GAS DSM AND FUEL-SWITCHING:
OPPORTUNITIES AND EXPERIENCES

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PREFACE

All parties participating in this study recognize the need for and fully support the effort to identify the potential for natural gas demand-side management (DSM), as evidenced by the ongoing partnership of the New York State Energy Research and Development Authority (NYSERDA), the natural gas distribution companies (individually and collectively in the form of the New York Gas Group (NYGAS), the New York State Department of Public Service (DPS) and the New York State Energy Office (NYSEO).

This study represents an important, initial step for the State of New York in exploring the possible benefits associated with pursuing natural gas DSM strategies. While all parties have a level of concern with respect to some portions of this study, and in particular with respect to how the results will be used, we nonetheless believe that it provides valuable experience and information for natural gas resource planning and demand-side management efforts within New York State and across the country.

The study's objectives can be summarized into two areas:

- First, to provide information to identify end-use energy efficiency opportunities for both natural gas conservation and fuel switching opportunities, including insights as to where energy efficiency can be obtained and the relative importance of each source.

- Second, to provide an estimate of the potential amount or magnitude of energy efficiency available. The magnitude of efficiency can be used to judge the relative importance of DSM strategies as a resource in meeting the energy requirements of the State's natural gas users.

The first objective has been met to the extent that ACEEE has identified a wide range of end-use, energy efficient measures and provided a relative quantification of these measures with regard to technical potential. The identification of measures is a useful first step in the ongoing investigation of various demand-side management (DSM) strategies which could be used to promote energy efficiency and has, in fact, been used by the State's natural gas utilities in preparing their initial DSM plans (submitted in April 1993).

Due to insufficient data in some areas and methodological constraints, some of the conclusions regarding DSM potential require further investigation, and thus this study does not fully address the second objective. A more detailed discussion of NYGAS concerns is provided in Appendix E, "NYGAS Observations." The results should be regarded as a valuable preliminary estimate of the magnitude of the technically available range of energy-efficiency measures for the customer populations examined. The achievable potential will be less than this technical potential. As an example, of the 32 percent electric conservation technical potential estimated by ACEEE in 1990 for LILCO's service territory, ACEEE identified only 12 percent as achievable from utility DSM programs by 2008 in a separate 1990 study.

There are some important issues involving energy policy that cannot be fully resolved until representative pilots, demonstrations and studies across the country which are applicable to New York State have been developed, implemented and evaluated. One issue is determining the relationship between gas energy-efficiency programs and peak day gas requirements. A second issue involves assessing DSM programs' impact on non-participating customers, which is influenced by program costs and peak day savings. The rate impact component may be a critical element in those geographic areas where even a modest increase in gas rates could place those utilities in an unfavorable economic position with competing fuels.

In view of the limited data and the methodological constraints of the research, we believe that the actual magnitude of economic-efficiency potential remains to be verified by field experience across the country. Additional work is necessary to form more robust estimates of technical, economic and achievable gas DSM and fuel-switching potential in New York State. The results of the NYGAS utilities' 1993-94 DSM pilot programs should provide further input to statewide energy policy.

We believe that the successful completion and publication of this study represents a significant milestone for natural gas utilities, their customers, regulatory authorities and participating state agencies. All participants' efforts should be applauded.

The New York State Research and Development Authority
Member Companies of the New York Gas Group
The New York State Department of Public Service
The New York State Energy Office

SUMMARY

INTRODUCTION

Background

New York State's electric utilities and the State government have pursued electric demand-side management (DSM) since the mid- to late-1980's. While their efforts produced significant energy savings, utility plans for the next decade project a dramatic increase in savings.

However, in New York State, as in many other states and provinces throughout the United States and Canada, gas utility DSM efforts are more limited. Unlike the full-scale incentive programs offered by New York electric utilities, gas utility efforts are primarily limited to studies, mandated energy audits, and an occasional pilot program. Another type of DSM program, fuel switching (or converting customers from one fuel to another when the costs of conversion are less than the costs to society of not converting) is also limited due primarily to a long history of controversy about interfuel competition.

The potential advantages of gas DSM in New York State are several-fold. First, DSM can lower customer bills. Participating customers benefit because their consumption is lower. All customers taken as a whole benefit provided the DSM programs are less expensive per unit of gas saved than the marginal cost of gas. Second, DSM programs can reduce pollutant emissions by reducing the amount of gas that is burned. In particular, reductions in natural gas use reduce nitrogen oxide emissions, an important contributor to acid rain. Third, DSM programs can free up gas for other uses such as in the industrial and transportation sectors. Use of gas in these end-uses will usually reduce emissions and will often save consumers money. Additional incentive to pursue gas DSM comes from the federal Energy Policy Act of 1992, which requires state utility commissions to consider implementing integrated resource planning for gas utilities and regulatory changes that would make energy efficiency investments profitable for gas utilities (U.S. Congress 1992).

Based in part on these considerations, the New York State Public Service Commission, other government agencies, and New York State gas utilities are interested in pursuing gas DSM programs more extensively. Gas-cooling programs recently offered by several gas and electric utilities provide the groundwork for further fuel- switching efforts.

To provide a foundation for these discussions, the New York State Energy Research and Development Authority (NYSERDA), in conjunction with the New York Gas Group (a consortium of New York gas utilities, abbreviated NYGAS) asked the American Council for an Energy-Efficient Economy (ACEEE) to the study the economic savings potential for gas DSM and fuel-switching measures and to review gas DSM and fuel-switching program experience to date throughout the country.

To confine the project's scope, the project steering committee limited the analysis to the residential and commercial sectors, and to an examination of savings opportunities in the service areas of three representative New York gas utilities: Long Island Lighting Company (LILCo), Brooklyn Union Gas (BUG), and National Fuel Gas (NFG). These utilities serve a downstate suburban area (Long Island), a downstate urban area (parts of New York City), and an upstate mixed urban/suburban/rural area (in and around Buffalo), respectively.

Economic Potential Analysis

Definition

A technical potential analysis evaluates how much energy can be saved from a technical perspective without considering measure economics. An economic potential analysis goes a step farther to include an examination of measure economics. An economic potential analysis examines the costs and savings of efficiency and fuel-switching measures and determines which measures are both technically feasible and cost-effective.

For purposes of this study, cost effectiveness is evaluated from two perspectives, a modified total resources perspective and a participant perspective. The total resources perspective compares the cost to implement a measure to the marginal cost of the avoided energy source. If the cost per unit of gas saved is less than the marginal cost of gas, a measure is cost-effective. Generally, total resource cost analyses include the total cost of measures, including utility and customer payments, and the cost of programs that are needed to convince consumers to adopt the measures. The participant perspective compares the cost to the consumer to implement a measure to the retail price of gas. If the cost per unit of gas saved is less than the retail price of gas, a measure is cost-effective. In calculating measure costs, both equipment and installation costs are included. The participant perspective does not include program costs.

Uses and Limitations

Economic potential analyses have many uses, and several limitations. Economic potential analyses identify the size of the available resource, identify opportunities for savings, and generate data that can be used to design programs.

However, an economic potential analysis does not consider barriers to measure adoption, but assumes that all measures that are technically feasible and cost-effective can be adopted. Furthermore, an economic potential analysis assumes that measures are properly installed and properly maintained. Thus an economic potential analysis estimates the maximum amount of energy that can be saved from DSM or fuel-switching programs at a particular point in time—as new technologies enter the market, the potential for cost-effective DSM and fuel-switching may increase.

When program participation rates are factored into the analysis (it is a very rare program that can enroll all eligible customers), and the quality of installation and maintenance obtainable in the field are factored into the analysis, the achievable DSM and fuel-switching potential may be significantly less than the economic potential. Thus, economic potential analyses are limited because they do not show how much energy savings can actually be achieved. They also do not show how savings can be achieved (which measures will be adopted as a result of normal market forces and which will require additional inducements) or how long it will take to achieve a specific level of savings.

Additional caveats to the analysis are discussed in Chapter 1 and Appendix E.

METHODOLOGY

To assess the economic potential for gas efficiency and fuel-switching measures, computer models of several prototype buildings that are representative of the existing housing and commercial building stock in the LILCo, BUG, and NFG service areas were developed (new construction was not examined). Prototype models were calibrated to actual utility gas sales. For each prototype the costs and savings of individual efficiency and fuel-switching measures were examined. All of the analyses examined annual energy savings; only the commercial fuel-switching analysis examined savings at the time of peak energy demand. Measures examined affect energy use for space heating, space cooling, water heating, cooking, and clothes drying. All measures examined are either commercialized today or expected to be commercialized in the next one to two years. Savings were estimated using a combination of computer simulations and a review of case studies of the savings achieved by different measures in real homes and commercial buildings. The savings were modeled to capture the interactive effects among different measures and to avoid double-counting savings.

For the gas efficiency analyses, measures were ranked in order of levelized cost per unit of gas saved. As long as a measure has a lower levelized cost than the marginal cost of gas, it will be cost-effective from the total resource perspective, the most widely used cost-effectiveness test in New York State for utility planning. As long as a measure has a lower levelized cost than the average retail cost of gas to a specific class of customers, it will be cost-effective from the consumer perspective. Thus, for any given level of avoided or retail cost, the economic savings potential can be identified. Analyses were conducted based on measure costs as well as measure costs plus 25 percent, 50 percent, and 75 percent. These increments reflect program administrative costs as well as allowances for possible errors in cost or savings estimates.

For fuel-switching analyses, the energy use of various gas and electric systems for the different prototype buildings were examined and the savings of converting from electricity to gas were compared with the costs of the conversion. For each possible conversion, a breakeven levelized cost of gas was calculated assuming gas service is already available in the building. If gas marginal costs are less than this breakeven value, fuel switching will be cost-effective from the total resource perspective. As with the gas efficiency analysis, a variety of sensitivity cases were run, including 25 percent, 50 percent, and 75 percent cost increments (to reflect program administrative costs and other uncertainties), use of higher avoided electricity costs, and inclusion of gas hookup costs for buildings that do not presently have gas service.

In addition to the technical potential analyses, a database of gas DSM and fuel-switching programs in the U.S. and Canada was developed. For each program, information was collected on participation rates, costs, and savings. Also, program managers were interviewed to identify the lessons they had learned.

Marginal Energy Costs

In conducting an economic potential analysis and examining the economics of gas efficiency and fuel-switching programs, a key variable is the long-run marginal cost, also called the avoided cost, of electricity and gas. In New York State electric long-run avoided costs (LRAC) have been calculated by utilities and the New York Public Service Commission (NYPSC) for many years. For this study, recent electric LRACs were used to assess the economics of switching from electricity to gas for a variety of end-uses.

In New York State, methods for calculating gas marginal costs are still being developed. In May 1992, each of the New York State gas utilities filed a first-cut estimate of marginal costs with the NYPSC. Until these estimates are confirmed, the economics of gas efficiency and fuel-switching measures cannot be fully evaluated. However, these filings indicate that marginal gas costs are likely to range from as low as \$2.00/Dth in the summer (1 decatherm of gas = 10 therms = 1 million BTUs), and a low of \$2.50/Dth for year-round use, to a high of \$4.00/Dth in the winter. This range of gas marginal costs was used to assess gas DSM and fuel-switching cost-effectiveness. However, there are some indications that over the long-term, marginal costs may increase above these levels.

FINDINGS

Residential DSM Potential

For the residential sector, assuming program administrative costs of 50% of measure costs, the total economic savings potential is 23 to 30 percent of gas sales at a marginal gas cost of $2.50/DTh and 38 to 42 percent at a marginal gas cost of $4.00/DTh, varying slightly from utility to utility. Of this total potential, approximately 10 percentage points are from measures mandated under Federal law and the remainder are potential targets for utility programs. If program costs are only 25 percent, the economic savings potential increases by approximately six percentage points. From the participant perspective (based on average retail gas costs and excluding administrative costs), the economic savings potential from all measures (mandated and non-mandated) is more than 50 percent in the residential sector. Results of the analyses from the total resource perspective are summarized in Table S-1.

Table S-1. Residential Economic Savings Potential by Utility for the Different Sensitivity Cases as a Percent of Residential Gas Sales.

	LILCo		BUG		NFG	
Marginal gas cost/DTh	$2.50/$4.00		$2.50/$4.00		$2.50/$4.00	
Sensitivity Case						
All Measures:						
25% Program Costs	28%	42%	33%	48%	35%	45%
50% Program Costs	23%	38%	30%	42%	26%	42%
75% Program Costs	21%	35%	23%	37%	23%	37%
Utility Measures only:						
25% Program Costs	19%	33%	22%	37%	25%	35%
50% Program Costs	14%	29%	19%	31%	16%	32%
75% Program Costs	12%	26%	12%	26%	13%	27%

Note: Data in this table are subject to many assumptions and caveats discussed in the report.

At $4.00/DTh, assuming 50 percent administrative costs, space heating and water heating gas use can be reduced by approximately 41 to 47 percent and 30 to 35 percent respectively. Cooking and clothes drying gas use can be reduced by about 25 percent.

Several measures account for substantial savings at levelized costs less than $2.50/DTh. Among them are equipment efficiency upgrades at the time of replacement, up to medium levels of efficiency (e.g., heating system AFUEs in the 80s and water heater EFs in the 60s); clock thermostats; infiltration reduction in all but the tightest homes; low-flow showerheads and faucet aerators; water heater tank and pipe insulation; and mainline steam vents.

While the savings potential is quite large in each of the three service areas, these savings cannot be quickly achieved. A substantial portion of the savings—approximately one-third—are due to measures that are cost-effective only at the time existing equipment is replaced; the remaining two-thirds can be cost-effectively implemented on a retrofit basis (see Table S-2). It will take several decades before most of the existing equipment stock is replaced. In addition, it will take more than a decade to effectively implement most of the retrofit opportunities. Thus, the savings potential identified should be considered a long-term opportunity, one that we may still be pursuing through 2020.

Table S-2. Economic Savings Potential by Utility from Replacement and Retrofit Measures as a Percent of Residential Gas Sales (50% Program Cost Case).

	Mandated Measures	Additional Replacement Measures		Retrofit Measures	
		$2.50/DTh	$4.00/DTh	$2.50/DTh	$4.00/DTh
LILCo	9%	4%	6%	10%	23%
BUG	11%	5%	8%	14%	23%
NFG	10%	4%	6%	12%	26%

Note: Data in this table are subject to many assumptions and caveats discussed in the report.

For this study to have meaning in the real world, the results must compare favorably with savings achieved from installing packages of measures in real homes. Accordingly, we compared our savings estimates to two field studies: a study of small single-family homes conducted in the NFG territory, and ongoing studies of steam-heated multifamily buildings conducted by the Center for Neighborhood Technology (CNT) in Chicago. After adjusting our savings estimates to cover only those measures included in these field tests, there was good agreement between our estimates and the field test results. This conclusion is based strictly on measure costs and savings; neither field study addressed program costs in a comprehensive manner. However, one analysis indicated that one of the CNT programs was not cost-effective due to high administrative costs resulting from lower than expected participation.

Commercial DSM Potential

For the commercial sector, assuming 50 percent program costs, the economic savings potential is 17 to 21 percent of gas sales for gas marginal costs of $2.50 to 4.00/DTh, varying slightly by utility. Mandated measures account for less than one percentage point of this potential. If program costs are only 25 percent, the economic savings potential increases by approximately one percentage point. From the participant perspective (based on average retail gas costs and excluding administrative costs), the economic savings potential from all measures (mandated and non-mandated) is approximately 30 percent in the commercial sector. Results of the analyses from the total resource perspective are summarized in Table S-3.

Table S-3. Commercial Economic Savings Potential by Utility for the Different Sensitivity Cases as a Percent of Commercial Gas Sales.

	LILCo		BUG		NFG	
Marginal gas cost/DTh	$2.50/$4.00		$2.50/$4.00		$2.50/$4.00	
Sensitivity Case						
Measure costs + 25%	17%	18%	20%	22%	18%	23%
Measure costs + 50%	17%	18%	19%	21%	16%	19%
Measure costs + 75%	17%	17%	19%	20%	16%	19%

Note: Data in this table are subject to many assumptions and caveats discussed in the report.

At $4.00/DTh and 50 percent program costs, space heating and water heating gas use can be reduced by approximately 20 to 25 percent. Cooking gas use can be reduced by about 15 percent. Measures that are cost-effective only when existing equipment is being replaced account for approximately 10 percent of the savings.

Among the measures with the largest savings at levelized costs less than $2.50/DTh were HVAC controls—particularly automatic controls that reset supply air temperatures in central HVAC systems and night set-back controls for both central and packaged HVAC systems—and reduced hot water temperatures. Installing high efficiency cooking equipment (e.g., direct convection ovens, infrared fryers and griddles, and power burner ranges) at time of equipment replacement also resulted in substantial savings.

A comparison of our savings estimates with the results of monitored field studies indicate generally good agreement.

Residential Fuel Switching

In the residential sector, assuming 50 percent program costs, it will be generally cost-effective from the total resource perspective to switch electric water heat to gas and will often be cost-effective to switch electric dryers to gas at the time of equipment replacement. For homes with electric baseboard heat, conversion to a gas hydronic system will generally be cost-effective from the total resources perspective upstate for detached homes but not attached homes. Downstate, conversion of electric baseboard systems will occasionally be cost-effective. For homes with electric heat pumps, conversion to a primary or backup gas furnace will generally be cost-effective upstate, and is of marginal cost-effectiveness downstate in all but the apartments. However, the economics of fuel-switching will vary from house to house, and thus site-specific economic analyses must be done before converting.

The economic savings potential for fuel-switching in the residential sector is estimated to be approximately 3 to 4 percent of downstate electricity sales and 10 percent of upstate electricity sales. Put another way, residential fuel-switching can increase gas utility sales to the residential sector by approximately 1 to 2 percent downstate and 4 percent upstate. Space heating and water heating generally account for the largest proportion of the savings.

Commercial Fuel Switching

In the commercial sector all analyses assumed that fuel-switching is done when existing equipment is replaced. At 50 percent program costs it is usually cost-effective to replace an all-electric packaged heating and cooling system with either a gas heating/electric cooling system or an all-gas engine-driven packaged system. Downstate it is sometimes cost-effective to change a gas heating/electric cooling packaged system to an all-gas engine-driven packaged system. Similarly it is usually cost-effective to convert an electric boiler to a gas boiler but rarely cost-effective to convert an electric chiller to a gas chiller. Without program costs, gas engine-driven chillers often are cost-effective downstate and may be marginally cost-effective in some applications upstate. Several cogeneration/gas absorption chiller systems become marginally cost-effective downstate. New gas and electric equipment has recently entered the market; the economics of these new systems may be different from the results described above. As with the residential analysis, the economics of fuel-switching will vary from building to building, and thus site-specific economic analyses must be done before actually switching fuels.

The economic savings potential for fuel-switching in the commercial sector is approximately 3 to 4 percent of LILCo's, Con Edison's, and Niagara Mohawk's commercial electric sales. Cost-effective commercial fuel-switching can increase commercial gas sales in the LILCo, Con Edison, and Niagara Mohawk service territories by approximately 14 percent, 30 percent, and 7 percent respectively. Upstate most of this potential occurs in space heating, downstate the majority of the potential savings are attributable to gas air conditioning.

Gas DSM and Fuel-Switching Programs

A number of successful gas DSM and fuel-switching programs have been offered by utilities; however, program design in these areas is generally limited. While there are more than 150 gas DSM and fuel-switching programs throughout the United States and Canada, most programs have recently begun and have achieved limited results to date. However, a few programs have achieved annual participation rates of 5 percent or more and/or have reduced utility gas or electricity sales by at least 0.5 percent, indicating that substantial savings are possible.

Still, the most successful gas DSM and fuel-switching programs had lower participation rates and savings as a percent of total sales than the most successful electric DSM programs, which indicates that even the most successful gas DSM and fuel-switching programs can probably be improved.

More than half of the gas DSM programs analyzed, including most of the programs with high participation rates and savings, had estimated levelized costs to the utility of less than $2.50/Dth. This indicates that DSM programs can be designed that will be cost-effective to New York State gas utilities assuming long-run marginal gas costs are between $2.50 to $4.00/Dth, but programs must be carefully designed so that program costs are kept within cost-effectiveness limits. Most of the fuel-switching programs analyzed have estimated levelized costs to the utility of less than $0.03/kWh, indicating that fuel-switching programs can be designed that are cost-effective to electric utilities.

Despite the limited data available on gas DSM and fuel-switching programs, a number of trends emerged that may aid future program design. For example, the analysis of gas conservation programs indicates that joint audit and installation programs (involving both shell and equipment measures) tend to have greater savings per customer than equipment replacement programs. However, the higher savings come at a somewhat higher cost, although they are still generally cost-effective. On the other hand, equipment replacement programs tend to have higher participation rates at a lower cost. For gas DSM to have a significant impact on a utility's overall gas load, both types of programs should be offered. Successful fuel-switching and gas conservation programs use a variety of marketing techniques, offer financial incentives, not just loans, are user-friendly for the customer, and offer a variety of options to the customers.

RECOMMENDATIONS

Two types of recommendations are discussed: recommended changes to programs and policies in New York State and recommendations for future research projects.

Programs and Policies

There is a substantial resource available from cost-effective gas efficiency and fuel-switching measures. Even our worst-case sensitivity analyses indicate a cost-effective gas efficiency savings potential from non-mandated measures of at least 12 percent in the residential sector and at least 16 percent in the commercial sector. Furthermore, experience with gas DSM and fuel-switching programs shows that programs which are cost-effective from the utility perspective can be offered. New York State gas utilities should expand current efforts to pursue this resource by:

1. Expanding the range of current pilot DSM and fuel-switching programs to gain more program design and operation experience and lay the groundwork for possible full-scale programs that may be offered in the future. Both existing programs and these new programs should be thoroughly evaluated.

2. Begin preparing integrated least-cost plans (LCPs) that develop long-range strategies for meeting future energy needs at the lowest cost to consumers and society. Such plans, should include extensive reliance on DSM and fuel-switching programs to the extent these programs have a lower cost to society than traditional gas and electric supply options.

In selecting targets for initial programs, two priorities appear to be justified: equipment replacement programs, which promote high-efficiency equipment and fuel-switching when existing equipment is replaced; and comprehensive residential weatherization programs, that identify optimal weatherization packages for each home and assist homeowners with measure financing and arranging for measure installation. These programs target several of the largest opportunities for achieving energy savings. The first program also targets a "lost opportunity" resource: if high efficiency equipment is not installed when existing equipment is replaced, it will be many years before the equipment is again replaced and thus the opportunity to achieve energy savings will be lost for a long time. The second program can build upon the existing HEICA program operated by all New York utilities. To be truly comprehensive, the number of measures covered by HEICA needs to be expanded as should the range of financing and installation services that are offered.

In addition to these two priorities, gas utilities should explore opportunities to offer joint programs with electric utilities because cost sharing can reduce program costs for each utility. Joint programs are also less confusing to customers than separate electric and gas programs for the same population and joint programs allow gas utilities to benefit from electric utility DSM experience.

To encourage gas utility actions, we recommend that the NYPSC:

1. Continue to work with gas utilities to develop long-run avoided gas costs so that a methodology to compute marginal gas costs is agreed on and estimates of marginal gas costs are available for each utility. These values are essential for determining the cost-effectiveness of gas DSM and fuel-switching programs;

2. Encourage gas utilities to prepare pilot program plans and begin preparing LCPs.

3. Set up cost-recovery procedures so that gas utilities know how prudent investments in gas DSM will be charged to rate payers.

4. Review the impact of gas efficiency and fuel-switching programs on gas and electric utility profitability and take steps to ensure that the LCP to society is the most-profitable plan for utilities. The NYPSC has been a national leader promoting electric DSM. Similar steps should be taken to promote gas DSM and fuel-switching programs.

