsa, 1994. *Baseline Conditions for Efficient Gas-Fired Equipment in Minnegasco's Service Territory*. Minneapolis, Minn: Center for Energy and Environment.

Hurley, J., K. Shukla, P. Kohil, 1992. *Commercial Appliance Energy Use Update—1989, Final Report*, February, 1992. GRI-92/0225. Chicago, Ill: Gas Research Institute.

Krauss, W.E., M.J. Hewett, M.S. Lobenstein, 1992. *Commercial Gas Space Heating Equipment: Opportunities to Increase Energy Efficiency*. CEE/TR91-3-CM. Minneapolis, Minn: Center for Energy and Environment.

Lobenstein, M.S., M.J. Hewett, S.K. Nathan, 1994. Commercial Gas Cooking Appliances: Current Status and Future Directions. *Proceedings of the ACEEE 1994 Summer Study on Energy Efficiency in Buildings*. Washington, D.C.: American Council for an Energy Efficient Economy.

SPSS 1993. *SPSS for Windows, Release 6.0*. Chicago, IL: SPSS.