5. Open a docket or collaborative program design process for both gas and electric utilities to discuss optimal ways to promote cost-effective fuel-switching. This should address who should implement fuel-switching programs (gas or electric utilities or some combination) and how costs should be allocated.

To complement the previous activities, gas utilities and the New York State Energy Office (NYSEO) should work on developing contractor skills in areas that will be critical for the success of gas DSM programs. Several major opportunities for gas savings are not widely understood by New York contractors. Contractors should be trained so that savings are maximized and costs are reasonable. Contractor training efforts should be paced to keep just ahead of the anticipated demand for DSM services. Contractor training will probably be needed in:

- Infiltration reduction;
- Duct sealing;
- Comprehensive furnace and boiler tuneups including boiler temperature modulation (similar to successful programs in Colorado (Proctor and Mills 1987, Proctor 1987);
- Comprehensive heating and hot water equipment system conservation packages for multifamily buildings similar to programs operated by the Center for Energy and the Urban Environment in Minneapolis and the Center for Neighborhood Technology in Chicago.

Research

While the analyses discussed in this report justify specific program and policy actions, many questions still remain that should be addressed by additional research. Areas meriting research attention include:

1. Field studies on the gas savings that can actually be achieved from comprehensive gas efficiency packages.

2. Preparation of thorough evaluations on existing gas DSM and fuel-switching programs.

3. Offering a set of pilot programs to examine customer response to different levels of gas DSM and fuel-switching incentives.

4. Field studies on the gas savings that can be achieved by specific efficiency measures whose performance in the field is not well understood.

5. An examination of how gas DSM and IRP could affect gas rates, and how competition with oil might affect gas DSM and IRP.

6. An investigation of the gas savings and fuel-switching potential in the industrial sector.

7. Research on the marginal costs of extending and reinforcing local gas distribution networks.

8. An investigation of gas use patterns in upstate New York to explore why upstate homes use substantially less gas per square foot per heating degree day than downstate homes.

9. A review of the administrative costs of DSM programs in New York State, including electric DSM programs, gas DSM programs, and fuel switching programs.

10. Preparation of improved commercial sector forecasting data including energy use intensities, equipment saturations, and floor areas.

11. Further analysis of gas DSM and fuel-switching programs.

12. A field study to examine the relationship between gas savings from different efficiency and fuel-switching measures and gas demands at different times of the year, including the period of peak demand.

13. A study on the costs and savings of actual fuel-switching installations.

14. A field survey of a random sample of electrically heated and cooled buildings to assess the costs and savings from fuel-switching.

15. A study on the economics of fuel-switching to other fuels besides natural gas.

Further explanations of each of these research recommendations are provided in Chapter 8.

CONCLUDING THOUGHTS

By implementing these recommendations, New York State has an opportunity to achieve substantial long-term energy and cost savings for its citizens. However, achieving these savings will require extensive long-term effort because it will take time to develop and test program designs and because many savings opportunities are only available when equipment is replaced, and these opportunities will occur over several decades. Still, in order to achieve significant savings this decade, initial steps must be made now. Just as New York State is a now a national leader in electric DSM efforts, with diligent work, New York can also become a leader in the gas DSM arena.

Chapter 1

INTRODUCTION

CONTEXT, GOALS AND SCOPE

New York State government and New York State utilities have implemented electric demand-side management (DSM) programs since the mid-1980's. These programs promote installing energy-efficiency measures at customer facilities when the cost of the measure (including utility administrative expenses) is lower than the marginal cost of the energy and power required to serve the load. As a result of these efforts, New York State electric utilities anticipate that a substantial portion of future resource needs will come from DSM activities (New York State Energy Office et al. 1991).

In New York State, as in many other states and provinces throughout the United States and Canada, natural gas DSM efforts are not as far advanced as electric DSM efforts. During the 1970's, in response to rapidly increasing natural gas prices, New York gas utilities and state government offered energy audit, information, and technical assistance programs to encourage reduced gas use. As a result of consumer response to higher gas prices and utility and government conservation programs, natural gas consumption declined through much of the 1970's and into the 1980's. At a national level, natural gas sales peaked in 1972, and then declined 24 percent by 1983 (DOE/EIA 1992a). In New York State, natural gas sales peaked in 1971, and declined 22 percent by 1977 (DOE/EIA 1991a). In the 1980's, natural gas prices declined somewhat and gas conservation programs were scaled back. As a result, natural gas use increased through the 1980's. For example, in New York State, by 1989, natural gas use was 18% higher than the 1971 low point. This increase was led by the commercial and utility sectors (use of gas for electric power generation); 1989 natural gas use in the residential sector was nearly identical to 1971 consumption (although due to growth in the number of housing units over the period, 1989 use was somewhat lower per unit), while 1989 industrial sector use was slightly below 1971 levels (DOE/EIA 1991a).

In light of increases in natural gas consumption, and the apparent success of electric utility DSM efforts, utilities and state governments throughout the U.S. are exploring whether and how to expand gas utility DSM programs. Several states and utilities have begun substantial DSM efforts; many other states and utilities are still in the discussion stage (Goldman and Hopkins 1991). Increased attention to these issues can be expected in the next few years. For example, the federal Energy Policy Act of 1992, requires state utility commissions to consider implementing integrated resource planning for gas utilities and regulatory changes that would make energy efficiency investments profitable for gas utilities (U.S. Congress 1992).

In New York State, the primary gas DSM program is the statewide Home Insulation and Energy Conservation Act (HEICA) program under which gas utilities provide free energy audits and financing for the improvements recommended by the audit. For example, Brooklyn Union Gas reports that over 35 percent of eligible customers have received a HEICA energy survey. In addition, several gas utilities have begun pilot programs to promote home weatherization and insulation, high efficiency equipment, heating system retrofits, gas cooling, and industrial heat recovery (New York State Energy Office et al. 1991).

Based on the success of many of these efforts, the New York State Public Service Commission, other government agencies, and New York State gas utilities are interested in pursuing gas DSM programs more extensively. To provide a foundation for these discussions, the New York State Energy Research and Development Authority (NYSERDA), in conjunction with the New York Gas Group (a consortium of New York gas utilities, abbreviated NYGAS) asked the American Council for an Energy-Efficient Economy (ACEEE) to study the gas savings that can be achieved as a function of cost per therm of gas saved. They also asked for a review of gas DSM program experience to date throughout the country.

The potential advantages of gas DSM in New York State are several-fold. First, DSM can lower customer bills. Participating customers benefit because their consumption is lower. All customers taken as a whole benefit provided the DSM programs are less expensive per unit of gas saved than the marginal cost of gas. Second, DSM programs can reduce pollutant emissions by reducing the amount of gas that is burned. In particular, reductions in natural gas use reduce nitrogen oxide emissions, an important contributor to acid rain. Third, DSM programs can free up gas for other uses such as in the industrial and transportation sectors. Use of gas in these end-uses will usually reduce emissions and will often save consumers money.

However, from the perspective of a private gas utility, efficiency programs can be problematic because they reduce gas sales and potential profits. On the other hand, many gas utilities are interested in promoting gas sales by encouraging consumers to switch to gas for space heating, water heating, air conditioning, cooking and clothes drying. Both gas efficiency and gas fuel switching are generally justified on the same basis—that they provide economic benefits to society. Decisions to pursue gas efficiency are often linked to decisions about fuel switching. One type of program, gas efficiency, is often thought to reduce gas utility profitability, the other, fuel-switching, to increase profitability. While the impacts on profitability of these different programs are quite complex and can result in profitable efficiency programs and unprofitable fuel-switching programs,[1] within the industry these general adages are widely believed, and hence, linking the two types of programs provides a package that maximizes benefits to society while potentially providing the gas utility a profit incentive. Due to these links, ACEEE was asked to review the economics of fuel-switching to estimate the approximate size of the available fuel-switching resource, and to review utility fuel-switching program efforts.

In addition to the gas load-building aspects of fuel-switching,[2] fuel-switching can sometimes provide electric DSM benefits, meaning that electricity is economically saved. By examining the economics of fuel-switching and the applications where benefits occur, potential savings can be assessed.

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[1] Profitable DSM programs are particularly likely when regulators have provided a profit incentive for their successful implementation. Moskovitz (1989) discusses these issues at length.

[2] In the residential and commercial sectors—the subject of this study—interfuel economics tend to favor using gas instead of electricity. However, in the industrial sector, some studies have found that there may be opportunities to save money by switching from gas or other fossil fuels to electricity. These opportunities are discussed in studies by Resource Dynamics (1986) and the Energy Research Group (1989).

Thus, this study has these general goals:

- Examine the economics and savings potential of gas efficiency measures;
- Examine the economics of fuel-switching programs and their potential to add gas loads and save electricity; and
- Examine experience to date with gas DSM and fuel-switching programs.

In addition, a fourth goal was added by NYSERDA and NYGAS:

- Recommend research that is needed to answer outstanding questions and discuss policy options that make sense based on available information.

To fully address these goals would require more research than time or budget permitted. To narrow the project's scope it was decided that the study would be limited to the residential and commercial sectors. The industrial sector may be the focus of a follow-up study. It was also decided that the study would concentrate on the economic potential for cost-effective gas efficiency and fuel-switching measures and analyze three representative New York gas utilities out of the 17 gas utilities serving the state. The utilities selected were the Long Island Lighting Company (a downstate dual-fuel utility serving suburbs outside New York City, abbreviated LILCo); Brooklyn Union Gas (a downstate gas-only utility serving the urban Brooklyn, Queens, and Staten Island areas in New York City, abbreviated BUG), and National Fuel Gas (an upstate gas-only utility serving the urban, suburban, and rural area in western New York State, in and around Buffalo, abbreviated NFG). Finally, it was decided that the energy-savings analysis would be limited to annual energy use—and not address savings at the time of system—and that the fuel-switching analysis would be limited to electricity and natural gas. While there may be cost-effective opportunities to switch from or to other fuels such as oil, these issues are not addressed in this study.

ECONOMIC POTENTIAL ANALYSIS

A technical potential analysis evaluates how much energy can be saved from a technical perspective without considering measure economics. An economic potential analysis goes a step farther to include an examination of measure economics. An economic potential analysis examines the costs and savings of efficiency and fuel-switching measures and determines which measures are both technically feasible and cost-effective.

For purposes of this study, cost effectiveness is evaluated from two perspectives, a total resources perspective and a participant perspective.

The total resources perspective compares the cost to implement a measure to the marginal cost of the avoided energy source. If the cost per unit of gas saved is less than the marginal cost of gas, a measure is cost-effective. The cost to implement measures includes equipment and installation costs as well as the cost of demand-side management programs that are used to promote these measures.

The participant perspective compares the cost to the consumer to implement a measure to the retail price of gas. If the cost per unit of gas saved is less than the retail price of gas, a measure is cost-effective. In calculating consumer costs, both equipment and installation costs are included. Analysis from this perspective does not include program administrative costs paid by the utility.

In conducting the economic potential analysis from the total resources perspective, program administrative costs were assumed to be equal to 50% of measure costs (equipment plus installation) based on rough estimates made by the New York Public Service Commission for New York State electric DSM programs (Ulrich 1993). This estimate is substantially higher than other estimates of program administrative costs. For example, Berry conducted a nationwide survey of data on administrative costs and found that administrative costs were generally between 10 percent and 35 percent of measure costs, depending on program type (Berry 1989). Similarly, Nadel (1990), in a review of administrative costs for 46 programs, found average program administrative costs equal to 36% of direct utility costs. Direct utility costs typically represented 50% of total measure costs, and thus administrative costs were approximately 18% of total measure costs. Thus, data from two national studies indicate that the preliminary New York estimate of 50% administrative costs may be too high. To reflect this uncertainty, the analysis was also conducted for 25% program costs, in line with experience outside of New York. However, even use of these two estimates represent a simplification of reality. Program costs are highly program specific, and can vary from just a few percent of measure costs to more than 100% of measure costs (Berry 1989, Nadel 1990).

An economic potential analysis does not consider barriers to measure adoption, but assumes that all measures that are technically feasible and cost-effective can be adopted. Furthermore, an economic potential analysis assumes that measures are properly installed and properly maintained. Thus an economic potential analysis estimates the maximum amount of energy that can be saved from DSM or fuel-switching programs. When participation rates programs actually achieve (it is a very rare program that can enroll all eligible customers), and the quality of installation and maintenance obtainable in the field are factored into the analysis, the achievable DSM and fuel-switching potential may be significantly less than the economic potential.

Just because a measure makes economic sense does not mean it will be implemented immediately. It can well take several decades for homeowners and businesses to learn about and implement specific measures. Likewise, for measures that are generally implemented when existing equipment wears out (e.g., new high-efficiency boilers), it can take 40 years or more for the entire stock of existing equipment to turn over. Due to these considerations, this analysis should be viewed as an estimate of the long-term opportunity for gas DSM and fuel switching savings, e.g., the potential as of about 2020. On the other hand, this study was limited to existing technologies (including a few just entering the market). As new technologies are developed, the amount of energy that can be saved in the long-term will increase beyond the estimates made here.

Economic potential analyses have many uses, and several limitations. Economic potential analyses identify the size of the available resource, identify opportunities for savings, and generate data that can be used to design programs.

Economic potential analyses are limited because they do not show how much energy savings can actually be achieved. They also do not show how savings can be achieved (which measures will be adopted as a result of normal market forces and which will require additional inducements) or how long it will take to achieve a specific level of savings. For this information an achievable potential analysis is needed. To conduct an achievable potential analysis, data are needed on program types, costs and participation rates. When this study was started, data on gas DSM and fuel-switching program costs and savings were unavailable. One of the goals of this study was to compile the available data. Only when sufficient data on program costs and participation rates are available can a useful achievable potential analysis be made. Unfortunately, as the available data are limited (see Chapters 6 and 7), conducting an achievable potential analysis will undoubtedly depend on collecting additional data.

Additional caveats to the analysis are discussed in Appendix E.

MARGINAL AND AVERAGE ENERGY COSTS

In New York State, several different benefit-cost tests are used to assess the cost-effectiveness of DSM programs. For most of these tests, including the total resource tests, the benefits of DSM programs are assessed based on the long-run marginal (avoided) cost of electricity and gas. In New York State, electric long-run avoided costs (LRACs) have been calculated by utilities and the New York Public Service Commission (NYPSC) for many years. LRACs were approved and issued by the NYPSC in June 1992 (NYPSC 1992). In this ruling there are many pages of data, including energy and capacity values for each utility, year, and delivery voltage. Harvey Tress (1992a) analyzed the NYPSC ruling and levelized and weighted the different values for the 1992-2012 time period into a set of seven numbers per electric utility: summer capacity value; winter capacity value; on-peak energy value (year-round since costs varied only slightly throughout the year); off-peak energy value; and weighted average energy value (weighted average on- and off-peak values assuming 70 hours per week on-peak and 98 hours off-peak); year-round energy value including capacity; and winter-only energy value including capacity. These values do not include the impact of environmental externalities on marginal costs.

In this study, the first five values are used to analyze commercial fuel-switching, and the last two values to analyze winter-only and year-round residential fuel-switching options such as water heating and space heating. These values are summarized in Table 1-1 for each of the three electric utilities (LILCo, Consolidated Edison (Con Ed), and Niagara Mohawk Power Corp. (NMPC)) whose service areas overlap with the three gas utilities included in this study (LILCo, BUG, and NFG respectively).

In New York State, methods to calculate marginal gas costs are still being developed. Until recently no estimates of gas marginal costs were available. However, in May 1992, each of the New York gas utilities filed their first-cut estimate of marginal costs with the NYPSC. Discussions are taking place between the NYPSC and the gas utilities as to how these initial estimates will be revised and finalized. Until this process is completed, the economics of gas efficiency and fuel-switching measures cannot be fully evaluated. Thus, in this study we report the levelized gas cost of each efficiency and fuel-switching measure. If the marginal gas cost, when it is ultimately determined, is less than this value, the measure will likely be cost-effective.

However, the May 1992 utility filings may approximate the final marginal costs. Tress (1992b) analyzed these filings for the 1992-2001 period (the figures often do not extend farther) and estimated the average levelized marginal gas cost for each of three applications, winter-only (e.g., space heating); summer-only (e.g., gas air conditioning); and year-round (e.g., water heating, cooking, and clothes drying). These values are also reported in Table 1-1.

Since these are preliminary values that are likely to change, we did not want to put too much faith in the specific values listed. Instead, based on the values for each of the three gas utilities in this study, a bandwidth was developed within which gas marginal costs are likely to

Table 1-1. Long-Run Levelized Marginal Electric and Gas Costs.

ELECTRICITY	LILCo	Con Ed (BUG)	NMPC (NFG)
Commercial			
Summer capacity ($/kW-yr)	$122.6	$121.5	$57.8
Winter capacity ($/kWyr)	13.6	6.2	87.2
On-peak energy($/kWh)	.0460	.0407	.0404
Off-peak energy ($/kWh)	.0345	.0330	.0336
Weighted-average energy ($/kWh)	.0393	.0362	.0364
Residential			
Winter-only energy + capacity ($/kWh)	$.0416	$.0372	$.0514
Year-round energy + capacity ($/kWh)	.0548	.0508	.0530

NATURAL GAS	LILCo	BUG	NFG
Winter-only energy + capacity ($/Dth)	$5.22	$3.35	$3.79
Summer-only energy + capacity ($/Dth)	NA	2.35	2.03
Year-round energy + capacity ($/DTh)	2.82	2.85	2.76

Note:

Data are from Tress 1992a and Tress 1992b. Electric marginal costs are calculated from NYPSC issued data (1992). Gas marginal costs are calculated using data in May 1992 filings by each utility. Gas marginal costs are for firm, not interruptible, service. All costs are levelized assuming a five percent real discount rate (*real* means excluding the effects of inflation—the real rate is lower than the *nominal* rate charged by banks because the nominal rate includes an allowance for inflation). For cost streams expressed in nominal terms, an 8.9% nominal discount rate was used to present value the nominal stream; the present value was then levelized at 5% (the difference between the real and nominal rates is a 3.7% annual inflation factor). Levelized electric costs include distribution capacity credits as filed by each utility with the NYPSC. Other assumptions imbedded in the analysis are described in the source documents. For analyses that also include summer-only applications, the bandwidth ranges from $2.00 to $4.00 per Dth. Most of the preliminary marginal cost estimates listed in Table 1-1 are within these bandwidths.[3]

[3] The one exception is the LILCo winter-only marginal cost listed in Table 1-1, which is $5.22/Dth. This value differs substantially from the values provided by the other

lie. For analyses of winter-only and year-round applications, the bandwidth ranges from $2.50 to $4.00 per decatherm (decatherm (Dth) = 10 therms = one million BTUs).

It should be noted that these bandwidths are significantly lower than current retail costs for natural gas, which average approximately $6.00/DTh statewide (NYSEO 1992b). Furthermore, over the long term, the U.S. Department of Energy predicts that average real retail prices will increase substantially, with particularly dramatic increases (40%) in the 2000-2010 period (DOE/EIA, 1992b). This implies that after 2000 marginal costs are likely to be significantly higher than the values discussed above.

While marginal costs are used for most cost-effectiveness tests, for the participant test, energy saving benefits are valued based on retail prices charged consumers. These costs are summarized in Table 1-2 for each of the three gas utilities covered by this study.

Table 1-2. Average 1991 Retail Natural Gas Prices ($/DTh) for Selected New York State Utilities .

Utilities:	**Residential**	**Commercial**
Long Island Lighting Co.	6.60	6.00
Brooklyn Union Gas	8.83	8.46
National Fuel Gas	6.22	5.13

Source: Smolenski 1992; Gobris 1992b; Pijacki 1992a.

gas utilities and does not appear to be consistent with previous data provided by LILCo for this project which indicated marginal costs similar to the other two utilities. While the ultimate marginal cost may be this high, there is a good chance a lower value will ultimately be chosen. To be conservative, we limit the bandwidth to $4.00/Dth for winter-only applications.

ORGANIZATION OF THIS REPORT

The remainder of this report presents our findings. Chapter 2 discusses the analysis of gas-efficiency measures for the residential sector. Chapter 3 discusses the analysis of residential fuel switching.[4] Chapters 4 and 5 are similar to Chapters 2 and 3 but they deal with the commercial sector. Chapter 4 addresses commercial efficiency measures and Chapter 5 discusses fuel-switching.[5] Chapters 6 and 7 address program and policy experience to date in the United States and Canada with gas DSM and fuel switching respectively.[6] Finally, Chapter 8 summarizes our findings and recommends further research, and policy and program initiatives that should be undertaken in New York State.

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[4] The residential analyses were prepared by Mark Kelly, Building Science Engineering, Harvard, MA, and Steven Nadel, ACEEE.

[5] The commercial analyses were done by Joe Eto, an independent consultant, Oakland, CA.

[6] These analyses were done by Jennifer Jordan, ACEEE.

Chapter 2

THE POTENTIAL FOR RESIDENTIAL GAS EFFICIENCY IMPROVEMENTS

INTRODUCTION

This chapter describes the analysis to estimate the economic potential for cost-effective gas-efficiency measures in the residential sector. This chapter is divided into three sections: methodology, measure descriptions and assumptions, and results.

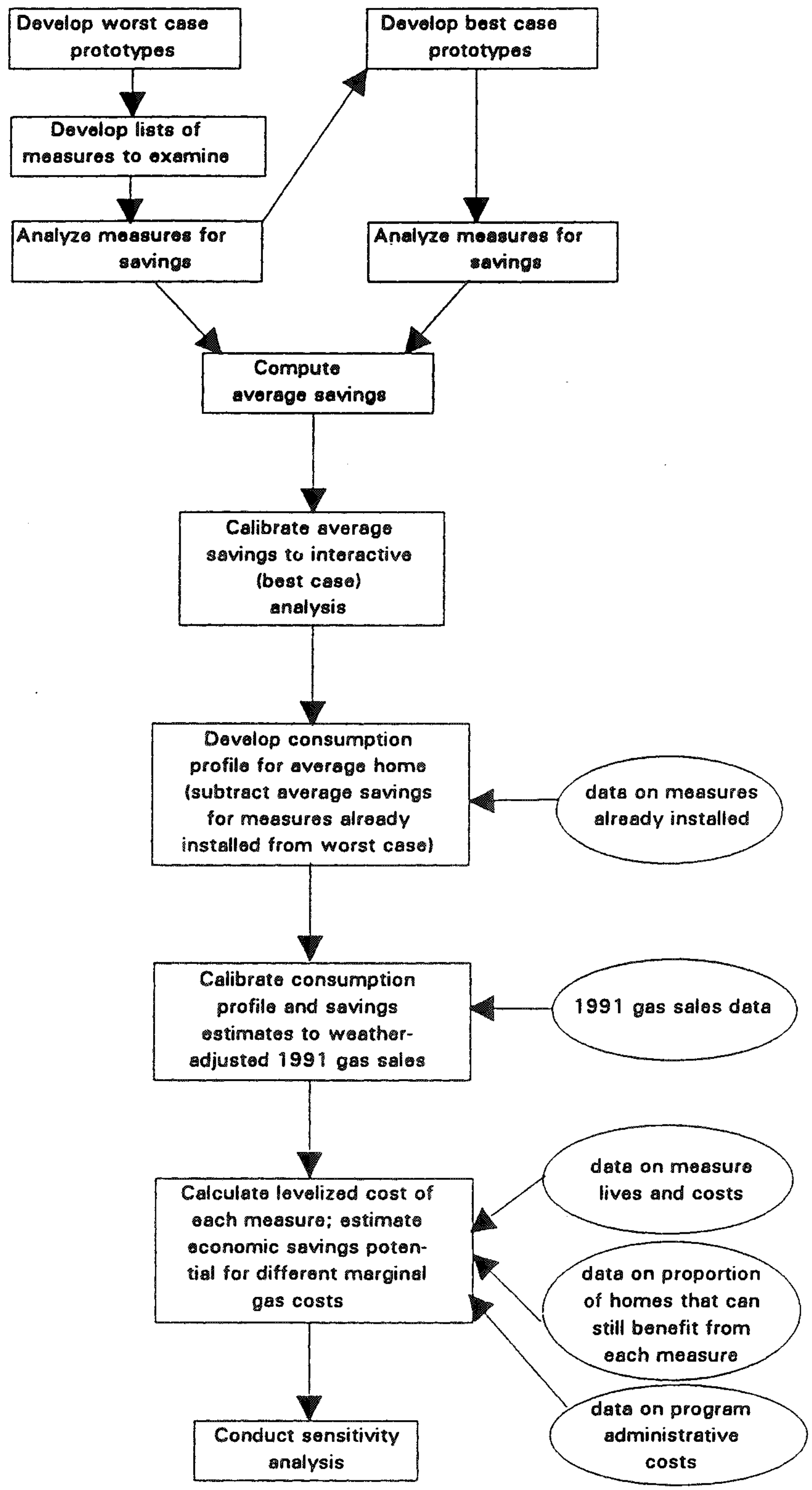
METHODOLOGY

The analysis involved four different components. First, data on the housing stock in each of the utility service territories was examined and six prototype buildings were developed to reflect the range of housing types in each service territory. The energy performance of each prototype was modeled using computer simulation. Second, the energy savings for more than 50 efficiency measures were estimated based on computer simulations and the results of published studies on measure performance in the field. This step also included an examination of data on the proportion of homes in each territory that had already installed a particular efficiency measure or that could install it in the future. Third, the results of the first two steps were compared to actual residential gas sales by each utility, and calibration factors were developed so that the energy consumption of the models reflected actual gas sales. Fourth, data on measure costs were compiled and used to calculate the levelized cost of each measure. These components, as well as many of the detailed steps that contribute to each component, are illustrated in Figure 2-1. Each of these components and steps is described in more detail in the following sections.

Prototypes

Based on utility data on housing types, and discussions with utility staff, six building types were selected to represent the housing range across the three utility service territories:

Figure 2-1. Flowchart of Residential Efficiency Potential Analysis.



NB: Squares denote steps in analysis process, ovals denote data inputs.

- Two-story colonial house (large single-family detached);
- Single-story ranch house (small single-family detached);
- Brownstone townhouse (attached single-family);
- Wood-frame townhouse (attached single-family);
- Low-rise apartment (containing large family-sized units); and
- High-rise apartment (containing small units).

These prototypes represent most homes in each service territory, although some homes do not quite match these descriptions. In these cases the most similar prototype was selected. For example, two-family attached homes were represented by townhouse prototypes. Data on the number of homes of each type for each utility are summarized in Table 2-1.

Table 2-1. Homes by Type and Utility.

Building Types	**LILCo**	**BUG**	**NFG**
Single-family colonial	134,355	70,086	89,950
Single-family ranch	68,783	14,045	269,849
Woodframe townhouse	4,191	6,772	88,992
Brownstone townhouse	0	349,865	0
Low-rise apartment	13,233	134,027	29,664
High-rise apartment	0	42,283	0
TOTAL:	220,562	617,078	478,455

Source: Smolenski 1992, Gobris 1992b, Pijacki 1992a.

For each prototype energy performance was modeled using the REM Design computer simulation package. REM Design is a PC-based model that examines the annual energy performance of a building based on four characteristic days for each month of the year (Architectural Energy Corp. 1991). REM Design is based on the SERI RES mainframe computer model, an enhanced version of the DOE2 simulation package designed for residential buildings. Reviews of residential computer simulation packages have consistently given REM Design high ratings (Rosenbaum 1991, Energy Design Update 1991). REM Design was used to estimate the heat loss across different building components and the annual heating load attributable to these losses. Fuel use for space and water heating was modeled by dividing the heating loads from REM Design by the heating system efficiency and the distribution system efficiency (a factor which accounts for heat losses from ducts and pipes). For heating system efficiencies, the Annual Fuel Utilization Efficiency (AFUE) was used for space heating and the Energy Factor (EF) was used for water heating.

In calculating energy performance parameters, REM Design requires detailed hourly weather data on temperatures, wind speed, and solar insolation. For BUG and LILCo, New York City weather data were used for the simulations. For NFG, Buffalo weather data were used.

Detailed assumptions for each prototype were developed for this project by Building Science Engineering (BSE) using utility energy audit data, blueprints in BSE's files for typical homes of each type, and other published studies. Assumptions for each prototype are summarized in Tables 2-2 through 2-7. The prototypes were used to model space and water heating energy use. For each prototype a basic heating system was selected (e.g. a warm-air furnace for the single-family detached homes). However, since many homes have other types of heating systems (e.g., some single-family homes have hot water or steam boilers) the prototypes were also run for several alternate heating systems. These alternate analyses were then factored into the energy use and energy savings calculations based on the proportion of homes that had each type of alternate heating system.

For cooking and drying clothes, simple spreadsheet models were constructed that assumed a single baseline stove or dryer, regardless of home type.

Measure Analysis

Existing homes range widely in their energy efficiency, from homes with few efficiency measures installed to homes with most efficiency measures installed. We captured this variation by starting with worst case homes and progressively counting savings potentials for only those measures that could still be implemented. For some measures that have been widely implemented, the proportion of homes still needing the measure is small and hence savings are small. For measures that have rarely been implemented, the proportion needing the measure is much higher and thus savings are large. But even for these measures, the proportion who can still implement a measure is seldom 100 percent -- there is almost always someone who has already implemented the measure.

Thus, the initial prototypes described in Tables 2-2 through 2-7 represent inefficient homes without insulation, with single-glazed windows and inefficient space and water heating systems. These prototypes capture savings in homes that are much less efficient than the average homes. However, many homes have insulation, double-glazed windows, and other efficiency improvements. In fact, a few homes may contain nearly all efficiency measures. In order to incorporate these average and "best case" homes into the analysis and estimate the average savings for individual efficiency measures, a multi-step analysis was conducted.

First, lists of appropriate efficiency measures were developed for each prototype. Measures selected are all either commercially available, or are expected to be commercialized in the next one to two years.

Second, the initial ("worst case") prototypes were used to estimate the energy savings from each measure. For each space and water heating efficiency measure, energy may be saved by either: (a) reducing the demand for energy (reduction of load), such as when efficiency measures are applied to the shell of the building; (b) improving the efficiency of the heating system; (c) improving the efficiency of the system that delivers the heat from the equipment to the rooms where it is needed. Measures in this last category include insulating pipes and sealing air leaks in ducts.

Table 2-2. Two-Story Colonial Characteristics.

Characteristic	Value	Source/Comment
Dimensions	26x52 ft.	BSE
Heated floor area	2085 sf	BSE
Levels	2 floors plus basement in main house; 1 story w/ cathedral ceiling in family room.	BSE
Ceiling height	8 ft.	BSE
Wall type	Wood frame 2x4, 16" o.c., sheetrock interior.	BSE
Wall area	2130 sf (including windows.)	BSE
Door type	2 wood plus 1 wood w/ glass.	BSE
Door area	32.5 sf (not including 5.3 sf glass in door)	BSE
Roof type	8 on 12 pitch attic, 3/4 in. plywood w/ asphalt shingles.	BSE
Roof area	879 sf attic floor, 432 sf above family room.	BSE
Foundation type	Full basement, semi-heated 60°F)	BSE
Foundation area	1540 sf, slab, 7.5 ft high foundation walls, 1 ft above grade.	BSE
Window type	Single-glazed wood, double-hung, divided lights.	BSE
Window area	414 sf (North 0, East 69.4, South 69.6, West 156.8 plus 4 in basement, all 4.5 sf)	BSE
Infiltration	1 ACH	NYSERDA 1989
Heating system	Gas furnace, 65% AFUE, 526 sf of ducts, distribution efficiency 79%	BSE, Geller 1988, Andrews & Modera 1991.
Alternative heating systems	Gas hot water boiler, 65% AFUE, 160 lf pipe, 94% distribution efficiency. Gas steam boiler, 60% distribution efficiency.	BSE, Andrews & Modera 1991
Hot water	Gas storage water heater, 48% EF, 4 people.	Geller 1988, BSE

Table 2-3. Single-Story Ranch Characteristics.

Characteristic	Value	Source/Comment
Dimensions	28 x 55 ft.	BSE
Heated floor area	1485 sf	BSE
Levels	1 floor plus basement	BSE
Ceiling height	7' 8"	BSE
Wall type	Exterior 16" o.c. wood frame construction, sheetrock interior.	BSE
Wall area	1278 sf	BSE
Door type	2, wood	
Door area	21 sf each	
Roof type	6 on 12 pitch attic, 3/4" plywood w/ asphalt shingles.	BSE
Roof area	1540 sf	BSE
Foundation type	Full basement, semi-heated (60°F)	BSE
Foundation area	1540 sf slab, 7.5 ft. high foundation wall, 1 ft. above grade.	BSE
Window type	Single-glazed wood casements.	BSE
Window area	172 sf (North 50, East 27, South 50, West 27 sf); also 4 bsmnt. @4.5 sf each.	BSE
Infiltration	1 ACH	NYSERDA 1989
Heating system	Gas furnace, 65% AFUE, 456 sf of ducts, distribution efficiency 79%	BSE, Geller 1988, Andrews & Modera 1991.
Alternative heating systems	Gas hot water boiler, 65% AFUE, 120 lf pipe, 94% distribution efficiency. Gas steam boiler, 60% AFUE, 120 lf pipe, 61% distribution efficiency.	BSE, Andrews & Modera 1991
Hot water	Gas storage water heater, 48% EF, 4 people downstate, 3 people upstate	Geller 1988, BSE

Table 2-4. Woodframe Townhouse Characteristics.

Characteristic	Value	Source/Comment
Dimensions	20x30 ft. each fl.	BSE
# connected units	6	BSE
Heated floor area	1200 sf/unit	BSE
Levels	2 plus basement.	BSE
Ceiling height	8 ft. lower level, 7 ft upper level, 10" b/w floors.	BSE
Wall type	16" o.c. wood frame construction, sheetrock interior	BSE
Wall area	660 sf/unit plus 607.5 sq. ft. for end units.	BSE
Door type	2, wood	BSE
Door area	21 sf each	BSE
Roof type	6 on 12 pitch attic, 1" wood w/ asphalt shingles.	BSE
Roof area	617 sf.	BSE
Foundation type	Full basement, semi- heated (60°F)	BSE
Foundation area	600 sf/unit slab, 7.5 ft. high foundation walls, 1 ft. above grade.	BSE
Window type	Single-glazed, double-hung wood.	BSE
Window area	125 sf (North 55.3, South 70) plus 45 sf (West) for end unit.	BSE
Infiltration	1 ACH	NYSERDA 1989
Heating system	Gas furnace, 65% AFUE, 200 sf of ducts, distribution efficiency 79%	BSE, Geller 1988, Andrews & Modera 1991.
Alternative heating systems	Gas hot water boiler, 65% AFUE, 100 lf pipe, 94% distribution efficiency. Gas steam boiler, 60% AFUE, 100 lf pipe, 61% distribution efficiency.	Geller 1988, BSE
Hot water	Gas storage water heater, 48% EF, 3 people downstate, 2 people upstate	Geller 1988, BSE

Table 2-5. Brownstone Characteristics.

Characteristic	Value	Source/Comment
Dimensions	15 x 30 ft. each floor	BSE
# connected units	20	BUG
Heated floor area	1800 sf/unit	BSE
Levels	4 per building including basement	BSE
Ceiling height	8 ft. lower & mid-levels, 7' 8" upper level, 10" between floors.	BSE
Wall type	Exterior brownstone, lath & plaster interior.	BSE
Wall area	1013 sf per unit plus 750 sf for end unit.	BSE
Door type	2, wood	BSE
Door area	21 sf each	BSE
Roof type	6 on 12 pitch attic, 1" wood w/ asphalt shingles.	BSE
Roof area	600 sf/unit	BSE
Foundation type	Full basement, semi-heated. (60°F)	BSE
Foundation area	600 sf slab, 7.5 ft high foundation wall, 1 ft above grade.	BSE
Window type	Single-glazed double-hung wood.	BSE
Window area	175 sf (North 75, South 100), plus 65 sf (West) for end units	BSE
Infiltration	1.0 ACH	NYSERDA 1989
Heating system	Gas steam boiler, 60% AFUE, 98 lf pipe/unit, 61% distribution efficiency	BSE, Andrews & Modera 1991
Alternate heating system	Gas hydronic boiler, 65% AFUE, 98 lf pipe/unit, 94% distribution efficiency	BSE, Andrews & Modera 1991
Hot Water	Gas storage water heater, 48% EF, 3 people	BSE, Geller 1988

Table 2-6. Low-Rise Apartment Characteristics.

Characteristic	Value	Source/Comment
Exterior dimensions	54 x 108 ft	BSE
Apts/building	16	BSE
Heated floor area	1061 sf/apt., 4 apts./ floor, plus 940 sf/floor for heated hallways	BSE
Levels	1 for each apt., 4 for the whole building	BSE
Ceiling height	8 ft.	BSE
Wall type	Exterior & interior brick, w/ 2" cavity between interior & exterior walls; 10" overall thickness	BSE
Wall area	609.5 sf/apt.	BSE
Roof type	Flat, 1" plywood w/tar & gravel, 2 ft. above ceiling	BSE
Roof area	1296 sf/apt., including hallway	BSE
Foundation type	slab on grade	BSE
Foundation area	1296 sf/bottom floor apt., including hallway	BSE
Window type	single glazed sliding aluminum w/o thermal break.	BSE
Window area	151 (East 37.67, South 113 sf)	BSE
Infiltration	1.0 ACH	NYSERDA 1989
Heating system	Gas boiler, 65% AFUE, 45 lf pipe/apt, 94% distribution efficiency	BSE, Andrews & Modera 1991
Alternate heating system	Steam boiler, 60% AFUE, 45 lf pipe/apt, 61% distribution efficiency.	BSE, Andrews & Modera 1991
Hot water	Gas storage water heater, 48% EF, 2 people	BSE, Geller 1988

Table 2-7. High-Rise Apartment Building Characteristics.

Characteristic	Value	Source/Comment
Exterior dimensions	66 x 81 ft	BSE
Apts/bldg.	36	BSE
Heated floor area	756 sf/apt plus 672 sf/floor for hallways	BSE
Levels	1 for apt., 6 for whole building.	BSE
Ceiling height	8 ft.	BSE
Wall type	10" masonry w/ 3/4" airspace, lath & plaster	BSE
Wall area	440 sf for corner apts,224 sf for non-corner apts	BSE
Roof type	Flat, 1" plywood w/ tar & gravel, 2 ft. above ceiling.	BSE
Roof area	868 sf/unit including hallway	BSE
Foundation type	Full basement, unheated	BSE
Foundation area	756 sf slab/ground-floor apt, 7.5 ft high foundation walls, 1 ft above grade.	BSE
Window type	Single-glazed steel casement w/o thermal break.	BSE
Window area	113 sf (East 88.3, South 25 sf) for corner apts, 88.3 sf (E) for non-corner apts.	BSE
Infiltration	1.0 ACH	NYSERDA 1989
Heating system	Gas steam boiler, 60% AFUE, 22 lf pipe/apt, 61% distribution efficiency	BSE, Andrews & Modera 1991
Alternate heating system	Gas hydronic boiler, 65% AFUE, 22 if pipe/apt, 94% distribution efficiency	BSE, Andrews & Modera 1991
Hot water	Hot water off of boiler, 43% efficiency, 2 people	BSE, Geller 1988

Savings from the first class of measures were modeled using REM Design. In compiling these estimates, good quality workmanship was assumed. These calculations were compared to the results of field studies on savings from specific measures and where significant discrepancies were found, the analysis was revised to minimize these discrepancies (specific examples are discussed later in this chapter). The second and third classes of measures were modeled by changing the heating system efficiency (AFUE or EF) and the distribution system efficiency. These values were obtained from published field and laboratory studies.

Since each of the measures was applied to the worst case prototypes, there are large opportunities for savings, and hence the savings from each measure are likely to be close to the maximum savings achievable. For example, with the inefficient heating system assumed in the worst case analysis, fuel savings from all measures are larger than if a more efficient system is assumed.

Third, the worst case prototype was revised to include nearly all efficiency measures which are likely to be cost-effective to consumers. This analysis, the "best case" analysis, estimated the savings that can be achieved from a comprehensive package of efficiency measures, after allowing for the interaction of the different measures. Due to these interactive effects, the savings from a comprehensive package of measures are generally less than the sum of the savings if each measure is installed individually. The measures included in this analysis are summarized in Table 2-8.

Table 2-8. Interactive Analysis Measures.

R-30 attic insulation
R-13 cellulose wall insulation *
R-4 foam wall insulation **
Basement insulation (ceiling, wall or slab; as appropriate)
Storm windows
Air infiltration reduction to 0.35 ach
Duct (R-6) or pipe insulation (as appropriate)
High efficiency furnace (91% AFUE) or boiler (82-84% AFUE)
Setback thermostat (50% with 5^0 setback, 50% with 10^0)
High efficiency water heater (0.65 EF)
Low-flow showerheads and aerators
Hot water pipe insulation

* Wood frame homes
** Masonry homes

Fourth, the analysis of the savings attributable to each individual measure was repeated, except this new analysis was based on the best case prototypes. In other words, from the comprehensive efficiency package, measures were subtracted one-by-one to estimate the savings attributable to each. This analysis generally estimates the minimum savings that can be achieved by each measure because the presence of the other measures minimizes the potential for additional savings. For example, if the home is well insulated, with low infiltration, savings from installing a high-efficiency heating system will be relatively low.

Fifth, the average savings that could be achieved by each measure was estimated by averaging the maximum and minimum savings calculated previously in steps two and four. In actuality, the savings from the first measure implemented will be the maximum savings and the savings from the last measure implemented will be the minimum savings. Savings for all other measures will gradate from maximum savings to minimum savings depending on the order in which measures are implemented. Since measures are likely to be implemented in a different order from home to home (e.g. some homes start with storm windows and others with improved heating systems), choosing an arbitrary order may be misleading. By averaging the maximum and minimum savings figures, the implicit assumption is that each measure is implemented midway through a set of efficiency investments, which is more likely to represent the typical role of each measure than one of the extremes.

Sixth, the average savings figures from the previous step were adjusted so that when savings from all measures included in Table 2-8 are summed, the results exactly equal the results of the best case analysis. This adjustment was generally small, but necessary to ensure that interactions between measures were properly accounted for and no savings were double-counted.

Finally, the energy consumption of the average home for each prototype was estimated by taking the energy consumption of the worst case prototype and subtracting savings attributable to efficiency measures that are already in place. These savings were calculated by multiplying the average savings for each measure (from steps five and six) by the proportion of homes that have already installed each measure.

An alternative to this approach would be to start with the average home, and because all existing conservation measures are included in the average home, then any measures that are not included in the average home can be included in 100 percent of the homes. This approach ignores both the small portion of homeowners who have not implemented common measures such as stormwindows and the small portion of homeowners who have implemented uncommon measures such as condensing furnaces or zoning air distribution systems. Implicitly this approach assumes that savings from the unimplemented common measures and the implemented uncommon measures cancel each other out. We were not prepared to make this assumption, and hence we used the more complex approach of modeling the range of actual buildings -- starting with the worst case building.

To understand this process more clearly, it is useful to examine a simple example of a hypothetical home using 100 therms of gas annually. Four efficiency measures are installed. Savings from these measures can be estimated five ways -- maximum savings (as in stage two previously described), interactive savings (similar to stage three), minimum savings (as in stage four), average of maximum and minimum (as in stage five), and adjusted average savings (as in stage six). Data for this illustration are summarized in Table 2-9.

Table 2-9. Illustration of Different Approaches for Estimating Energy Savings from a Group of Measures (all data in therms per year).

	Maximum Savings	Interactive Savings	Minimum Savings	Avg. of Max & Min	Adjusted Avg. Savings
Measure #1	10	10	6	8	8
Measure #2	14	11	8	11	10
Measure #3	20	14	10	15	14
Measure #4	8	2	2	5	5
SUM	52	37	26	39	37

The maximum savings estimates assume that each measure is the first measure implemented and do not account for any interactive effects. The interactive savings analysis assumes that measures are implemented in sequential order, starting with measure #1 and ending with measure #4. Savings from each measure assume that previous measures have been implemented. Thus, savings from the first measure are the same in both the maximum and interactive cases. However, the maximum and interactive cases differ by progressively more as one advances down the list. Thus the interactive approach is highly sensitive to the order measures are installed. The sum of the interactive savings estimates represents the most accurate estimate of savings for the package of four measures because interactions between measures are fully accounted for. This sum (37 therms) is somewhat less than the sum of the maximum savings (52 therms). The minimum savings analysis assumes all measures are in place, except for the measure being analyzed. Minimum and interactive savings are the same for measure #4. For measures #1-3, minimum savings are lower than interactive savings. Average savings are the average of maximum and minimum savings. The sum of average savings (39 therms) is very close to the sum of interactive savings. However, to bring average savings exactly in line with interactive savings, an adjustment factor of 37/39 is applied to each of the average savings estimates. The results of this adjustment are shown in the adjusted average savings column.

Thus, by definition, the sum of the adjusted average savings figures will be the same as the sum of the interactive savings figures. The only difference are the figures used to equal this sum. If the exact order in which measures will be implemented is known, then the interactive approach provides a better answer. However, if the order is unclear, the interactive approach can be misleading. In the example above, under the interactive approach, savings from measure #4 are only two therms. However, if this measure were the first to be implemented, savings would be four times greater (eight therms). With the adjusted average approach, these potential errors are less pronounced. In the preceding example, with the adjusted average approach, measure #4 saves five therms, midway between the maximum and minimum savings (two and eight therms respectively). Regardless of the order measures are implemented, the adjusted average will be relatively close to the correct result.

For this study, the order in which measures will be implemented is uncertain, and thus the adjusted average approach is less likely to provide misleading answers. Also, the adjusted average approach is easier to implement because less computer runs are needed. Given the number of measures included in the residential analysis, this is an important factor. As a result, we elected to use the adjusted average approach. However the final answer -- how much will be saved if all measures are implemented -- is the same whether the interactive or adjusted average approach is used.

Calibration

A final step in the savings analysis was to compare the results of the models to actual weather-normalized gas sales for each utility. These analyses are shown in Tables 2-10, 2-11, and 2-12. For the two downstate utilities (BUG and LILCo), the models are within 6 percent and 14 percent of actual gas sales respectively. For National Fuel Gas, the analysis overestimates gas consumption by 46 percent.

Table 2-10. Calibration of LILCo 1991 Residential Sales to ACEEE Model Results.

MODEL RESULTS	**# Units**	**DTh/Unit**	**Total DTh**
Combined space and water-heating consumption in homes that use gas for both end-uses			
Ranch	68,783	164.3	11,301,047
Colonial	134,355	184.6	24,801,933
Townhouse	4,191	90.9	380,962
Brownstone	0	NA	0
Low-Rise	13,233	56.2	743,695
High-Rise	0	NA	0
Subtotal	**220,562**		**37,227,636**
Water heating consumption in homes w/ gas water heat but not gas space heat	49,237	30.7	1,511,576
Cooking	337,242	5.3	1,787,383
Drying	223,521	4.3	961,140
Subtotal			**4,260,099**
Total			**41,487,736**
ACTUAL 1991 SALES			
Space heating accounts			29,994,744
Space heat portion			23,574,897
Adjustment for heating degree days*			3,241,683
Other residential accounts			3,210,165
Total			**36,446,592**
Adjustment factor applied to model results			88%

Source of housing unit, gas sales, and degree day data: Smolenski 1992.

* Adjustment of space heating consumption to account for fact that 1991 heating degree days were 12 percent below normal.

Table 2-11. Calibration of BUG 1991 Residential Sales to ACEEE Model Results.

MODEL RESULTS	**# Units**	**DTh/Unit**	**Total DTh**
Combined space and water heating consumption in homes that use gas for both end-uses			
Ranch	14,045	153.2	2,151,694
Colonial	70,086	180.7	12,664,540
Townhouse	6,772	90.0	609,480
Brownstone	349,865	146.8	51,360,182
Low-Rise	134,027	56.2	7,532,317
High-Rise	42,283	68.2	2,883,701
Subtotal	**617,078**		**77,201,914**
Water heating consumption in homes w/ gas water heat but not gas space heat	139,205	25.8	3,591,489
Cooking	1,403,078	5.3	7,436,313
Drying - single family	191,000	4.3	821,300
Drying - multifamily	26,000	58.8	1,528,800
Subtotal			**13,377,902**
Total			**90,579,817**
ACTUAL 1991 SALES			30,456,383
Space heating accounts			65,379,000
Space heat portion			49,284,371
Adjustment for heating degree days*			10,586,645
Other residential accounts			9,547,000
Total			85,512,645
Adjustment factor applied to model results			94%

Source of housing unit, gas sales, and degree day data: Gobris 1992b.

* Adjustment to space heating consumption to account for fact that 1991 heating degree days were 18% below normal.

Table 2-12. Calibration of NFG 1991 Residential Sales to ACEEE Model Results.

MODEL RESULTS	**# Units**	**DTh/Unit**	**Total DTh**
Combined space and water heating consumption in homes that use gas for both end-uses			
Ranch	269,849	203.0	54,779,347
Colonial	89,950	238.5	21,453,075
Townhouse	88,992	105.0	9,344,160
Brownstone	0	NA	0
Low-Rise	29,664	75.4	2,236,666
High-Rise	0	NA	0
Subtotal	**478,455**		**87,813,248**
Subtract water heating consumption from above for homes with gas space heat but not gas water heat	(51,195)	34.2	(1,750,858)
Cooking	320,565	5.3	1,698,994
Drying	260,280	4.3	1,119,202
Subtotal			**1,067,337**
Total			**88,880,585**
ACTUAL 1991 SALES			**55,786,962**
Weather-adjusted 1991 sales			62,506,177
Adjustment factor applied to model results			68%

Source of housing unit and weather-adjusted gas sales data: Pijacki 1992a.

We investigated why the models are not very accurate for NFG and found several partial explanations including: this analysis classifies mobile homes as ranch-style homes, thereby overestimating the consumption by mobile homes; and the smallest home in the upstate analysis, the low-rise, is 1061 square feet despite the fact that there are a substantial number of units upstate that are less than 1000 square feet. However, these factors explain only part of the problem. The largest part of the problem seems to be due to the fact that energy-use patterns are distinctly different in the NFG service area than in the regions served by the other two utilities.

For example, consumption per home for LILCo customers is 14 percent higher than for NFG customers (136 compared to 119 DTh/year[1]) although heating degree days are usually 36 percent higher upstate (6755 compared to 4980) (Smolenski 1992, Pijacki 1992a). Larger homes in the LILCo area explain part of the difference (on average LILCo homes are 20 to 25 percent larger based on the data in Tables 2-10 and 2-12), but when consumption per home is adjusted for home size and heating degree days, there is approximately a 20 percent difference that is unexplained. It may be that upstate residents are more likely to turn down thermostats, shut off rooms, and use supplementary heating sources. For example, a survey by Niagara Mohawk of their electric customers included over 300 NFG gas space heating customers. These NFG customers reported an average thermostat setting of 67° F, including 67 percent who reported using supplemental fuels (Hamilton 1992). While no comparable data is available on downstate homes, we suspect that temperature settings may be higher downstate and use of supplemental fuels lower. Further research is needed to verify or refute this hypothesis.

Given the discrepancies between the models and actual sales, to accurately estimate the economic potential for gas savings, an adjustment factor was applied to the prototype models and savings estimates to bring the models exactly in line with data on actual gas sales that were derived from the calibration analyses (see Tables 2-10, 2-11 and 2-12). The same adjustment factor was applied to all end-uses because given the available data, there was no reason to

[1] A decatherm (DTh) is ten therms of natural gas. A therm of gas is the amount of gas needed to provide 100,000 Btu of heat. Thus, a DTh is a million Btu.

assume that the discrepancy between actual and modeled sales was due or was not due to particular end-uses.

As an outgrowth of developing data by building and appliance type for the calibration process, an estimate of the proportion of gas sales that is attributable to each end-use was assembled. This data is summarized in Table 2-13 and Figure 2-2.

Cost-Effectiveness Analysis

The final step in the analysis was to estimate the cost-effectiveness of each measure by calculating the cost of saved gas (CSG) for each measure. CSG is the levelized cost per therm of a measure over its lifetime. CSG is calculated using the following formula:

$$\text{CSG (\$/DTh)} = \frac{\text{(Measure cost + Program costs) * Capital recovery factor}}{\text{Annual DTh savings}}$$

Measure costs were obtained from published studies and product catalogs and from discussions with contractors in New York and adjacent states. Measure costs include both equipment and installation costs. For most measures these costs are the full cost of the measure. However, for some measures which are expensive and unlikely to be cost-effective as a retrofit measure, these costs are incremental costs relative to standard efficiency equipment. These measures are referred to in the tables and text as replacement measures, because the cost-effectiveness analysis is only applicable to situations where existing equipment is being replaced.

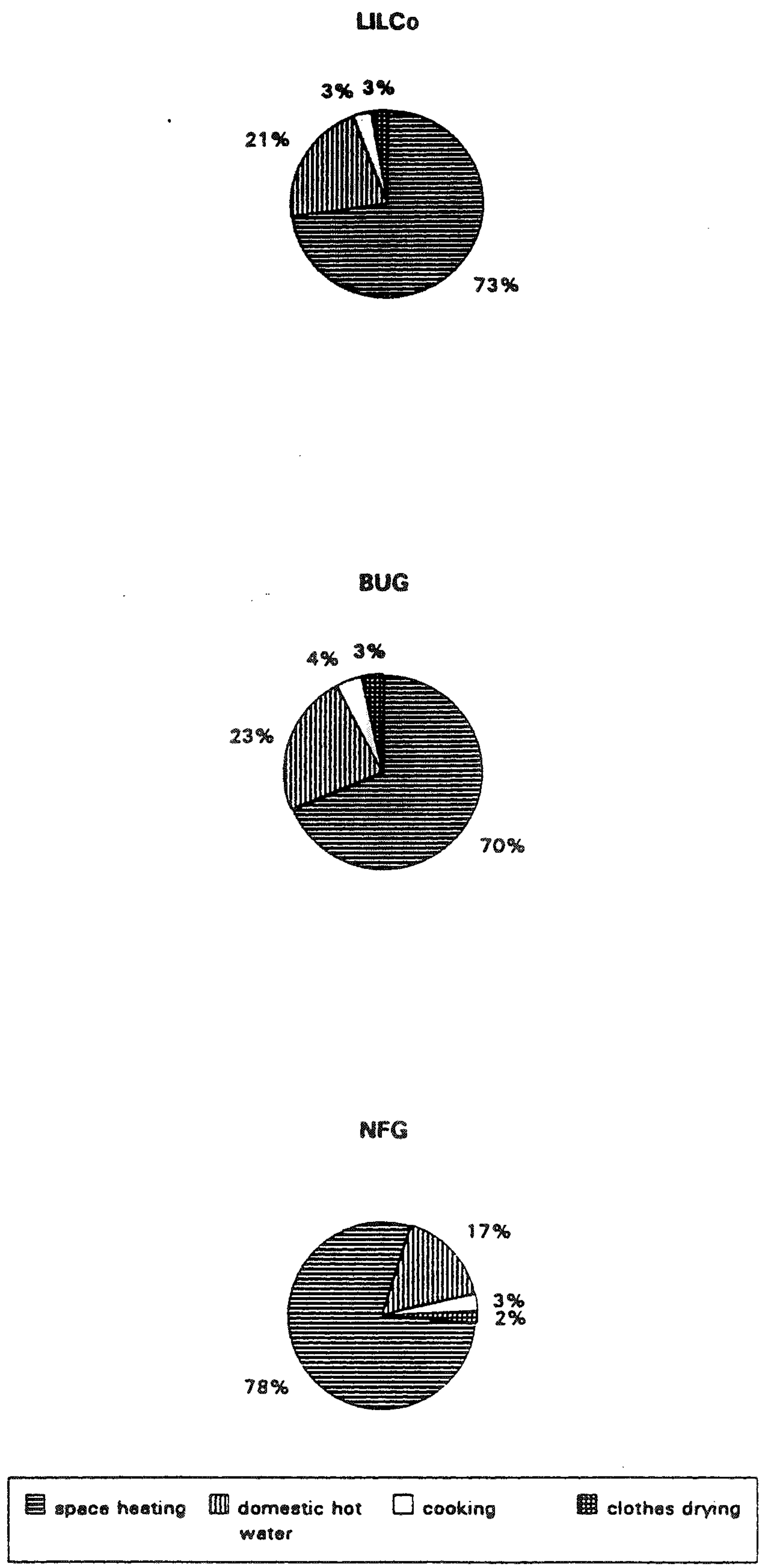
For a few measures, measure costs obtained by BUG from local contractors were substantially higher than measure cost estimates we obtained from other sources. These instances are noted with an asterisk in the cost tables. Generally, these discrepancies arose in situations where measures are rarely done today and hence BUG contractors were not especially experienced with the measures. At BUG's request, the BUG measure costs were used for the BUG analysis, but were not used for the other utility analyses. As BUG contractors become more familiar with these measures, costs may come down and measure cost-effectiveness improve.

Table 2-13. End Use Allocation Estimates - Primary Case *(including weatherization measures that have already been installed).*

	LILCo		BUG		NFG	
Colonial						
space heating	1,253	75%	1,267	73%	1,460	80%
domestic hot water	335	20%	369	21%	302	17%
cooking	48	3%	50	3%	37	2%
clothes drying	39	2%	40	2%	30	2%
Ranch						
space heating	1,076	72%	1,010	69%	1,249	80%
domestic hot water	333	22%	368	25%	239	15%
cooking	48	3%	50	3%	37	2%
clothes drying	39	3%	40	3%	30	2%
Townhouse						
space heating	484	57%	481	55%	584	70%
domestic hot water	272	32%	298	34%	180	22%
cooking	48	6%	50	6%	37	4%
clothes drying	39	5%	40	5%	30	4%
Brownstone						
space heating	n/a	n/a	1,025	73%	n/a	n/a
domestic hot water	n/a	n/a	288	21%	n/a	n/a
cooking	n/a	n/a	50	4%	n/a	n/a
clothes drying	n/a	n/a	40	3%	n/a	n/a
Low Rise						
space heating	247	46%	248	45%	383	62%
domestic hot water	199	37%	213	39%	168	27%
cooking	48	9%	50	9%	37	6%
clothes drying	39	7%	40	7%	30	5%
High Rise						
space heating	n/a	n/a	321	49%	n/a	n/a
domestic hot water	n/a	n/a	250	38%	n/a	n/a
cooking	n/a	n/a	50	8%	n/a	n/a
clothes drying	n/a	n/a	40	6%	n/a	n/a

Note: Range and dryer saturation figures are not included in this table.

Figure 2-2. Primary Case End Uses.



Program costs are funds paid by utilities to administer demand-side management programs which promote efficiency measures. As noted in Chapter 1, two program cost scenarios were modeled a 50 percent of total measure cost scenario, based on limited data from New York State electric utility DSM programs, and a 25 percent of total measure cost scenario based on studies of administrative costs throughout the U.S.

The capital recovery factor (CRF) is the annual payments on a $1 loan used to finance an efficiency measure, assuming an interest rate equal to the discount rate, and a loan term equal to the measure life.[2] In calculating the CRF for a measure, measure lives are the estimated average life of a measure in the field, not the engineering life as measured in a laboratory.

In the calculations, a 5 percent real discount rate is assumed (*real* means excluding the effects of inflation -- the real rate is lower than the *nominal* rate charged by banks because the nominal rate includes an allowance for inflation). This rate is based on the New York State Energy Office's projected nominal utility cost of capital (8.9 percent) (NYSEO 1992) divided by the estimated rate of inflation (3.7 percent) determined by the New York Public Service Commission (1992).[3]

For the CSG calculations, savings are based on the adjusted and calibrated values derived from the analysis described in the previous section.

The CSG can be used to roughly estimate the cost-effectiveness of a measure. If the CSG is less than the retail price of a DTh of gas, then a measure is likely to be cost-effective from the consumer perspective. If the CSG is less than the marginal price of a DTh, then the measure is likely to be cost-effective from the total resource cost perspective (for a discussion

[2] CRF is usually calculated using the loan payment formula in a computer spreadsheet program. The full formula for CRF is: $(d(1+d)^n)/((1+d)^n-1)$ where d is the discount rate and n the measure life. Thus, for a measure with a 30-year life, the CRF is 0.065, assuming a 5% discount rate.

[3] The exact calculation is as follows: 1.089/1.037 = 1.05.

of the different cost-effectiveness perspectives, see Krause and Eto 1988). Retail and marginal costs for the utilities covered by this study are discussed in Chapter 1.

Uncertainties in the Analysis

When interpreting the cost, savings, and CSG data in this report, it is important to keep in mind that CSG calculations represent typical cases, and that individual applications will vary considerably. Accordingly, even for measures with low CSGs, some applications are likely to have a CSG in excess of the marginal cost.

Furthermore, all of the estimates presented here are uncertain. For example, according to many studies, actual metered energy savings from efficiency measures are often less than savings predicted by engineering calculations. These discrepancies are primarily due to faulty assumptions used in many engineering estimates and problems with the quality of measure installations (Nadel and Keating 1991). To address this problem, as noted above, savings estimates used in this study were generally calibrated to field studies. Still, it is possible the savings estimates reported here are inaccurate. For example, a field study by BUG on attic insulation found even lower savings from attic insulation than is estimated in this study or than were estimated by energy audits conducted by BUG. Explanations for the discrepancy are not available (Gobris 1992a).

Similarly, there is some uncertainty about the costs of different efficiency measures. For example, for five measures (clock thermostats, mainline air vents, condensing and near-condensing furnaces, and foam wall insulation), BUG obtained cost estimates from local contractors that exceeded estimates we obtained from other sources by 25 to 190 percent. Most of these measures were infrequently installed in the BUG service area. We reasoned that as contractors become more familiar with these measures, prices will come down. BUG was skeptical about future price decreases. In the analysis, the BUG cost estimates were used for the BUG territory, and our estimates were generally used for the other territories. To the extent the BUG cost estimates are too high, the CSG's estimated for BUG will be too high. Likewise, to the extent prices for these measures remain high, the CSG's for LILCo and NFG may be too low.

Sensitivity Analysis

Given the many uncertainties about measure costs and savings, in addition to the 25 percent and 50 percent program cost cases, two additional sensitivity cases were run, one based on measure costs without any program cost adder, and one based on a 75 percent adder to measure costs.

The zero-adder case is the most optimistic scenario. It would apply if program costs are 25 percent of measure costs and measure costs are 25 percent less than the values discussed later in this chapter. This case also applies if measure cost estimates are correct, but savings are 33 percent more than are estimated in the analysis[4] or measure lives are 50 percent longer than the estimates discussed later in this chapter. Another use of this case is that it represents homes that use 33 percent more gas than the average home.

The 75 percent adder case is the most pessimistic scenario. It would apply if program costs are 50 percent of measure costs and measure costs are 25 percent more than the values discussed later in this chapter. It would also apply if program costs are as high as 75 percent of measure costs, a possibility raised by BUG (Gobris 1993). This case also applies if program costs are 50 percent and either savings are 20 percent less, or measure lives are 24 percent less than the primary estimates.

In addition to these two sensitivity cases, the 25 percent and 50 percent program cost scenarios serve as sensitivity cases for each other. For example, if program costs are 25 percent of measure costs, but savings estimates are 20 percent too high, then CSG's would be the same as the 50 percent program cost scenario. Similarly, if program costs are 50 percent of measure

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[4] In the CSG calculation costs are in the numerator and savings in the denominator and hence a 25 percent change to either costs or savings will produce slightly different percentage changes in CSG.

costs, but cost estimates are 25 percent too high, then CSG's would be the same as the 25 percent program cost scenario.

MEASURE DESCRIPTIONS AND ASSUMPTIONS

Five types of energy-efficiency measures were analyzed: shell, heating and distribution system, domestic hot water, cooking, and drying.

Shell Measures

Building shell measures examined include attic insulation, wall insulation, basement insulation, storm windows, replacement windows, and infiltration reduction. Measure costs and lifetimes are summarized in Table 2-14. The proportion of buildings that already have each measure or could benefit from each measure are summarized in Tables 2-15 and 2-16. This latter data is generally based on utility energy audit data. Internal inconsistencies in these data lead us to question the quality of the data and hence these estimates are subject to substantial uncertainty.

Savings for each of these measures were modeled using REM Design. For most measures this analysis is straightforward. However, when uninsulated attics, walls and floors are modeled, the analysis is susceptible to small changes in the assumed R-value of the uninsulated building sections. We examined these situations in detail and in several instances elected to change REM Design's default assumptions for the R-value of uninsulated building sections. These complex issues are discussed in Appendix A.

Attic Insulation

For the analysis, four attic insulation measures were modeled: R-0 to R-30; R-5 to R-30; R-11 to R-30; and R-19 to R-30. The first measure applies to uninsulated houses; the second measure to houses with old insulation that is heavily compressed; and the third and fourth measures to homes with more substantial insulation.

Table 2-14. Summary of Shell Measure Costs and Lifetimes.

Measure	Cost	Units	Lifetime	Source/Notes
Attic Insulation				
R-0 --> R-30	0.88	$/sqft	30	Avg. of LILCo 1992, BUG 1992, NFG 1992, NEES 1990.
R-5 --> R-30	0.78	$/sqft	30	
R-11 --> R-30	0.65	$/sqft	30	
R-19 --> R-30	0.52	$/sqft	30	
Wall Insulation				
R-13 cellulose	1.00	$/sqft	30	Avg. of LILCo 1992., BUG 1992, NFG 1992.
R-4 foam sheathing	1.50*	$/sqft	30	BUG 1993
Basement Insulation				
R-19 fiber. in ceiling	1.00	$/sqft	30	BSE estimate
R-28 cellulose in ceiling	1.00	$/sqft	30	NEES 1990
R-11 fiber. in walls	0.40	$/sqft	30	BSE estimate
R-5 foam on slab edge	1.00	$/sqft	30	BSE estimate
Windows				
Storm windows	7.86	$/sqft	20	NEES 1990
Infiltration Reduction				
1 ACH --> 0.35 ACH	300	$/home	15	BSE estimate based on NEES 1990, CSG 1992, BUG 1993.
0.75 ACH --> 0.35 ACH	250	$/home	15	
0.50 ACH --> 0.35 ACH	190	$/home	15	

*Denotes costs supplied by BUG which are substantially higher than cost estimates from other sources.

Notes:
1. Lifetimes based on engineering judgement by the project team.
2. Infiltration reduction costs are for the colonial. Costs for the low-rise and high-rise are respectively estimated to be 25 and 50 percent lower based on information from CSG 1992.

Table 2-15. Measure Applicability Assumptions -- Shell Measures: Colonial/Ranch/Townhouse

	LILCo		BUG		NFG		
Measure	**Already Installed**	**Can be Installed**	**Already Installed**	**Can be Installed**	**Already Installed**	**Can be Installed**	**Sources/Notes**
Attic Insulation							
R-0 --> R-30	10% w/R-30	36%	32%	17%	18%	14%	LILCo 1991, BUG 1991, NFG 1991
R-5 --> R-30	13% w/R-5	13%	27% w/R-5	27%	7% w/R-5	7%	LILCo 1991, BUG 1991, NFG 1991
R-11 --> R-30	25% w/R-11	25%	16% w/R-11	16%	23% w/R-11	23%	LILCo 1991, BUG 1991, NFG 1991
R-19 --> R-30	13% w/R-19	13%	5% w/R-19	5%	34% w/R-19	34%	LILCo 1991, BUG 1991, NFG 1991
Wall Insulation							
R-13 cellulose	55%	45%	37%	30%	62%	38%	LILCo 1991, BUG 1991, NFG 1991
Basement Insulation							
R-19 fiber. in ceiling	9%	45%	12%	12%	9%	10%	LILCo 1991, BUG 1991, NFG 1991
R-28 cellulose in ceiling	3%	13%	7%	3%	3%	13%	LILCo 1991, BUG 1991, NFG 1991
R-11 fiber. on walls	5%	25%	21%	12%	5%	50%	LILCo 1991, BUG 1991, NFG 1991
Windows							
Storm windows	83%	17%	66%	33%	94%	6%	LILCo 1991, BUG 1991, NFG 1991
Infiltration Reduction							
1 ACH --> 0.35 ACH	90% w/.75 or better	10%	90% w/.75 or better	10%	90% w/.75 or better	10%	NYSERDA 1989
0.75 ACH --> 0.35 ACH	60% w/.50 or better	30%	60% w/.50 or better	30%	60% w/.50 or better	30%	NYSERDA 1989
0.5 ACH --> 0.35 ACH	25% w/.35	35%	25% w/.35	35%	25% w/.35	35%	NYSERDA 1989

Table 2-16. Measure Applicability Assumptions -- Shell Measures: Brownstone, Low-Rise and High-Rise.

	Brownstone - BUG		Low Rise - BUG/LILCo		Low Rise - NFG		High Rise - BUG		
Measure	Already Installed	Can be Installed	Already Installed	Can be Installed	Already Installed	Can be Installed	Already Installed	Can be Installed	Sources/Notes
Attic Insulation									
R-0 --> R-30	32%	17%	28%	19%	28%	19%	24%	23%	BUG 1991 (1-family data for brownstone, 3-family data for low rise, 4-family data for high rise)
R-5 --> R-30	27% w/R-5	27%	39% w/R-5	39%	39% w/R-5	39%	43% w/R-5	43%	
R-11 --> R-30	16% w/R-11	16%	9% w/R-11	9%	9% w/R-11	9%	5% w/R-11	5%	
R-19 --> R-30	5% w/R-19	5%	1% w/R-19	1%	1% w/R-19	1%	1% w/R-19	1%	
Wall Insulation									
R-13 cellulose	NA	NA	14%	15%	9%	11%	NA	NA	BUG 1991
R-4 foam sheathing	37%	15%	NA	NA	NA	NA	9%	15%	ACEEE est. -- for remodeled homes
Basement Insulation									
R-19 fiber. in ceiling	19%	15%	NA	NA	NA	NA	2%	5%	BUG 1991 (brownstone based on 1-family data, high rise based on 4-family data)
R-28 cellulose in ceiling	NA	NA	NA	NA	NA	NA	2%	5%	
R-11 fiber. on walls	21%	12%	NA	NA	NA	NA	2%	8%	
Slab edge: R-5 foam bd	NA	NA	10%	40%	10%	40%	NA	NA	ACEEE estimate
Windows									
Storm windows	71%	29%	77%	23%	94%	6%	78%	21%	BUG 1991, NFG 1991
Infiltration Reduction									
1 ACH --> 0.35 ACH	90% w/.75	10%	60% w/.75	40%	76% w/.75	24%	76% w/.75	24%	BSE estimate based on NYSERDA 1989
0.75 ACH --> 0.35 ACH	60% w/.50	30%	30% w/.50	30%	38% w/.50	38%	38% w/.50	38%	
0.5 ACH --> 0.35 ACH	25% w/.35	35%	2% w/.35	28%	2% w/.35	36%	2% w/.35	36%	

In the early stages of the analysis R-40 insulation was also examined. However, these analyses found that the levelized cost to go from R-30 to R-40 of insulation was more than $10/DTh, both upstate and downstate, and hence the R-40 cases were dropped from the analysis.

Wall Insulation

Most of the prototype buildings have wood frame walls built from 2x4 studs. For these prototypes blown-in cellulose insulation was analyzed. High-density cellulose, R-13, was assumed. Savings were estimated based on the increase in wall R-value and a decrease in wall infiltration. Studies by the National Association of Home Builders (NAHB 1989) and others have found that blown-in cellulose insulation reduces air infiltration through the walls relative to a building with fiberglass batt insulation. Based on these studies we assumed that the cellulose insulation reduced the whole building infiltration rate by 23 percent.

Two of the prototypes, the brownstone and the high-rise apartment, feature masonry construction. For these buildings blown-in cellulose is rarely practical and instead adding R-4 of foam sheathing to the wall interior was modeled. After the insulation is added it must be covered with gypsum board. This measure will usually be installed during building renovation when walls are exposed and new gypsum board is included as part of the renovation package. The measure cost and applicability factors are based on renovation situations.

Basement Insulation

Four types of basement insulation were analyzed: R-19 fiberglass batts in the basement ceiling; R-28 blown-in cellulose in the basement ceiling; R-11 fiberglass insulation draped over the basement walls; and R-5 extruded polystyrene insulation installed along the edge of the basement slab down to a two foot depth. The first measure is primarily applicable to homes with unheated basements and exposed joists in the basement ceiling. The second measure is similar to the first except it is applicable to homes with finished basement ceilings without exposed joists. The third measure is applicable to homes with heated basements. The last measure is for homes with slab foundations instead of basements.

Windows

Three window measures were analyzed: aluminum storm windows; double-glazed, low-e, wood-frame replacement windows; and double-glazed, low-e replacement windows with an argon fill. U-values for the different measures are listed in Table 2-17.

Table 2-17. Window U-Values Used in the Analysis.

Case	U-Value		
	Metal frame	Metal w/ thermal break	Wood frame
Single-glazed	1.31	1.08	0.90
Single-glazed with storm	0.97	0.68	0.49
Double-glazed	0.87	0.64	0.49
Double-glazed, low-e	0.76	0.54	0.39
Double-glazed, low-e, argon filled	0.73	0.50	0.36

Source: Architectural Energy Corp. 1991.

In analyzing savings for each of these measures, in addition to the change in R-value, a 6 percent reduction in whole building air infiltration was assumed based on the results of a field study that compared air infiltration in homes with and without storm windows (NYSERDA 1989). While replacement windows were not included in this field study, due to low air infiltration ratings on most new replacement windows, a 6 percent infiltration reduction was assumed for these measures too.

Based on initial analyses it became apparent that the replacement window measures have a levelized cost as a retrofit measure substantially more than $10/DTh. However, when existing windows are being replaced as part of a home renovation project, the incremental cost of installing high efficiency windows is much lower, resulting in a competitive cost of saved gas. Still, since the number of homeowners replacing existing windows is very limited, these measures were dropped from subsequent analysis.

Infiltration Reduction

For this analysis we examined locating air infiltration sites using a blower door and sealing these sites with caulk, foam, and other appropriate sealants. Detailed descriptions of this type of work can be found in reports by Dutt et al. (1985), Wilson and Nadel (1986), and Proctor and deKieffer (1988). Three levels of air infiltration work were examined: one air-change-per hour (ach) to 0.35 ach; 0.75 ach to 0.35 ach; and 0.50 ach to 0.35 ach. The measure appropriate for a specific house will depend on the existing air infiltration rate. These packages will take an experienced crew about one half day to complete (Proctor and deKieffer 1988). Costs listed in Table 2-14 assume bulk-bid prices such as when work on many homes is scheduled with the same contractor through a program operated by a utility or government agency.

Heating and Distribution System Measures

The heating and distribution system measures include replacement heating systems; heating system retrofits; distribution system measures; and control measures. Savings for each were modeled by changing the heating system or distribution system efficiency in the calculations relative to the initial assumptions. When specific efficiency figures are provided, they represent the maximum savings analysis. Comparable estimates were also developed for the minimum savings analysis. Measure costs and lifetimes are summarized in Tables 2-18 and 2-19. Data on the proportion of homes that already have or that could benefit from each measure are summarized in Tables 2-20 and 2-21.

Replacement Heating Systems

The analysis included five types of improved-efficiency furnaces, two improved-efficiency hydronic boilers, and two improved-efficiency steam boilers. System types and efficiencies are summarized in Table 2-22.

Table 2-18. Summary of Heating System Measure Costs and Lifetimes.

Measure	Cost	Units	Lifetime	Sources/Notes
Replacement Heating Systems				
Furnace - 78% AFUE	2,000	Full cost	30	LILCo 1992, Cornerstones 1987
Furnace - 85% AFUE	130-250*	Increment	30	NFG 1992, Cornerstones 1987, BUG 1993
Furnace - 91% AFUE	470-1000*	Increment	30	Ternes et al. 1988, Cornerstones 1987, CU 1993, BUG 1993
Hydronic boiler - 80%	2600-2900	Full cost	30	BSE estimate, Bobenhausen 1992
Hydronic boiler - 84%	315	Increment	30	BSE estimate
Steam boiler - 75%	2750-3050	Full cost	30	LILCo 1992, BSE estimate
Steam boiler - 82%	270	Increment	30	BSE estimate
Modulating furnace	590	Increment	30	BSE estimate
Gas engine heat pump	1650	Increment	15	$1000 more than Hi-E elec. HP + $750 install. Accurso 1992, BSE estimate
Heating System Retrofits				
Derate furnace	268	Increment	15	NYSERDA 1979, RG&E 1978 + 79% inflation
Distribution System Measures				
Duct insulation - R-3	1.15	sqft	30	Avg, BUG 1992, NFG 1992
Duct insulation - R-3 — R-6	0.95	sqft	30	Avg, BUG 1992, NFG 1992
Pipe insul. (hydronic)	1.14	ft	30	Avg, BUG 1992, NFG 1992, LILCo 1992
Pipe insul. (steam)	1.81	ft	30	Avg, BUG 1992, NFG 1992, LILCo 1992, Ecological Innovations 1992
Seal ducts	0.16	sqft	30	Energy Investment 1992
Two zones - hydronic	600	home	30	Energy Investment 1992
Two zones - air	2000	home	30	Energy Investment 1992
Four zones - hydronic	1000	Brownstone	30	BSE estimate
Mainline air vents	400*	Brownstone	30	BUG 1993
Control Measures				
Setback thermostat	87.50-125*	each	15	LILCo 1992, Goeltz & Hirst 1986, CU 1993, BUG 1993
Thermo. steam valves	66.50	each	20	Katrakis 1989
Furnace fan/t-stat adj.	150	per house	5	Proctor 1984
Boiler temp modulation	200	per home	15	Proctor 1987

Notes:
1. Lifetimes based on engineering judgement by the project team.
2. When a range of heating system costs is provided, the low end of the range is for NFG and the high end of the range is for BUG. LILCo costs are the same as NFG except for 85% and 91% AFUE furnaces where LILCo costs are the same as BUG.

Table 2-19. Summary of Multifamily Building Space and Water Heating Measure Costs and Lifetimes.

Measure	Cost	Units	Lifetime	Sources/Notes
Replacement Heating Systems				
Low-rise apartment building: per bldg				
Hydronic boiler - 80%	6176	Full cost	30	BSE estimate based on Hydrotherm 1992
Hydronic boiler - 84%	518	Increment	30	
Steam boiler - 75%	8430	Full cost	30	
Steam boiler - 82%	402	Increment	30	
Front-end boiler	6047	Full cost	30	
High-rise apartment building: per bldg				
Hydronic boiler - 80%	10227	Full cost	30	BSE estimate based on Hydrotherm 1992
Hydronic boiler - 84%	1536	Increment	30	
Steam boiler - 75%	13729	Full cost	30	
Steam boiler - 82%	1560	Increment	30	
Front-end boiler	13013	Full cost	30	
Distribution System Measures				
Mainline air vents -- low-rise	450-1300*	per bldg	30	Katrakis 1993, BUG 1993
Mainline air vents -- high-rise	2500*	per bldg	30	BUG 1993
Control Measures				
Boiler temp modulation	600	per bldg	15	Hewett 1988

*Denotes costs supplied by BUG which are substantially higher than cost estimates from other sources.

Notes:
1. Lifetimes based on engineering judgement by the project team.
2. When a range of heating system costs is provided, the low end of the range is for NFG and the high end of the range is for BUG.
3. For all measures not listed in this table, costs and lifetimes are identical to values in Table 2-16.

Table 2-20. Measure Applicability Assumptions -- Heating System Measures: Colonial/Ranch/Townhouse

	LILCo		BUG		NFG		
Measure	Already Installed	Can be Installed	Already Installed	Can be Installed	Already Installed	Can be Installed	Sources/Notes
<u>Replacement Heating Systems</u>							
Furnace - 78% AFUE	8%	16%	9%	18%	27%	54%	ACEEE estimate based on GAMA 1989 and 1991 a BUG 1991. Figures incorporate warm air/hot water/steam market shares for each utility (LILCo 24/54/21%; BUG 27/20/53%; NFG 81/12/2%. High-efficiency furnace market split between 91% AFUE and modulating furnace.
Furnace - 85% AFUE	4%	20%	4%	23%	12%	69%	
Furnace - 91% AFUE	2%	11%	2%	12%	6%	37%	
Hydronic boiler - 80%	26%	28%	10%	10%	6%	6%	
Hydronic boiler - 84%	6%	48%	2%	18%	1%	11%	
Steam boiler - 75%	10%	11%	25%	28%	1%	1%	
Steam boiler - 82%	2%	19%	6%	47%	0%	2%	
Modulating furnace	0%	11%	0%	13%	0%	38%	
Gas engine heat pump	0%	24%	0%	27%	0%	81%	
<u>Heating System Retrofits</u>							
Derate furnace	7%	17%	8%	19%	24%	57%	Macriss et al. 1980
<u>Distribution System Measures</u>							
Duct insulation	7%	10%	8%	11%	24%	34%	BUG 1991
Duct insul. R-3 -- R-6	0%	17%	0%	19%	0%	57%	BUG 1991
Pipe insul. (hydronic)	24%	16%	9%	6%	5%	4%	BUG 1991
Pipe insul. (steam)	10%	6%	24%	16%	1%	1%	BUG 1991
Seal ducts	0%	17%	0%	19%	0%	57%	Andrews & Modera 1991
Two zones - hydronic	14%	27%	5%	10%	3%	6%	Andrews & Modera 1991
Two zones - air	0%	12%	0%	14%	0%	41%	Andrews & Modera 1991
<u>Control Measures</u>							
Setback thermostat - 5 ° F	24%	26%	24%	26%	19%	31%	BUG 1991, NFG 1991. Homes split between 5 & 10 degree setback.
Setback T-stat - 10 ° F	24%	26%	24%	26%	19%	31%	
Thermo. steam valves	4%	15%	11%	37%	0%	1%	ACEEE estimate
Furnace fan/t-stat. adj.	5%	17%	5%	19%	16%	57%	ACEEE est. based on Proctor & Mills 1987
Boiler temp. modulation	5%	38%	2%	14%	1%	8%	ACEEE estimate

Table 2-21. Measure Applicability Assumptions -- Heating System Measures: Brownstone, Low-Rise, and High-Rise.

Measure	Brownstone-BUG		Low Rise - BUG/LILCo		Low Rise - NFG		High Rise - BUG		Sources
	Already Installed	Can be Installed	Already Installed	Can be Installed	Already Installed	Can be Installed	Already Installed	Can be Installed	
Replacement heating systems									
Hydronic boiler - 80%	13%	15%	21%	18%	53%	47%	13%	15%	*
Hydronic boiler - 84%	3%	25%	5%	34%	13%	87%	3%	25%	
Steam boiler - 75%	35%	37%	32%	29%	0%	0%	38%	34%	
Steam boiler - 82%	8%	64%	8%	53%	0%	0%	8%	64%	
Front-end boiler	NA	NA	5%	29%	13%	75%	4%	21%	ACEEE estimate
Distribution System Measures									
Pipe insul. (hydronic)	13%	8%	21%	9%	53%	22%	15%	6%	BUG 1991
Pipe insul. (steam)	32%	22%	32%	13%	0%	0%	39%	15%	BUG 1991
Four zones - hydronic	14%	14%	NA	NA	NA	NA	NA	NA	**
Mainline air vents	11%	61%	9%	52%	0%	0%	11%	61%	BSE estimate
Control Measures									
Set back t-stat 5F	24%	26%	37%	13%	37%	13%	37%	13%	BUG 1991
Set back t-stat 10F	24%	26%	37%	13%	37%	13%	37%	13%	
Thermo steam valves	14%	50%	21%	34%	0%	0%	25%	40%	ACEEE estimate
Boiler temp modulation	3%	20%	16%	16%	40%	40%	11%	11%	

*ACEEE estimate based on BUG 1991 and GAMA 1991. Figures include allowance for hot water/steam market shares (Brownstone 28/72%; BUG/LILCo low rise 39/61%; NFG low rise 100/0%; High rise 28/72%)
**BSE estimate based on Andrews and Modera 1991

Table 2-22. Replacement Heating System Types and Efficiencies.

System	AFUE	Source
Furnaces:		
NAECA conforming	78%	NAECA
Near-condensing	85%	GAMA 1991b
Condensing	91%	GAMA 1991b
Modulating	92%	Feldman 1991
Engine-driven HP		
downstate	135%	ACEEE estimate based on
upstate	125%	GRI 1991
Hydronic boilers:		
NAECA conforming	78%	NAECA
Near-condensing	84%	Wilson & Morrill 1991
Condensing	90%	Wilson & Morrill 1991
Steam boilers:		
NAECA conforming	75%	NAECA
Near-condensing	82%	Wilson & Morrill 1991

For each type of system—warm air, hot water and steam—the first efficiency increment is a heating system that just meets the minimum efficiency standards specified in the National Appliance Energy Conservation Act (NAECA). These standards took effect January 1, 1992. As a result of these standards, units less efficient than these values are no longer on the market.

For each type of system, one or more efficiency increments are available that exceed the minimum efficiency standards. First, units are available with efficiencies of 82 to 85 percent that recover much of the heat from the exhaust gases without causing the water vapor in the exhaust gases to condense.[5] These "near-condensing" units are generally available for a modest cost premium relative to NAECA conforming units.

Second, in the case of warm air and hot water systems, units are available that recover additional heat from the exhaust gases causing water vapor in the exhaust gases to condense.

[5] For each type of system there are a few models with an efficiency rating several points higher than the values listed in Table 2-22 (GAMA 1991b, Wilson and Morrill 1991). For this analysis we have ignored these extreme values and instead based the analysis on a typical efficiency within each class of equipment.

These condensed gases are highly corrosive, and thus condensing units include extensive plastic and stainless steel components that are resistant to corrosion. Due to these extra components, the incremental cost of these units compared to near-condensing equipment can be substantial. In the case of condensing boilers, only one manufacturer makes condensing units (there used to be several manufacturers of this equipment, but heat-exchanger corrosion problems led several to withdraw from the market). The one product line on the market is very expensive, resulting in an incremental cost of saved energy relative to a near-condensing model in excess of $10/DTh. Due to the high cost of this measure it was not considered further.

Finally, two warm-air furnaces are available that are not easily classified, the modulating furnace and the engine-driven heat pump. The modulating furnace varies airflow and firing rate as a function of the demand for heat. When heat needs are modest, energy is saved because airflow and firing rates are below peak values. These are near-condensing systems, but due to the modulating features, tests by the Gas Research Institute (GRI) have found an AFUE of 92 percent (Feldman 1991). The modulating unit is now produced by several manufacturers for approximately the same cost as a condensing furnace and thus the two systems are likely to compete for market share. Accordingly, in Tables 2-18 and 2-19 the applicable market share for 90 percent+ efficient furnaces is divided evenly between these two technologies to avoid double-counting potential savings.

The engine-driven heat pump has been a major research project of GRI for several years. GRI has worked with a manufacturer -- York -- to develop a residential model. The first phase of field tests was completed and a second, larger, set of field tests is underway. Commercialization is expected in 1994 (EUN 1994). The unit is somewhat similar to an electric heat pump, but instead of using electric energy to run the compressor, a gas engine provides the rotary action to power the compressor. Since the unit uses a heat-pump cycle to transfer heat from the ambient air, efficiencies more than 100 percent are possible. Results of the first set of field tests found efficiencies of approximately 125 percent, with higher efficiencies in warm climates and lower efficiencies in cold climates (GRI 1991). Based on these results, an efficiency of 125 percent upstate and 135 percent downstate was assumed.

In addition to systems listed in Table 2-22, one additional new heating system was modeled, front-end boilers for multifamily buildings with hot-water distribution systems. In many multifamily buildings a single boiler, sized for the peak load, provides heat. At peak load conditions the efficiency of the boiler may be acceptable, but at part-load conditions the efficiency plummets. To address this situation a small, high-efficiency boiler can be installed to meet a building's load under part load conditions. The building's controls are wired to fire the new "front-end" boiler first, and then, when the need for heat exceeds this boiler's capacity, switch to the larger existing boiler. A Minnesota field study (Lobenstein et al. 1991) of this measure found average savings of approximately 15 percent in buildings that started out with atmospheric boilers and approximately 7.5 to 10 percent, depending on how outliers are treated, for buildings with power-burner boilers (efficiency 80 percent+).

Based on these results, front-end boilers were modeled as follows: For the maximum case, presuming an atmospheric boiler, the AFUE was increased by 10 percent and the DHW energy factor by 12 percent. This resulted in approximately 15 percent savings in the maximum savings cases for high-rise and low-rise apartments. For the minimum savings cases, the base case was assumed to be power vented, thus the AFUE was increased by 10 percent but the DHW remained the same as the base case. Since baseline DHW efficiency is good, little efficiency improvement is expected. The resulting savings ranged from 7.5 to 10 percent.

Equipment costs and savings assume that heating systems are properly sized -- heat loads for sizing purposes were determined by REM Design.

In examining the costs and savings of heating system improvements, the analysis generally focused on the incremental costs and savings compared to the next most efficient option. For example, costs and savings for the near-condensing systems were compared to NAECA conforming systems, and the engine driven heat pump was compared to a condensing furnace. The assumption underlying this treatment is that these measures would be installed when existing equipment was replaced, and so the key factor is the added costs and savings of each measure relative to the equipment that would otherwise be installed.

However, there were two exceptions -- the NAECA-conforming systems and the front-end boiler. The NAECA-conforming systems were modeled in two ways: as a retrofit measure, replacing functioning but inefficient existing equipment, and as a replacement measure when the existing equipment is being replaced. When installed as a retrofit measure, since a new heating system would not otherwise be needed, the cost of the efficiency improvement is the full cost of the new system. When installed as a replacement measure, since a new heating system must be purchased, and since a NAECA-conforming system is the least expensive system on the market, the incremental cost for the efficiency improvement is zero. The front-end boiler was modeled as a retrofit measure and all costs and savings relative to the existing system were included in the analysis.

Heating System Retrofits

Several heating system retrofit measures were examined for this project, but ultimately only furnace derating was included in the analysis. Electronic ignition and vent dampers were investigated, but found to be less cost-effective than new NAECA-conforming heating systems that contained these measures or their equivalent (i.e. many new furnaces feature sealed combustion that functions much as a vent damper). While these other retrofit measures may be cost-effective in inefficient heating systems that will remain in use for many years, in order to avoid double-counting of savings, these other retrofit measures were not analyzed.

Furnace derating applies to oversized furnaces. When a furnace is oversized it cycles on and off more often which lowers seasonal efficiency. Oversizing is common in homes where equipment was selected using guesswork and not sizing calculations, and in homes that have been weatherized, thereby reducing peak heat demands and the need for a large heating system. Derating reduces the firing rate by installing smaller orifices, extra baffles and a vent restrictor to slow air movement through the heat exchanger and vent, permitting air to be adequately heated despite the lower firing rate. Derating must be done by a skilled technician with special training because sloppy derating can lead to safety and equipment problems including incomplete combustion, draft spillage, and heat-exchanger corrosion (Adams 1979).

Due to these safety issues, derating may be more trouble than the savings justify. As existing systems are replaced with NAECA-conforming systems, oversizing becomes less of an issue because the sealed combustion systems used in most NAECA-conforming units reduce the inefficiencies of cycling. Field studies by NYSERDA (Adams 1979), Rochester Gas and Electric (Whitlock 1978) and the gas industry's Space Heating Efficiency Improvement Program (Macriss et al. 1980) indicate savings from derating of approximately 8 percent excluding savings from adjusting furnace fans and thermostat anticipators. Based on these results, 8 percent savings were assumed in the maximum savings case (which was modeled by increasing AFUE by from 65 percent to 71 percent) and 0 percent savings were assumed in the minimum savings case.

Distribution System Measures

Seven distribution system measures were examined for this study: duct insulation, pipe insulation for hot water and steam systems, duct sealing, zoning hot water and warm air distribution systems, and main line air vents for steam systems in multifamily buildings.

Savings from duct insulation were modeled using REM Design. Two different options were examined: R-3 and R-6 insulation. For the analysis it was assumed that only exposed ducts in the basement would be retrofit.

Savings from pipe insulation were calculated using the ASHRAE bin method (ASHRAE 1989). These calculations assumed that exposed basement hot water pipes are insulated with 3/4" of slip-on foam insulation and that steam pipes are insulated with 2 1/4" of fiberglass insulation. The savings are 6.78 million BTU per 150 linear feet of hot water pipe and 55 million BTU per 150 linear feet of steam pipe. The savings from hot water pipe insulation are on the order of 3 percent of space heating energy use. These savings were modeled by increasing delivery efficiency from 94 percent to 97 percent. The savings from steam pipe insulation (approximately 8 percent) are higher than field experience (approximately 5 percent savings -- Katrakis 1989). While the poor field experience was probably due to incomplete coverage or poor insulation performance, in an effort to be conservative, we reduced our savings estimate to 5 percent. This was modeled as an increase in delivery efficiency from 61 percent to 64 percent.

Recent studies have shown that leaks from duct systems contribute to large energy losses. Techniques have been developed to seal many of these leaks, reducing losses and saving energy (Palmiter and Brown 1989, Lambert and Robinson 1989, Modera 1989, Proctor 1991). For the analysis we assumed that duct leakage is 33 percent of total infiltration based on the studies cited previously and that sealing ducts reduces duct leakage by 15 percent. A 15 percent reduction in duct leakage is a conservative estimate of the minimum reduction likely in a duct-sealing program. Recent pilot programs have shown average reductions of nearly 60 percent (Proctor 1991), but these houses had attic and crawl space ducts, situations that result in high duct leakage. It is likely that reductions of 30 percent or more could occur in houses with basements, although no field studies have been reported.

Most warm-air and hot-water distribution systems treat the entire house as one zone, and when heat is needed in one room, the entire house is heated. Substantial energy can be saved by dividing the house into two or more zones, typically one zone for the bedrooms (which primarily need heat at night) and one zone for public areas such as the living room, kitchen, etc. With warm-air systems, zoning is accomplished by adding mechanized dampers at key points in the distribution system. The dampers are controlled by thermostats in each zone. In addition, the zoning system requires reducing the air flow when heat is needed in only one zone which is usually done by reducing the fan speed. With hot-water systems, zone values are added at key points in the distribution system. The valves are controlled by thermostats in each zone. Zoning is not applicable to all homes, for in some cases the distribution system is set up in ways that make zoning overly expensive, e.g., bedrooms and public areas are mixed on a single branch line.

Zoning can produce energy saving ranging from 12 percent to 30 percent. A 1991 review of many studies concluded that a 20 percent savings could be projected for splitting a forced air system into two zones in a cold climate (Andrews and Modera 1991). A field study in Iowa (Bierbaum 1982) found savings of 16 to 21 percent over two years comparing electric baseboard (fully zoned) and electric furnaces (one zone). For the analysis, savings were estimated at 19 percent based on the average of these different savings estimates.

In apartment and brownstone buildings with steam distribution systems, significant savings can be achieved by properly venting the mainline of the distribution system. Most systems in the field are improperly vented, which slows the flow of heat to distant apartments, resulting in overheating some apartments to achieve proper heating in the distant apartments. Installing new, larger vents can reduce energy use by up to 20 percent, with a midpoint reduction in one field study of approximately 10 percent (Katrakis 1989). This efficiency improvement was modeled by increasing distribution efficiency from 61 percent to 68 percent.

Control Measures

Four heating system control measures were examined: setback thermostats, thermostatic steam valves, furnace fan and thermostat adjustment, and modulating boiler water temperature.

Two setback thermostat options were modeled, a 5° F and a 10° F setback. Homes not currently setting back their thermostats were split evenly between these two measures. Savings were based on a simulation and field study conducted by Honeywell that estimated 6 percent and 10 percent savings in Buffalo (for 5° F and a 10° F setback) and 8 percent and 12 percent in New York City (Nelson and MacArthur 1978).

Thermostatic steam valves sense the temperature in a room and stop steam flow to the radiator serving that room when the setpoint temperature is reached. Steam systems are difficult to balance with the result that some rooms often overheat. Thermostatic valves prevent this problem thereby saving energy. Field studies indicate that this measure produces savings of 6 percent of space heating energy use (Katrakis 1989). These savings were modeled by increasing delivery efficiency from 61 percent to 65 percent.

Several studies have found that furnace fan thermostats are often set too high and thus useful heat in the furnace plenum is wasted and not moved to the living space (Proctor and Mills

1987). In addition, the anticipator on thermostats is often improperly set, which leads to overshooting the desired setpoint on each furnace cycle. Proper adjustment of these controls, as well as basic furnace maintenance can produce energy savings of approximately 8 percent according to several Colorado field studies (Proctor and Mills 1987). These savings were modeled by increasing the furnace AFUE from 65 percent to 71 percent.

Most hydronic boilers maintain a boiler water temperature of 160 to 180° F or higher regardless of the need for heat. While temperatures at this level are needed for cold days, on warmer days, boiler water temperatures can be lowered, reducing heat loss from the boiler and distribution system. Boiler water temperature can be modulated in several ways including installing an outdoor reset control, which varies boiler water temperature based on outside temperature, or by wiring the boiler so that boiler water temperature is allowed to drop until a sustained call for heat (e.g. a call for heat that cannot be met by just turning the circulation pump on) triggers the burner (Proctor 1987). The reset control is best for multifamily buildings when several apartments are served by the same boiler while the latter system is generally less expensive, and results in greater savings, in single-family homes (Proctor 1987, Hydronics Institute undated). Field studies of outdoor reset controls indicate savings of approximately 9 to 12 percent (Howett 1988) and a Colorado field study found average savings from rewiring boilers of 12.4 percent (Proctor 1987). Based on these field studies, 11 percent savings were assumed which was modeled by increasing AFUE from 65 percent to 73 percent.

Hot Water Measures

Hot water efficiency measures include more efficient water heaters, measures that reduce system losses, and measures that reduce hot water demand. Costs and lifetimes for these measures are summarized in Table 2-23. Table 2-24 provides the proportion of homes for which each measure is appropriate.

Table 2-23. Summary of Water Heating Measure Costs and Lifetimes.

Measure	Cost	Units	Lifetime	Sources/Notes
More Efficient Water Heaters				
Storage water heater - .54 EF	425	Full cost	12	Wilson & Morril 1991
Storage water heater - .65 EF	75	Increment	12	Wilson & Morril 1991
Instantaneous water heater	650	Increment	20	Wilson & Morril 1991
Boiler/DHW Combo System: per bldg				
Low-Rise	3000	Increment	20	BSE estimate based on Weil-McLain 1992
High-Rise	6000	Increment	20	
Reduce System Losses				
Pipe insulation	1.64	ft	15	NEES 1990, Goeltz & Hirst 1986
Tank wrap - R-6	27	per home	6	Energy Investment 1992
Demand controller	1400	per bldg.	15	Lobenstein et al. 1992
Reduce Hot Water Use				
Low-flow shower & faucet	30.50	per shower	10	NEES 1990, Goeltz & Hirst 1986
Horiz. axis washing machine	175	Increment	14	Nadel et al. 1992

Notes:

1. Lifetimes based on engineering judgement by the project team.
2. The boiler/DHW combination and the demand controller are only applied to the apartment buildings.

Table 2-24. Measure Applicability Assumptions -- Water Heating Measures: All Prototypes.

	LILCo		BUG		NFG		
Measure	Already Installed	Can be Installed	Already Installed	Can be Installed	Already Installed	Can be Installed	Sources/Notes
More Efficient Water Heaters							
Storage wtr. htr. - .54 EF	40%	60%	40%	60%	40%	60%	ACEEE estimate based on Kenny 1989.
Storage wtr. htr. - 65 EF	6%	89%	6%	89%	6%	89%	
Instantaneous water heater	5%	80%	5%	80%	5%	80%	BSE estimate
Boiler/DHW Combo System							
Lowrise	5%	45%	5%	45%	5%	45%	ACEEE estimate
Highrise	NA	NA	15%	60%	NA	NA	ACEEE estimate
Reduce System Losses							
Pipe insulation	50%	50%	50%	50%	50%	50%	BUG 1991
Tank wrap - R-6	77%	22%	51%	30%	30%	70%	BUG 1991, LILCo 1991, NFG 1991
Demand controller	10%	80%	10%	80%	10%	80%	ACEEE estimate
Reduce Hot Water Use							
Low-flow shower & faucet	30%	70%	30%	70%	30%	70%	BSE estimate
Horiz-axis washing mach.	5%	92%	5%	55%	5%	39%	ACEEE estimate based on clothes dryer satuations *1.2 where 1.2 is the ratio of clothes washers to dryers in the U.S.

Notes:

1. The boiler/DHW combination system and the demand controller are applied only to the high-rise and low-rise apartment buildings.

2. For the low-rise, percentages given here for the tank wrap, storage water heaters, and instantaneous water heater were divided by two since we assume that only half the low-rise apartment buildings have stand-alone water heaters.

More Efficient Water Heaters

Four improved-efficiency water heaters were examined: a 54 percent efficient stand-alone water heater (as measured by DOE tests for "energy factor"); a 65 percent efficient stand-alone heater; an instantaneous water heater; and a boiler/hot water combination system.

Stand-alone heaters are the most common system in New York homes today. Under NAECA new water heaters must have an energy factor (EF) of approximately 0.54 (the exact required EF varies with water heater size). The 54 percent efficient water heater was modeled as a zero cost option at time of equipment replacement, and as a full-cost retrofit option (see the discussion on replacement heating systems for a fuller discussion of these issues). For the 65 percent efficient water heater, incremental costs and savings relative to the 54 percent efficient model were analyzed.

An alternative to the stand-alone system is the instantaneous water heater. These systems have no storage, so heat losses from the storage tank are eliminated. The burner fires only when there is a demand for hot water; the water is heated as it flows through the water heater. Energy factors for these systems are approximately 70 percent (Wilson and Morrill 1991). All of these units have pilot lights, and adding electronic ignition would improve efficiency further. For this measure incremental costs and savings were modeled relative to the 65 percent EF stand-alone heater.

In multifamily buildings where hot water is provided by the main boiler, considerable energy is wasted when the inefficient boiler operates all summer -- annual water heating efficiencies of 40 to 45 percent appear to be typical (Ludwig 1989). Purchase of a high-efficiency boiler dedicated to hot water, combined with an insulated storage tank to store this hot water, can produce substantial energy savings. For example, one field study found that this measure increased annual water heating efficiency to 65 percent (Park and Kelly 1989). The insulated storage tank is useful because it reduces boiler cycling due to lower heat loss, and because small demands for hot water do not trigger the boiler on. Savings for this measure were calculated by changing the water heating efficiency from 43 percent to 65 percent. This measure was applied in the high-rise apartment and in half the low-rise apartments; the other half were assumed to use stand-alone water heaters.

This measure can also be used in single-family homes with high-efficiency boilers; however, tests by the National Institute of Standards and Technology (NIST) found an Energy Factor of 0.65, the same as a high-efficiency stand-alone heater (Park and Kelly 1989). This system is more expensive than a stand-alone heater (Wilson and Morrill 1991) and was dropped from the analysis of single-family homes.

Reduced System Losses

Four retrofit measures were examined that reduce system losses from hot water systems: tank wrap, pipe wrap, circulation loop demand controls, and check valves.

Tank wrap reduces heat loss from the hot water storage tank. Savings for R-6 tank wrap were modeled using REM Design.

Pipe wrap reduces standby losses from hot water pipes. Savings were based on measured results from the Hood River Conservation Project which had an average savings of 9.9 percent of water heating energy use (Berry et al. 1987). These results are similar to results using an algorithm developed by the California Energy Commission (1985).

In multifamily buildings, in an effort to reduce the time for hot water to reach individual apartments, hot water is often continuously pumped through a loop that runs throughout the building. While such an arrangement is useful while people are awake, operating this loop at night at full temperature promotes heat loss from the pipes. An electronic control that memorizes building hot water demand patterns and reduces hot water loop temperatures during periods of low hot water demand, can produce substantial energy savings. A Minnesota field study found average hot water savings of 16 percent from this measure. These savings were modeled by increasing the water heating efficiency in buildings that obtain hot water from the main boiler (the high-rise and half of the low-rises) from 43 percent to 51 percent.

Standby losses from water heaters include convection losses through the pipes immediately above the water heater. Hot water in the storage tank rises into the pipes. Heat is lost from the pipes, causing the water to cool and fall back into the storage tank. These losses can be largely eliminated using check valves that permit water to flow in only one direction. Since convective cycles require flow in both directions, the one-way valves arrest the convective cycle. Check valves are most economically installed when equipment is replaced. However, most new 65 percent water heaters already have check valves. To prevent double-counting savings, this measure was dropped.

Reduced Hot Water Use

The simplest way to lower water heating energy demand is to reduce the amount of hot water used. For this study, two measures were analyzed: low-flow showerheads and aerators to cut shower and faucet hot water flows, and horizontal axis clothes washers (for reducing hot water used to wash clothes.

Savings for the low-flow showerheads and faucet aerators were estimated based on the results of the Hood River Conservation Project which found average savings of 10.7 percent (Berry et al. 1987). These savings were modeled by reducing hot water demand by 10.7 percent.

More than 95 percent of clothes washers in the U.S. are top-loading units that spin on a vertical axis. To wash clothes, the wash tub must be filled so that all clothes are covered. In Europe the dominant type of washer is the horizontal-axis machine. Horizontal-axis machines reduce hot water use more than 50 percent because the washtub is only partially filled. With each rotation of the tub, clothes are dipped in the water at the bottom of the half-filled tub. Many horizontal-axis units are front-loading machines, but some units can be loaded through a door on top. To use the top-loading feature, a user first opens a conventional top-loading door, but then the user must also open a second door in the rotating metal drum. In the U.S., Frigidaire manufactures horizontal-axis units, but all these units are front-loaders. Staber Industries plans to introduce a top-loading horizontal axis machine to the U.S. market in 1994.

In addition to saving energy and water, horizontal axis machines also create less wear and tear on clothes, use less detergent, and may do a better job cleaning clothes than a vertical axis unit (Nadel et al. 1992). Savings for this measure were estimated by multiplying the proportion of hot water used for clothes washing (26 percent—Bancroft et al. 1991) by a 69 percent reduction from using horizontal-axis machines (Lebot et al. 1990).

Cooking Measures

Opportunities for reducing gas used for residential cooking were modeled based on a typical cooktop and oven that uses 53 therms/year. This figure is based on estimates compiled by Meier et al. (1983) and adjusted for two factors: (1) penetration of electronic ignition (required in New York State since 1980, which means that given the typical 18 year life of this equipment, two-thirds of the units probably have these devices), and (2) a 17 percent average decline in cooking energy use over the past decade due to greater use of microwaves, convenience foods, and eating out (Quantum Consulting 1988, Van Lierop and Parris 1988, Berkeley Solar Group and Xenergy 1990).

Opportunities for more efficient cooking are limited. For this study full saturation of electronic ignition, infrared gas impingement burners, and convection ovens were investigated.

Electronic ignition is required on all new ranges and ovens. Electronic ignition eliminates the need for a pilot light, thereby saving gas. This is a zero cost measure when equipment is replaced. Savings of 40 therms come from Meier et al. (1983). This measure applies to the 33 percent of homes that do not presently have ranges with electronic ignition. Additional data on this measure is provided in Table 2-25.

Infrared burners burn more efficiently than conventional burners, reducing energy use 33 percent according to one GRI study (1984). Infrared burners for commercial sector applications are now on the market (see Chapter 4). However, residential units have not been commercialized due to the high cost of the technology. Thus, this measure was not analyzed.

Table 2-25. Summary of Cooking and Clothes Drying Measure Costs, Lifetimes and Measure Applicability Assumptions.

Measure	Cost	Units	Lifetime	Already Installed	Can be Installed	Sources/Notes
Cooking						
Electronic ignition	$0	Incremental	18	67.%	33.%	Wilson & Morrill 1991, ACEEE est. based on NY elec. ignition law
Clothes Drying						
Electronic ignition	$0	Incremental	17	67	33	DOE 1990, ACEEE est. based on NY elec. ignition law
Automatic controls	$0	Incremental	17	60	40	ACEEE est.
High-spin speed washer	$60	Incremental	14	0	100.%	Nadel, et al. 1992, utility appliance saturation surveys.

Steam convection ovens are being developed by GRI to compete with microwave ovens. Prototype units have been developed which circulate steam in the oven chamber, resulting in cooking times approaching those of microwave ovens (McFadden et al. 1991). However, reports are that this measure results in little or no energy savings compared to standard gas ovens (Rosenquist 1992) and thus this measure was dropped from further analysis.

Clothes Drying Measures

Opportunities for reducing the gas used for clothes drying were modeled assuming a gas dryer that consumes 43 therms annually. This figure comes from an analysis by Meier et al. (1983) adjusted for an assumed 67 percent penetration of electronic ignition (required in New York since 1980) and also adjusted to reflect a 28 percent reduction in the number of washloads per family over the past decade (DOE 1990). Three options to reduce drying energy were investigated: full saturation of electronic ignition, use of automatic cycle termination controls, and use of high spin-speed clothes washers. Data on each of these measures is summarized in Table 2-25.

Electronic ignition is required on all new dryers. Thus, this is a zero cost measure when the equipment is replaced. This measure applies to the 33 percent of homes that do not presently have dryers with electronic ignition. Savings of 30 therms comes from Meier et al. (1983).

Dryers are usually operated with a timer cycle—the user estimates the amount of time needed to dry the clothes and the dryer operates for the user-selected time interval. If the clothes are not dry at the end of the cycle, the timer is reset so that drying may continue. If the clothes dry before the end of the cycle, the dryer continues to operate until the end of the cycle, wasting energy. Automatic controls which sense either temperature or moisture level can determine when clothes are dry and turn the dryer off, eliminating this source of energy waste. These controls reduce dryer energy use an average of 12 percent (DOE 1990). As of 1994, this feature will be required on all new dryers as a result of minimum efficiency standards recently promulgated by the U.S. Department of Energy. Thus, this measure was modeled as a zero cost measure when the equipment is replaced.

Dryer energy use can be reduced by reducing the water content of clothes before they are put in the dryer. Moisture content can be reduced by changes to clothes washer spin cycles. The spin cycle in standard American clothes washers is at a speed of approximately 600 rpm and this cycle reduces the moisture content of the load from 100 percent to approximately 70 percent. Typically laundry with 70 percent water content is moved to a dryer to reduce the moisture content to 2.5 - 5 percent (Shepard et al. 1990). However, a study by the National Institute of Science and Technology (NIST) found that to reduce moisture content of a typical laundry load from 70 percent to 40 percent, a spin cycle is approximately 70 times more energy efficient (requires 1/70th the energy) as a dryer thermal cycle. Thus, using a spin cycle to reduce moisture content to 40 percent reduces dryer energy use by approximately 40 percent. Increasing spin speed to 850 rpm can do this without vibration or major redesign (NIST 1981). High spin speeds are common in Europe; many machines have spin speeds of more than 800 rpm, and some machines have spin speeds as high as 1500 rpm. The cost of modifying clothes washers to increase spin speed is approximately $60 (Nadel et al. 1992).

RESULTS

Results of the analysis for each utility and each building type are summarized in Tables 2-26 through 2-42. These tables also list opportunities for improving the efficiency of ranges and dryers. Tables 2-26 through 2-30 cover LILCo; Tables 2-31 through 2-37 cover BUG; and Tables 2-38 through 2-42 cover NFG.

Measures are listed in three different categories: mandated measures (high efficiency replacement equipment mandated under existing Federal appliance efficiency standards), potential utility measures (non-mandated measures that are potential targets for utility DSM programs), and additional measures which were examined, but due to their high CSG, are beyond the calibration point established by the "best case" analysis of interactive savings (see discussion on p. 2-12). Within each category, measures are listed in order of cost of saved gas, starting with zero-cost measures and progressing to increasingly costly measures. In the tables, five different types of data are reported.

First, savings are listed for each measure for homes that can implement each measure. Both unadjusted savings and adjusted savings are reported. Unadjusted savings are the savings estimated by REM Design and other models, before the various calibration steps. Adjusted savings include the effects of the calibration adjustments. Adjusted savings are calibrated to actual gas sales of each utility and are adjusted to fully reflect the interactions between measures and hence eliminate any double-counting of savings.

Second, savings in the average home (weighted average of homes that can and cannot implement each measure) are reported. Average savings are the product of adjusted savings from homes implementing the measure multiplied by the proportion of homes that can implement the measure (from Tables 2-15, 2-16, 2-20, 2-21, 2-24, and 2-25).

Third, savings in all homes of each type (e.g. all ranch-style homes) are reported. Savings represent the product of average savings per home times the number of homes (Tables 2-10 through 2-12).

Fourth, cumulative savings from each measure and all preceding measures are reported in two forms -- thousands of decatherms (1 DTh = 10 therms = one million BTUs) and as a percentage of total gas use by each type of building.

Finally, the cost of saved gas is reported for the four different sensitivity cases -- 0 percent, 25 percent, 50 percent and 75 percent program costs. The cost of saved gas is based on the measure costs reported in Tables 2-14, 2-18, 2-19, 2-23, and 2-25. In these tables, the 50% program cost case is the reference case and is the primary focus of subsequent discussions.

Table 2-26. Savings and Levelized Cost by Measure -- LILCo, Colonial.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs			
	Unadjstd.	Adjustd.					None	25%	50%	75%
MANDATED MEASURES										
Replace water heater-.54 EF	48	31	19	251	251	1%	0.00	0.00	0.00	0.00
Replace furnace-78% AFUE	339	221	36	478	729	3%	0.00	0.00	0.00	0.00
Replace steam boiler-75%	594	387	43	574	1,302	6%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	258	168	47	633	1,935	9%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures					*0*	*0%*				
Setback thermostat - 10	199	130	34	453	453	2%	0.36	0.45	0.54	0.64
Setback thermostat - 5	132	86	22	300	753	3%	0.55	0.69	0.82	0.96
DHW pipe insulation	39	26	13	171	924	4%	0.61	0.76	0.91	1.06
Infiltration - 1->.35	398	259	26	348	1,273	6%	1.09	1.36	1.63	1.91
Furnace - 85% AFUE*	127	83	17	228	1,500	7%	1.25	1.56	1.87	2.18
Steam boiler - 82%*	203	132	25	335	1,835	8%	1.30	1.63	1.95	2.28
Low-flow shower and faucet	43	28	19	260	2,096	9%	1.40	1.74	2.09	2.44
Infiltration- .75->.35	255	166	75	669	2,764	12%	1.42	1.77	2.13	2.48
Tank wrap - R-6	49	32	7	94	2,858	13%	1.64	2.04	2.45	2.86
Storage water heater-.65 EF*	65	42	38	504	3,363	15%	1.96	2.45	2.94	3.43
Boiler temperature modulation	135	88	33	446	3,809	17%	2.14	2.68	3.21	3.75
Pipe insulation (steam)	130	85	5	73	3,882	17%	2.17	2.71	3.26	3.80
Attic insulation - R0->R30	479	312	112	1509	5,391	24%	2.35	2.94	3.53	4.12
Two zones - hydronic	246	160	43	580	5,971	27%	2.39	2.98	3.58	4.18
Infiltration - .5->.35	100	65	23	307	6,278	28%	2.74	3.43	4.11	4.80
Seal ducts	29	19	3	43	6,321	28%	3.05	3.81	4.58	5.34
Basement wall insulation-R11	147	95	24	321	6,641	30%	3.33	4.16	4.99	5.82
Modulating furnace*	135	88	10	130	6,771	30%	3.34	4.17	5.01	5.84
Derate furnace	114	74	12	167	6,938	31%	3.41	4.26	5.12	5.97
Attic insulation - R5->R30	245	159	21	278	7,216	32%	4.08	5.10	6.12	7.15
Furnace fan/t-stat adj	123	80	13	180	7,397	33%	4.24	5.30	6.36	7.42
Retro steam boiler-75%	594	387	43	**	7,397	33%	4.52	5.65	6.79	7.92
Horizontal-axis washing machine*	58	38	35	464	7,861	35%	4.60	5.75	6.90	8.05
Pipe insulation (hydronic)	37	24	4	53	7,914	35%	4.77	5.97	7.16	8.36
Wall insulation - R13 cellulose	323	210	95	1272	9,186	41%	5.11	6.39	7.67	8.95
Thermostatic steam valves	168	109	16	218	9,404	42%	5.74	7.17	8.60	10.04
Retro furnace-78% AFUE	339	221	36	**	9,404	42%	5.75	7.19	8.63	10.07
Hydronic boiler - 84%	53	35	17	224	9,627	43%	5.79	7.24	8.68	10.13
Two zones - air	308	201	24	324	9,951	45%	6.34	7.92	9.51	11.09
Duct insulation - R0->R3	84	55	6	74	10,025	45%	6.73	8.42	10.10	11.79
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Gas engine heat pump	351	229	55	737	10,763	***	6.80	8.50	10.20	11.90
Attic insulation - R11->R30	115	75	19	251	11,014	***	7.24	9.05	10.86	12.67
Basement ceiling insulation-R28	160	104	14	182	11,196	***	7.40	9.25	11.11	12.96
Duct insulation - R3->R6	60	39	7	90	11,286	***	7.77	9.71	11.65	13.59
Instantaneous water heater	23	15	12	159	11,445	***	7.96	9.95	11.94	13.93
Basement ceiling insulation-R19	127	83	37	501	11,946	***	9.31	11.64	13.97	16.29
Retro hydronic boiler - 80%	258	168	47	**	11,946	***	9.86	12.32	14.79	17.25
Furnace - 91% AFUE*	92	60	7	89	12,035	***	9.93	12.41	14.90	17.38
Storm windows	295	192	32	426	12,460	***	12.39	15.49	18.59	21.69
Retro water heater-.54 EF	48	31	19	**	12,460	***	15.05	18.82	22.58	26.34
Attic insulation - R19->R30	38	25	3	43	12,504	***	17.47	21.84	26.21	30.57

Notes:

*Measures to be implemented at time of equipment replacement.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings from more expensive application zeroed out to prevent double-counting of savings.

***Measures that will result in some savings, but after more cost-effective measures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceeding text for explanation of each column in this table.

Table 2-27. Savings and Levelized Cost by Measure -- LILCo, Ranch.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs			
	Unadjstd.	Adjustd.					None	25%	50%	75%
MANDATED MEASURES										
Replace furnace-78% AFUE	253	194	31	214	214	2%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	209	160	45	309	523	5%	0.00	0.00	0.00	0.00
Replace steam boiler-75%	524	401	44	305	828	8%	0.00	0.00	0.00	0.00
Replace water heater-.54 EF	48	37	22	151	979	10%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures										
Setback thermostat - 10	157	120	31	215	215	2%	0.39	0.49	0.59	0.69
DHW pipe insulation	39	30	15	103	318	3%	0.51	0.64	0.77	0.90
Setback thermostat - 5	104	80	21	142	460	5%	0.59	0.74	0.89	1.04
Infiltration - 1->.35	298	228	23	157	617	6%	0.99	1.24	1.49	1.73
Low-flow showerhead & faucet	43	33	23	157	774	8%	1.19	1.48	1.78	2.08
Steam boiler - 82%*	179	137	26	178	952	9%	1.25	1.57	1.88	2.19
Tank wrap - R-6	50	38	8	58	1,010	10%	1.36	1.70	2.05	2.39
Furnace - 85% AFUE*	99	75	15	106	1,116	11%	1.37	1.71	2.05	2.40
Infiltration- .75->.35	186	143	64	294	1,410	14%	1.45	1.81	2.17	2.53
Pipe insulation (steam)	115	88	6	38	1,448	14%	1.57	1.97	2.36	2.75
Storage water heater-.65 EF*	65	50	44	303	1,752	17%	1.67	2.09	2.50	2.92
Attic insulation - R0->R30	540	414	149	1,024	2,776	27%	1.86	2.32	2.78	3.25
Derate furnace	93	71	12	82	2,859	28%	1.98	2.48	2.97	3.47
Basement wall insulation-R11	195	149	37	256	3,115	31%	2.12	2.66	3.19	3.72
Boiler temperature modulation	102	78	29	202	3,317	33%	2.42	3.03	3.63	4.24
Seal ducts	23	18	3	21	3,338	33%	2.63	3.29	3.95	4.61
Two zones - hydronic	184	141	38	262	3,599	35%	2.71	3.39	4.06	4.74
Infiltration - .5->.35	71	55	19	132	3,731	37%	2.81	3.51	4.21	4.91
Attic insulation - R5->R30	288	220	29	197	3,928	39%	3.09	3.86	4.63	5.41
Horizontal-axis washing machine*	71	55	50	345	4,273	42%	3.17	3.96	4.75	5.54
Thermostatic steam valves	147	113	17	115	4,389	43%	3.70	4.62	5.55	6.47
Pipe insulation (hydronic)	28	21	3	24	4,413	43%	4.07	5.09	6.11	7.13
Modulating furnace*	88	67	7	51	4,463	44%	4.36	5.44	6.53	7.62
Retro steam boiler-75%	524	401	44	**	4,463	44%	4.36	5.45	6.54	7.63
Furnace fan/t-stat adj	99	76	13	87	4,551	45%	4.48	5.59	6.71	7.83
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Basement ceiling insulation-R28	83	64	16	109	4,660	***	4.98	6.23	7.47	8.72
Wall insulation - R13 cellulose	201	154	69	476	5,137	***	5.28	6.60	7.92	9.24
Attic insulation - R11->R30	128	98	25	169	5,305	***	5.78	7.23	8.67	10.12
Retro furnace-78% AFUE	253	194	31	**	5,305	***	6.56	8.20	9.84	11.48
Hydronic boiler - 84%*	40	30	15	100	5,406	***	6.60	8.25	9.90	11.55
Storm windows	126	96	16	109	5,515	***	6.63	8.29	9.95	11.60
Instantaneous water heater*	23	17	14	96	5,610	***	6.77	8.46	10.16	11.85
Gas engine heat pump*	299	229	55	378	5,989	***	6.79	8.48	10.18	11.88
Two zones - air	244	187	22	154	6,143	***	6.82	8.52	10.23	11.93
Duct insulation - R0->R3	47	36	4	25	6,168	***	9.23	11.53	13.84	16.14
Duct insulation - R3->R6	35	27	5	32	6,199	***	10.21	12.76	15.31	17.86
Retro hydronic boiler - 80%	209	160	45	**	6,199	***	10.35	12.94	15.53	18.11
Furnace - 91% AFUE*	71	54	6	41	6,240	***	11.06	13.82	16.59	19.35
Retro water heater-.54 EF	48	37	22	**	6,240	***	12.80	16.00	19.21	22.41
Attic insulation - R19->R30	43	33	4	30	6,270	***	13.75	17.18	20.62	24.05
Basement ceiling insulation-R19	86	66	29	203	6,473	***	14.94	18.68	22.42	26.15

Notes:

*Measures to be implemented at time of equipment replacement.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings from more expensive application zeroed out to prevent double-counting of savings.

***Measures that will result in some savings, but after more cost-effective measures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceeding text for explanation of each column in this table.

Table 2-28. Savings and Levelized Cost by Measure -- LILCo, Wood-frame Townhouse.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs			
	Unadjstd.	Adjustd.					None	25%	50%	75%
MANDATED MEASURES										
Replace steam boiler-75%	187	145	21	9	9	3%	0.00	0.00	0.00	0.00
Replace water heater-.54 EF	38	30	18	7	16	5%	0.00	0.00	0.00	0.00
Replace furnace - 78% AFUE	87	67	11	5	21	6%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	75	58	21	9	29	9%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures					*0*	*0%*				
DHW pipe insulation	31	24	12	5	5	1%	0.64	0.80	0.96	1.11
Setback thermostat - 10	57	44	12	5	10	3%	1.06	1.33	1.59	1.86
Low-flow showerhead & faucet	34	26	18	8	18	5%	1.47	1.84	2.20	2.57
Setback thermostat - 5	38	29	8	3	21	6%	1.60	2.01	2.41	2.81
Storage water heater-.65 EF	52	40	36	15	36	10%	2.06	2.58	3.10	3.61
Basement wall insulation-R11	79	61	15	6	42	12%	2.12	2.65	3.19	3.72
Tank wrap - R-6	31	24	5	2	44	13%	2.14	2.68	3.22	3.75
Infiltration - 1->.35	115	89	9	4	48	14%	2.22	2.77	3.33	3.88
Attic insulation - R0->R30	202	156	56	24	72	21%	2.41	3.01	3.61	4.21
Furnace - 85% AFUE*	46	36	7	3	75	22%	2.89	3.61	4.33	5.05
Infiltration- .75->.35	72	56	25	7	82	24%	2.97	3.71	4.46	5.20
Seal ducts	8	6	1	0	82	24%	3.14	3.92	4.71	5.49
Steam boiler - 82%*	64	49	9	4	86	25%	3.47	4.34	5.21	6.08
Pipe insulation (steam)	41	32	2	1	87	25%	3.64	4.55	5.46	6.37
Horizontal-axis washing machine	57	44	41	17	104	30%	3.92	4.90	5.88	6.86
Attic insulation - R5->R30	103	79	10	4	108	32%	4.19	5.24	6.29	7.34
Wall insulation - R13 cell.	157	122	55	23	131	38%	4.53	5.66	6.79	7.93
Derate furnace	33	25	4	2	133	39%	5.56	6.95	8.34	9.72
Infiltration - .5->.35	27	21	7	3	136	40%	6.10	7.62	9.15	10.67
Boiler temperature modulation	39	30	11	5	141	41%	6.19	7.74	9.29	10.84
Two zones - hydronic	71	55	15	6	147	43%	6.91	8.64	10.36	12.09
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Attic insulation - R11->R30	48	37	9	4	151	***	7.41	9.26	11.12	12.97
Pipe insulation (hydronic)	11	8	2	1	152	***	8.83	11.04	13.25	15.46
Modulating furnace*	36	28	3	1	153	***	10.54	13.18	15.81	18.45
Storm windows	84	65	11	4	158	***	11.08	13.85	16.62	19.39
Thermostatic steam valves	52	41	6	3	160	***	11.56	14.45	17.34	20.23
Retro steam boiler-75%	187	145	21	**	160	***	12.07	15.09	18.11	21.13
Furnace fan/t-stat adj	35	27	5	2	162	***	12.38	15.47	18.57	21.66
Basement ceiling insulation-R19	32	25	14	6	168	***	15.21	19.01	22.81	26.61
Retro water heater-.54 EF	38	30	18	**	168	***	15.84	19.80	23.76	27.72
Hydronic boiler - 84%*	15	12	5	2	170	***	16.78	20.97	25.16	29.36
Gas engine heat pump*	117	91	22	9	179	***	17.11	21.38	25.66	29.94
Attic insulation - R19->R30	16	12	2	1	180	***	17.92	22.39	26.87	31.35
Two zones - air	89	69	8	3	184	***	18.51	23.14	27.77	32.40
Retro furnace-78% AFUE	87	67	11	**	184	***	18.85	23.56	28.28	32.99
Duct insulation - R0->R3	7	6	1	0	184	***	25.96	32.45	38.94	45.43
Retro hydronic boiler - 80%	75	58	21	**	184	***	28.57	35.72	42.86	50.00
Duct insulation - R3->R6	5	4	1	0	184	***	30.48	38.10	45.72	53.35
Furnace - 91% AFUE*	25	20	2	1	185	***	30.54	38.17	45.81	53.44
Instantaneous water heater*	18	14	11	5	190	***	36.29	45.37	54.44	63.51

Notes:

*Measures which will be automatically adopted at time of replacement due to NAECA standards.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings from more expensive application zeroed out to prevent double-counting of savings.

***Measures that will result in some savings, but after more cost-effective measures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceeding text for explanation of each column in this table.

Table 2-29. Savings and Levelized Cost by Measure -- LILCo, Low-Rise Apartment.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh)			
							Program Costs			
	Unadjstd.	Adjustd.					None	25%	50%	75%
MANDATED MEASURES										
Replace steam boiler-75%	166	112	32	42	42	6%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	75	51	9	12	55	8%	0.00	0.00	0.00	0.00
Replace water heater-.54 EF	29	19	6	8	62	9%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures					0	0%				
Steam boiler - 82% *	57	38	20	27	27	4%	0.29	0.36	0.43	0.50
Main line air vents	79	53	28	36	63	9%	0.34	0.43	0.52	0.60
DHW pipe insulation	24	16	8	11	74	11%	0.40	0.50	0.60	0.70
Boiler temperature modulation	40	27	4	6	79	12%	0.90	1.12	1.35	1.57
Setback thermostat - 10	47	32	4	5	85	13%	1.03	1.29	1.54	1.80
Tank wrap - R-6	50	34	5	7	91	14%	1.07	1.33	1.60	1.87
Pipe insulation (steam)	37	25	3	4	96	14%	1.09	1.36	1.63	1.90
Slab edge insulation - R5	10	6	3	3	99	15%	1.26	1.58	1.90	2.21
Hydronic boiler - 84% *	15	10	4	5	104	16%	1.36	1.70	2.04	2.38
Low-flow showerhead & faucet	26	17	12	16	120	18%	1.54	1.93	2.31	2.70
Setback thermostat - 5	31	21	3	4	124	18%	1.56	1.95	2.33	2.72
Retro steam boiler-75%	166	112	32	**	124	18%	2.06	2.58	3.09	3.61
Attic insulation - R0->R30	90	61	12	15	139	21%	2.06	2.58	3.09	3.61
Pipe insulation (hydronic)	12	8	1	1	140	21%	2.11	2.64	3.17	3.70
Storage water heater-.65 EF*	39	26	12	15	155	23%	2.17	2.71	3.25	3.79
Hot water demand control	38	26	13	17	172	26%	2.21	2.76	3.31	3.86
Boiler/DHW combination system*	49	33	8	10	182	27%	3.07	3.84	4.61	5.38
Infiltration- .75->.35	41	28	8	11	193	29%	3.29	4.11	4.93	5.75
Infiltration - 1->.35	67	45	18	24	217	32%	3.24	4.06	4.87	5.68
Retro hydronic boiler - 80%	75	51	9	**	217	32%	3.34	4.18	5.01	5.85
Attic insulation - R5->R30	48	32	13	17	234	35%	3.43	4.29	5.15	6.01
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Front-end boiler	65	44	13	17	251	***	3.78	4.73	5.67	6.62
Horizontal-axis washing machine*	43	29	27	35	286	***	4.12	5.14	6.17	7.20
Wall insulation - R13 cellulose	93	62	9	12	298	***	4.27	5.34	6.41	7.48
Attic insulation - R11->R30	21	14	1	2	300	***	6.43	8.04	9.64	11.25
Thermostatic steam valves	47	32	11	14	314	***	6.80	8.50	10.20	11.90
Instantaneous water heater*	14	9	7	10	324	***	8.80	11.00	13.19	15.39
Infiltration - .5->.35	16	10	3	4	328	***	9.49	11.86	14.23	16.61
Storm windows	69	46	11	14	342	***	13.76	17.19	20.63	24.07
Attic insulation - R19->R30	7	5	0	0	342	***	15.53	19.41	23.29	27.18
Retro water heater-.54 EF	29	19	6	**	342	***	16.64	20.80	24.95	29.11

Notes:

*Measures to be implemented at time of equipment replacement.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings from more expensive application zeroed out to prevent double-counting of savings.

***Measures that will result in some savings, but after more cost-effective measures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceeding text for explanation of each column in this table.

Table 2-30. Savings and Levelized Cost by Measure -- LILCo, Ranges and Dryers.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs			
	Unadjstd.	Adjustd.					None	25%	50%	75%
MANDATED MEASURES										
Range - electric ignition*	40	35	12	392	392	16%	0.00	0.00	0.00	0.00
Dryer - electric ignition*	30	26	9	195	586	24%	0.00	0.00	0.00	0.00
Dryer - auto termination*	4	4	1	31	618	25%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
High spin-speed washer*	13	11	11	256	874	35%	4.50	5.63	6.75	3.38

Notes:
*Measures which will be automatically adopted at time of equipment replacement due to NAECA standards.
**Measures to be implemented at time of equipment replacement.

See preceeding text for explanation of each column in this table.

Table 2-31. Savings and Levelized Cost by Measure -- BUG, Colonial.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home	Savings in all Homes	Cumulative Savings in all Homes	Cumulative Savings as % of	Cost of Saved Gas ($/DTh)			
							Program Costs			
	Unadjstd.	Adjustd.	(therms)	(1000 DTh)	(1000 DTh)	Bldg Type	None	25%	50%	75%
MANDATED MEASURES										
Replace water heater-.54 EF	48	33	20	139	139	1%	0.00	0.00	0.00	0.00
Replace furnace-78% AFUE	339	235	43	298	438	4%	0.00	0.00	0.00	0.00
Replace steam boiler-75%	594	412	113	795	1,233	10%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	258	179	19	130	1,364	11%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures					*0*	*0%*				
Setback thermostat - 10	199	138	36	252	252	2%	0.49	0.61	0.73	0.85
DHW pipe insulation	39	27	14	95	347	3%	0.57	0.71	0.85	1.00
Setback thermostat - 5	132	91	24	166	513	4%	0.74	0.92	1.11	1.29
Infiltration - 1->.35	398	276	28	194	707	6%	1.03	1.28	1.54	1.79
Steam boiler - 82%*	203	141	66	465	1,172	10%	1.22	1.53	1.84	2.14
Low-flow shower and faucet	43	29	21	145	1,316	11%	1.31	1.64	1.97	2.30
Infiltration- .75->.35	255	177	79	371	1,688	14%	1.34	1.67	2.00	2.34
Tank wrap - R-6	49	34	10	71	1,759	14%	1.54	1.92	2.31	2.69
Furnace - 85% AFUE*	127	88	20	142	1,830	15%	1.80	2.25	2.70	3.15
Storage water heater-.65 EF*	65	45	40	280	2,110	17%	1.85	2.31	2.77	3.23
Boiler temperature modulation	135	94	13	92	2,202	18%	2.02	2.52	3.02	3.53
Pipe insulation (steam)	130	90	14	101	2,303	19%	2.04	2.55	3.06	3.57
Attic insulation - R0->R30	479	332	56	396	2,698	22%	2.21	2.77	3.32	3.87
Two zones - hydronic	246	170	17	119	2,818	23%	2.24	2.81	3.37	3.93
Infiltration - .5->.35	100	70	24	171	2,988	24%	2.58	3.22	3.87	4.51
Seal ducts	29	20	4	27	3,015	25%	2.87	3.59	4.30	5.02
Basement wall insulation-R11	147	102	12	85	3,101	25%	3.13	3.91	4.69	5.48
Modulating furnace*	135	93	12	85	3,186	26%	3.14	3.92	4.71	5.49
Derate furnace	114	79	15	105	3,290	27%	3.21	4.01	4.81	5.61
Attic insulation - R5->R30	245	170	46	321	3,611	29%	3.84	4.80	5.76	6.72
Furnace fan/t-stat adj	123	85	16	113	3,724	30%	3.99	4.99	5.98	6.98
Horizontal-axis washing machine*	58	40	14	95	3,819	31%	4.33	5.41	6.49	7.57
Pipe insulation (hydronic)	37	26	2	11	3,830	31%	4.49	5.61	6.74	7.86
Retro steam boiler-75%	594	412	113	**	3,830	31%	4.72	5.90	7.08	8.26
Wall insulation - R13 cellulose	323	224	67	471	4,301	35%	4.81	6.01	7.21	8.42
Thermostatic steam valves	168	116	43	302	4,604	37%	5.40	6.74	8.09	9.44
Retro furnace-78% AFUE	339	235	43	**	4,604	37%	5.41	6.77	8.12	9.47
Hydronic boiler - 84%*	53	37	7	46	4,650	38%	5.44	6.81	8.17	9.53
Two zones - air	308	214	29	202	4,852	39%	5.96	7.45	8.94	10.43
Duct insulation - R0->R3	84	59	7	47	4,898	40%	6.33	7.92	9.50	11.08
Gas engine heat pump*	351	244	66	461	5,359	44%	6.39	7.99	9.59	11.19
Attic insulation - R11->R30	115	80	13	89	5,449	44%	6.81	8.51	10.21	11.92
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Basement ceiling insulation-R28	160	111	3	23	5,472	***	6.96	8.70	10.45	12.19
Duct insulation - R3->R6	60	42	8	56	5,528	***	7.30	9.13	10.96	12.78
Instantaneous water heater*	23	16	13	88	5,617	***	7.49	9.36	11.23	13.10
Basement ceiling insulation-R19	127	88	11	74	5,691	***	8.76	10.95	13.14	15.33
Furnace - 91% AFUE*	92	64	8	54	5,745	***	9.94	12.42	14.91	17.39
Retro hydronic boiler - 80%	258	179	19	**	5,745	***	10.34	12.93	15.51	18.10
Storm windows	295	205	68	**	5,745	***	11.66	14.57	17.48	20.40
Attic insulation - R19->R30	38	26	1	**	5,745	***	16.43	20.54	24.65	28.76
Retro water heater-.54 EF	48	33	20	**	5,745	***	16.66	20.82	24.98	29.15

Notes:

*Measures to be implemented at time of equipment replacement.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings from more expensive application zeroed out to prevent double-counting of savings.

***Measures that will result in some savings, but after more cost-effective measures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceeding text for explanation of each column in this table.

Table 2-32. Savings and Levelized Cost by Measure -- BUG, Ranch.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs			
	Unadjstd.	Adjustd.					None	25%	50%	75%
MANDATED MEASURES										
Replace furnace-78% AFUE	253	192	35	49	49	2%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	209	159	16	23	72	3%	0.00	0.00	0.00	0.00
Replace steam boiler-75%	514	391	108	151	223	11%	0.00	0.00	0.00	0.00
Replace water heater-.54 EF	48	36	22	31	254	12%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures										
DHW pipe insulation	39	30	15	21	21	1%	0.52	0.65	0.78	0.91
Setback thermostat - 10	157	119	31	44	64	3%	0.57	0.71	0.85	0.99
Setback thermostat - 5	104	79	21	29	93	4%	0.85	1.07	1.28	1.49
Infiltration - 1->.35	298	226	23	32	125	6%	1.00	1.25	1.50	1.75
Pipe insulation (steam)	160	122	19	27	152	7%	1.14	1.42	1.70	1.99
Low-flow shower and faucet	43	32	23	32	184	9%	1.20	1.50	1.80	2.10
Steam boiler - 82%*	176	133	63	88	272	13%	1.29	1.61	1.93	2.26
Tank wrap - R-6	50	38	11	16	288	14%	1.38	1.72	2.06	2.41
Furnace - 85% AFUE*	99	75	17	24	313	15%	1.38	1.73	2.07	2.42
Infiltration- .75->.35	186	142	64	60	372	18%	1.46	1.82	2.19	2.55
Storage water heater-.65 EF*	65	49	44	62	434	21%	1.68	2.10	2.53	2.95
Attic insulation - R0->R30	540	411	70	98	532	25%	1.87	2.34	2.81	3.28
Derate furnace	93	71	13	19	551	26%	2.00	2.50	3.00	3.50
Basement wall insulation-R11	195	148	18	25	576	28%	2.14	2.68	3.22	3.75
Boiler temperature modulation	102	77	11	15	591	28%	2.44	3.06	3.67	4.28
Seal ducts	23	17	3	5	595	29%	2.66	3.32	3.99	4.65
Two zones - hydronic	184	140	14	20	615	29%	2.73	3.42	4.10	4.78
Infiltration - .5->.35	71	54	19	27	642	31%	2.83	3.54	4.25	4.96
Thermostatic steam valves	192	146	54	76	718	34%	2.86	3.58	4.29	5.01
Attic insulation - R5->R30	288	219	59	83	801	38%	3.12	3.90	4.68	5.45
Horizontal-axis washing machine	71	54	18	26	827	40%	3.20	4.00	4.79	5.59
Pipe insulation (hydronic)	28	21	1	2	828	40%	4.11	5.14	6.17	7.19
Modulating furnace*	88	67	7	10	839	40%	4.39	5.49	6.59	7.69
Furnace fan/t-stat adj	99	75	14	20	859	41%	4.52	5.65	6.77	7.90
Retro steam boiler-75%	514	391	108	**	859	41%	4.97	6.21	7.46	8.70
Basement ceiling insulation-R28	83	63	2	3	861	41%	5.03	6.28	7.54	8.80
Wall insulation - R13 cellulose	201	153	46	64	926	44%	5.33	6.66	7.99	9.32
Attic insulation - R11->R30	128	97	16	22	948	45%	5.84	7.29	8.75	10.21
Retro furnace-78% AFUE	253	192	35	**	948	45%	6.62	8.28	9.93	11.59
Hydronic boiler - 84%*	40	30	5	8	955	46%	6.66	8.33	9.99	11.66
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Storm windows	126	96	32	44	999	***	6.69	8.36	10.04	11.71
Instantaneous water heater*	23	17	14	19	1,019	***	6.83	8.54	10.25	11.95
Gas engine heat pump*	299	227	61	86	1,105	***	6.85	8.56	10.27	11.98
Two zones - air	244	185	25	35	1,140	***	6.88	8.60	10.32	12.04
Duct insulation - R0->R3	47	36	4	6	1,146	***	9.31	11.64	13.96	16.29
Duct insulation - R3->R6	35	27	5	7	1,153	***	10.30	12.87	15.45	18.02
Furnace - 91% AFUE*	71	54	13	19	1,172	***	11.16	13.95	16.74	19.53
Retro hydronic boiler - 80%	209	159	16	**	1,172	***	11.65	14.56	17.47	20.39
Retro water heater-.54 EF	48	36	22	**	1,172	***	12.92	16.15	19.38	22.61
Attic insulation - R19->R30	43	33	2	2	1,174	***	13.87	17.34	20.80	24.27
Basement ceiling insulation-R19	86	65	8	11	1,185	***	15.08	18.85	22.62	26.39

Notes:

*Measures to be implemented at time of equipment replacement.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings from more expensive application zeroed out to prevent double-counting of savings.

***Measures that will result in some savings, but after more cost-effective measures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceeding text for explanation of each column in this table.

Table 2-33. Savings and Levelized Cost by Measure -- BUG, Wood-frame Townhouse.

	Savings in Homes Implementing Measure (therms) Unadjstd.	Adjustd.	Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs None	25%	50%	75%
MANDATED MEASURES										
Replace steam boiler-75%	187	160	57	38	38	7%	0.00	0.00	0.00	0.00
Replace water heater-.54 EF	38	33	20	13	52	9%	0.00	0.00	0.00	0.00
Replace furnace - 78% AFUE	87	75	13	9	61	10%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	75	64	9	6	67	11%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures					*0*	*0%*				
DHW pipe insulation	31	27	13	9	9	2%	0.58	0.72	0.87	1.01
Low-flow shower & faucet	34	29	20	14	23	4%	1.33	1.66	2.00	2.33
Setback thermostat - 10	57	49	13	9	31	5%	1.38	1.72	2.06	2.41
Storage water heater-.65 EF*	52	44	39	27	58	10%	1.87	2.34	2.81	3.28
Basement wall insulation-R11	79	68	8	6	64	11%	1.93	2.41	2.89	3.37
Tank wrap - R-6	31	27	8	5	69	12%	1.95	2.43	2.92	3.41
Infiltration - 1->.35	115	98	10	7	76	13%	2.01	2.52	3.02	3.52
Setback thermostat - 5	38	32	8	6	81	14%	2.08	2.60	3.12	3.64
Attic insulation - R0->R30	202	172	29	20	101	17%	2.18	2.73	3.27	3.82
Furnace - 85% AFUE*	46	40	9	6	107	18%	2.62	3.28	3.93	4.59
Infiltration- .75->.35	72	61	28	12	120	20%	2.69	3.37	4.04	4.72
Seal ducts	8	7	1	1	121	20%	2.85	3.56	4.27	4.98
Steam boiler - 82%*	64	55	25	17	137	23%	3.15	3.94	4.72	5.51
Pipe insulation (steam)	41	35	6	4	142	24%	3.30	4.13	4.95	5.78
Horizontal axis washing machi	57	49	17	11	153	26%	3.56	4.44	5.33	6.22
Attic insulation - R5->R30	103	88	24	16	169	29%	3.80	4.76	5.71	6.66
Wall insulation - R13 cellulose	157	134	40	27	196	33%	4.11	5.14	6.16	7.19
Derate furnace	33	28	5	4	200	34%	5.04	6.30	7.56	8.82
Infiltration - .5->.35	27	23	8	5	205	35%	5.53	6.91	8.30	9.68
Boiler temperature modulation	39	34	5	3	203	34%	5.62	7.03	8.43	9.84
Two zones - hydronic	71	61	6	4	207	35%	6.27	7.84	9.40	10.97
Attic insulation - R11->R30	48	41	7	4	212	36%	6.72	8.40	10.09	11.77
Pipe insulation (hydronic)	11	9	1	0	212	36%	8.01	10.02	12.02	14.02
Modulating furnace*	36	31	4	3	215	36%	9.56	11.96	14.35	16.74
Storm windows	84	72	24	16	231	39%	10.05	12.56	15.08	17.59
Thermostatic steam valves	52	45	17	11	242	41%	10.49	13.11	15.73	18.36
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Furnace fan/t-stat adj	35	30	6	4	246	***	11.23	14.04	16.84	19.65
Retro steam boiler-75%	187	160	57	**	246	***	12.15	15.19	18.22	21.26
Basement ceiling insulation-R1	32	28	4	3	249	***	13.79	17.24	20.69	24.14
Retro water heater-.54 EF	38	33	20	**	249	***	14.37	17.96	21.56	25.15
Hydronic boiler - 84%*	15	13	2	2	250	***	15.22	19.02	22.83	26.63
Gas engine heat pump*	117	100	27	18	269	***	15.52	19.40	23.28	27.16
Attic insulation - R19->R30	16	14	1	0	269	***	16.25	20.32	24.38	28.44
Two zones - air	89	76	10	7	276	***	16.80	20.99	25.19	29.39
Retro furnace-78% AFUE	87	75	13	**	276	***	17.10	21.38	25.65	29.93
Duct insulation - R0->R3	7	6	1	0	277	***	23.55	29.44	35.33	41.21
Duct insulation - R3->R6	5	4	1	1	277	***	27.65	34.57	41.48	48.40
Furnace - 91% AFUE*	25	22	3	2	279	***	27.70	34.63	41.56	48.48
Retro hydronic boiler - 80%	75	64	9	**	279	***	28.91	36.14	43.37	50.60
Instantaneous water heater*	18	16	12	8	287	***	32.93	41.16	49.39	57.62

Notes:

*Measures which will be automatically adopted at time of replacement due to NAECA standards.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings from more expensive application zeroed out to prevent double-counting of savings.

***Measures that will result in some savings, but after more cost-effective measures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceeding text for explanation of each column in this table.

Table 2-34. Savings and Levelized Cost by Measure -- BUG, Brownstone Townhouse.

	Savings in Homes Implementing Measure (therms) Unadjstd.	Adjustd.	Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs None	25%	50%	75%
MANDATED MEASURES										
Replace water heater-.54 EF	38	35	20	689	689	1%	0.00	0.00	0.00	0.00
Replace steam boiler-75%	337	304	114	3,980	4,668	9%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	156	141	21	719	5,387	11%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
Base for Utility Measures				-	*0*	*0%*				
DHW pipe insulation	36	33	16	569	569	1%	0.29	0.36	0.43	0.50
Setback thermostat- 10	193	174	45	1,581	2,149	4%	0.39	0.48	0.58	0.68
Setback thermostat - 5	127	115	30	1,043	3,192	6%	0.59	0.73	0.88	1.03
Tank wrap - R-6	52	47	14	488	3,680	7%	1.12	1.40	1.68	1.96
Infiltration - 1->.35	207	187	19	653	4,333	9%	1.21	1.52	1.82	2.12
Attic insulation - R0->R30	271	245	42	1,456	5,789	12%	1.37	1.72	2.06	2.40
Low-flow shower & faucet	28	26	18	628	6,417	13%	1.51	1.89	2.26	2.64
Infiltration- .75->.35	128	116	52	1,215	7,632	15%	1.53	1.91	2.29	2.67
Steam boiler - 82%*	115	104	66	2,326	9,957	20%	1.66	2.07	2.49	2.90
Pipe insulation (steam)	74	67	14	503	10,461	21%	1.70	2.12	2.54	2.97
Storage water heater-.65 EF*	52	47	43	1,489	11,950	24%	1.77	2.22	2.66	3.10
Attic insulation - R5->R30	145	130	35	1,232	13,182	26%	2.29	2.86	3.43	4.00
Boiler temperature modulation	81	73	14	502	13,684	27%	2.58	3.22	3.87	4.51
Mainline air vents	159	143	88	3,071	16,755	34%	2.63	3.29	3.95	4.61
Basement wall insulation-R11	107	97	12	407	17,162	34%	2.90	3.63	4.35	5.08
Infiltration - .5->.35	48	44	16	573	17,735	36%	2.93	3.67	4.40	5.13
Wall insulation - R4 foam*	501	452	68	2,374	20,108	40%	2.96	3.70	4.44	5.18
Horizontal-axis washing machine*	57	51	18	612	20,720	42%	3.36	4.20	5.05	5.89
Pipe insulation (hydronic)	23	20	2	60	20,780	42%	3.49	4.37	5.24	6.11
Attic insulation - R11->R30	64	58	9	326	21,106	42%	4.27	5.34	6.40	7.47
Four zones - hydronic	148	134	19	655	21,761	44%	4.76	5.96	7.15	8.34
Retro steam boiler-75%	337	304	114	**	21,761	44%	6.40	8.00	9.59	11.19
Hydronic boiler - 84%*	32	29	7	254	22,015	44%	6.89	8.61	10.34	12.06
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Storm windows	141	127	37	1,288	23,303	***	7.15	8.94	10.73	12.52
Instantaneous water heater*	18	16	13	459	23,762	***	7.19	8.99	10.78	12.58
Thermostatic steam valves	95	86	43	1,511	25,273	***	7.32	9.15	10.98	12.81
Basement ceiling insulation-R19	57	52	8	271	25,544	***	7.42	9.27	11.12	12.98
Attic insulation - R19->R30	20	18	1	32	25,576	***	11.01	13.76	16.51	19.26
Retro hydronic boiler - 80%	156	141	21	**	25,576	***	13.09	16.36	19.64	22.91
Retro water heater-.54 EF	38	35	20	**	25,576	***	13.59	16.99	20.39	23.79

Notes:

*Measure to be implemented at time of equipment replacement.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings frm more expensive application zeroed out to prevent double-coding of savings.

***Measures that will result in some savings, but after more cost-effective mreasures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceding text for explanation of each column in this table.

Table 2-35. Savings and Levelized Cost by Measure -- BUG, Low-Rise Apartment.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home	Savings in all Homes	Cumulative Savings in all Homes	Cumulative Savings as % of	Cost of Saved Gas ($/DTh) Program Costs			
	Unadjstd.	Adjustd.	(therms)	(1000 DTh)	(1000 DTh)	Bldg Type	None	25%	50%	75%
MANDATED MEASURES										
Replace steam boiler-75%	166	112	32	431	431	6%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	75	51	9	124	556	8%	0.00	0.00	0.00	0.00
Replace water heater-.54 EF	29	19	6	78	634	9%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures					*0*	*0%*				
Steam boiler - 82%*	57	38	20	273	273	4%	0.29	0.36	0.43	0.50
DHW pipe insulation	24	16	8	107	379	5%	0.40	0.50	0.60	0.70
Boiler temperature modulation	40	27	4	57	436	6%	0.90	1.12	1.35	1.57
Main line air vents	79	53	28	369	805	11%	0.99	1.24	1.49	1.74
Tank wrap - R-6	50	34	5	68	873	12%	1.07	1.33	1.60	1.87
Pipe insulation (steam)	37	25	3	44	917	13%	1.09	1.36	1.63	1.90
Slab edge insulation - R5	10	7	3	35	952	13%	1.26	1.58	1.90	2.21
Hydronic boiler - 84%*	15	10	4	48	1,000	14%	1.36	1.70	2.04	2.38
Setback thermostat - 10	47	32	4	55	1,055	14%	1.47	1.84	2.20	2.57
Low-flow showerhead & faucet	26	17	12	162	1,217	17%	1.54	1.93	2.31	2.70
Retro steam boiler-75%	166	112	32	**	1,217	17%	2.06	2.58	3.09	3.61
Attic insulation - R0->R30	90	61	12	154	1,371	19%	2.06	2.58	3.09	3.61
Pipe insulation (hydronic)	12	8	1	9	1,380	19%	2.11	2.64	3.17	3.70
Storage water heater-.65 EF*	39	26	12	157	1,537	21%	2.17	2.71	3.25	3.79
Hot water demand control	38	26	13	173	1,710	23%	2.21	2.76	3.31	3.86
Setback thermostat - 5	31	21	3	36	1,746	24%	2.22	2.78	3.34	3.89
Boiler/DHW combination system*	49	33	8	104	1,850	25%	3.07	3.84	4.61	5.38
Infiltration - 1->.35	67	45	18	242	2,092	29%	3.24	4.06	4.87	5.68
Infiltration- .75->.35	41	28	8	112	2,203	30%	3.29	4.11	4.93	5.75
Retro hydronic boiler - 80%	75	51	9	**	2,203	30%	3.34	4.18	5.01	5.85
Attic insulation - R5->R30	48	32	13	169	2,372	32%	3.43	4.29	5.15	6.01
Front-end boiler	65	44	13	172	2,544	35%	3.78	4.73	5.67	6.62
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Horizontal-axis washing machine*	43	29	10	132	2,676	***	4.12	5.14	6.17	7.20
Wall insulation - R13 cellulose	93	63	9	126	2,802	***	4.27	5.34	6.41	7.48
Attic insulation - R11->R30	21	14	1	17	2,819	***	6.43	8.04	9.64	11.25
Thermostatic steam valves	47	32	11	143	2,962	***	6.80	8.50	10.20	11.90
Instantaneous water heater*	14	9	7	99	3,061	***	8.80	11.00	13.19	15.39
Infiltration - .5->.35	16	10	3	39	3,100	***	9.49	11.86	14.23	16.61
Storm windows	69	47	11	144	3,244	***	13.76	17.19	20.63	24.07
Attic insulation - R19->R30	7	5	0	1	3,244	***	15.53	19.41	23.29	27.18
Retro water heater-.54 EF	29	19	6	**	3,244	***	16.64	20.80	24.95	29.11

Notes:

*Measures to be implemented at time of equipment replacement.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings from more expensive application zeroed out to prevent double-counting of savings.

***Measures that will result in some savings, but after more cost-effective measures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceeding text for explanation of each column in this table.

Table 2-36. Savings and Levelized Cost by Measure -- BUG, High-Rise Apartment.

	Savings in Homes Implementing Measure (therms) Unadjstd.	Adjustd.	Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs None	25%	50%	75%
MANDATED MEASURES										
Replace hydronic boiler - 80%	54	29	4	19	19	1%	0.00	0.00	0.00	0.00
Replace steam boiler-75%	158	86	29	123	142	5%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures					0	0%				
Pipe insulation (steam)	65	35	5	23	23	1%	0.72	0.90	1.08	1.26
DHW pipe insulation	25	14	7	29	51	2%	1.13	1.41	1.70	1.98
Main line air vents	105	57	35	147	199	7%	1.15	1.44	1.73	2.02
Steam boiler - 82%*	41	22	14	60	258	9%	1.25	1.56	1.88	2.19
Hot water demand control	41	22	18	75	333	12%	1.66	2.08	2.50	2.91
Infiltration - 1->.35	116	63	15	64	397	14%	2.10	2.63	3.15	3.68
Setback thermostat - 10	55	30	4	16	413	15%	2.28	2.85	3.42	4.00
Infiltration- .75->.35	73	39	15	63	476	17%	2.50	3.13	3.75	4.38
Low-flow shower and faucet	27	15	10	44	520	19%	2.61	3.26	3.91	4.56
Thermostatic steam valves	73	39	16	66	586	21%	2.66	3.32	3.99	4.65
Retro steam boiler-75%	158	86	29	**	586	21%	2.83	3.54	4.25	4.96
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Attic insulation - R0->R30	53	29	7	28	614	***	2.85	3.56	4.27	4.98
Wall insulation - R4 foam*	148	80	9	38	652	***	3.24	4.06	4.87	5.68
Setback thermostat - 5	35	19	2	10	662	***	3.57	4.47	5.36	6.26
Boiler temperature modulation	28	15	2	7	669	***	3.61	4.51	5.41	6.32
Pipe insulation (hydronic)	8	4	0	1	670	***	3.77	4.71	5.65	6.59
Boiler/DHW combination system*	57	31	18	78	748	***	4.26	5.32	6.39	7.45
Attic insulation - R5->R30	31	17	7	30	779	***	4.29	5.36	6.43	7.50
Hydronic boiler - 84%*	11	6	2	6	785	***	4.49	5.61	6.73	7.85
Retro hydronic boiler - 80%	54	29	4	**	785	***	6.17	7.71	9.25	10.79
Horizontal-axis washing machine*	46	25	8	36	821	***	6.96	8.70	10.43	12.17
Front-end boiler	60	32	7	29	850	***	7.09	8.87	10.64	12.42
Infiltration - .5->.35	27	14	5	22	872	***	7.39	9.23	11.08	12.92
Attic insulation - R11->R30	13	7	0	2	873	***	8.24	10.30	12.36	14.42
Storm windows	73	40	8	35	909	***	14.64	18.30	21.95	25.61
Basement wall insulation-R11	9	5	0	2	910	***	17.38	21.73	26.07	30.42
Attic insulation - R19->R30	5	3	0	0	910	***	18.37	22.96	27.56	32.15
Basement ceiling insulation-R28	7	4	0	1	911	***	21.16	26.45	31.74	37.03
Basement ceiling insulation-R19	7	4	0	1	913	***	22.33	27.91	33.49	39.07

Notes:
*Measures to be implemented at time of equipment replacement.
**Cases where measures analyzed for both replacement and retrofit applications and for which savings from more expensive application zeroed out to prevent double-counting of savings.
***Measures that will result in some savings, but after more cost-effective measures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceeding text for explanation of each column in this table.

Table 2-37. Savings and Levelized Cost by Measure -- BUG, Ranges and Dryers.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs			
	Unadjstd.	Adjustd.					None	25%	50%	75%
MANDATED MEASURES										
Range - elec. ignition	40	38	13	1,759	1,759	22%	0.00	0.00	0.00	0.00
Dryer - elec. ignition	30	29	9	180	1,939	24%	0.00	0.00	0.00	0.00
Dryer - auto terminatn	4	4	2	29	1,968	25%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
High spin-speed washer	13	4	4	83	2,051	26%	4.50	5.63	6.75	3.38

Notes:
*Measures which will be automatically adopted at time of equipment replacement due to NAECA standards.
**Measures to be implemented at time of equipment replacement.

See preceeding text for explanation of each column in this table.

Table 2-38. Savings and Levelized Cost by Measure – NFG, Colonial.

	Savings in Homes Implementing Measure (therms) Unadjstd.	Adjustd.	Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs None	25%	50%	75%
MANDATED MEASURES										
Replace steam boiler-75%	804	394	4	37	37	0%	0.00	0.00	0.00	0.00
Replace water heater-.54 EF	51	25	15	135	172	1%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	376	184	11	103	275	2%	0.00	0.00	0.00	0.00
Replace furnace-78% AFUE	508	249	135	1215	1,490	10%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
–Base for Utility Measures					*0*	*0%*				
Setback thermostat - 10	244	120	37	333	333	2%	0.39	0.49	0.59	0.68
Setback thermostat - 5	145	71	22	198	532	3%	0.66	0.82	0.99	1.15
DHW pipe insulation	42	21	10	92	624	4%	0.75	0.93	1.12	1.31
Furnace - 85% AFUE*	190	93	64	576	1,200	8%	0.88	1.10	1.32	1.55
Infiltration - 1->.35	596	292	29	263	1,463	9%	0.96	1.20	1.44	1.68
Infiltration- .75->.35	382	187	84	505	1,968	13%	1.25	1.56	1.88	2.19
Steam boiler - 82%*	275	134	2	22	1,989	13%	1.27	1.59	1.90	2.22
Low-flow shower and faucet	45	22	16	140	2,130	14%	1.72	2.15	2.58	3.02
Boiler temperature modulation	196	96	8	73	2,202	14%	1.95	2.44	2.92	3.41
Two zones - hydronic	374	183	11	99	2,301	15%	2.07	2.59	3.10	3.62
Pipe insulation (steam)	177	87	1	5	2,306	15%	2.11	2.64	3.17	3.70
Tank wrap - R-6	50	24	17	154	2,459	16%	2.12	2.65	3.18	3.71
Attic insulation - R0->R30	694	340	48	428	2,887	19%	2.14	2.68	3.22	3.75
Infiltration - .5->.35	153	75	26	236	3,124	20%	2.37	2.96	3.55	4.14
Storage water heater-.65 EF*	69	34	30	272	3,395	22%	2.42	3.03	3.64	4.24
Seal ducts	44	22	12	111	3,506	23%	2.63	3.28	3.94	4.59
Basement wall insulation-R11	231	113	57	508	4,015	26%	2.79	3.49	4.19	4.88
Modulating furnace*	201	98	37	336	4,351	28%	2.95	3.69	4.43	5.17
Derate furnace	167	82	46	417	4,768	31%	3.07	3.84	4.61	5.38
Attic insulation - R5->R30	354	173	12	109	4,877	32%	3.73	4.66	5.59	6.52
Furnace fan/t-stat adj	180	88	50	450	5,327	34%	3.81	4.76	5.72	6.67
Pipe insulation (hydronic)	54	27	1	9	5,336	35%	4.33	5.41	6.49	7.58
Retro steam boiler-75%	804	394	4	**	5,336	35%	4.42	5.52	6.62	7.73
Furnace - 91% AFUE*	137	67	25	223	5,559	36%	4.44	5.55	6.66	7.77
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Wall insulation - R13 cellulose	464	227	86	776	6,335	***	4.70	5.88	7.06	8.23
Retro furnace-78% AFUE	508	249	135	**	6,335	***	5.08	6.35	7.62	8.89
Hydronic boiler - 84%*	78	38	4	36	6,372	***	5.24	6.55	7.86	9.18
Two zones - air	472	231	94	841	7,213	***	5.47	6.84	8.21	9.58
Thermostatic steam valves	228	111	2	14	7,227	***	5.58	6.98	8.37	9.77
Duct insulation - R0->R3	134	65	22	200	7,427	***	5.62	7.03	8.43	9.84
Horizontal-axis washing machine*	62	30	17	150	7,576	***	5.68	7.10	8.52	9.94
Gas engine heat pump*	514	252	204	1833	9,410	***	6.14	7.67	9.20	10.74
Duct insulation - R3->R6	97	48	27	244	9,654	***	6.38	7.98	9.57	11.17
Attic insulation - R11->R30	167	82	19	169	9,823	***	6.60	8.25	9.90	11.55
Basement ceiling insulation-R28	228	112	14	130	9,953	***	7.07	8.84	10.61	12.38
Basement ceiling insulation-R19	188	92	9	83	10,036	***	8.34	10.42	12.50	14.59
Retro hydronic boiler - 80%	376	184	11	103	10,139	***	8.93	11.16	13.40	15.63
Instantaneous water heater*	24	12	10	86	10,225	***	9.83	12.29	14.75	17.20
Storm windows	426	208	13	112	10,337	***	11.35	14.18	17.02	19.86
Attic insulation - R19->R30	56	27	9	83	10,420	***	15.85	19.81	23.77	27.73
Retro water heater-.54 EF	51	25	15	135	10,555	***	18.59	23.24	27.89	32.54

Notes:

*Measure to be implemented at time of equipment replacement.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings frm more expensive application zeroed out to prevent double-coding of savings.

***Measures that will result in some savings, but after more cost-effective mreasures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceding text for explanation of each column in this table.

Table 2-39. Savings and Levelized Cost by Measure -- NFG, Ranch.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh)			
								Program Costs		
	Unadjstd.	Adjustd.					None	25%	50%	75%
MANDATED MEASURES										
Replace furnace-78% AFUE	376	225	122	3,291	3,291	8%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	306	183	11	308	3,600	9%	0.00	0.00	0.00	0.00
Replace steam boiler-75%	672	402	4	113	3,713	9%	0.00	0.00	0.00	0.00
Replace water heater-.54 EF	41	24	15	397	4,109	10%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures					*0*	*0%*				
Setback thermostat - 10	191	114	35	955	955	2%	0.41	0.51	0.61	0.72
Setback thermostat - 5	114	68	21	569	1,524	4%	0.69	0.86	1.03	1.20
DHW pipe insulation	34	20	10	271	1,795	5%	0.76	0.96	1.15	1.34
Infiltration - 1->.35	438	262	26	707	2,502	6%	0.86	1.07	1.29	1.50
Furnace - 85% AFUE*	145	87	60	1,608	4,110	10%	0.95	1.19	1.42	1.66
Infiltration- .75->.35	275	164	74	1,331	5,441	14%	1.25	1.56	1.87	2.18
Steam boiler - 82%*	229	137	2	66	5,507	14%	1.24	1.55	1.86	2.18
Pipe insulation (steam)	147	88	1	14	5,521	14%	1.56	1.95	2.33	2.72
Attic insulation - R0->R30	779	466	65	1,761	7,282	18%	1.64	2.05	2.46	2.86
Tank wrap - R-6	50	30	21	563	7,845	20%	1.73	2.17	2.60	3.03
Derate furnace	135	81	46	1,236	9,081	23%	1.74	2.17	2.61	3.04
Low-flow showerhead & fauce	36	22	15	411	9,492	24%	1.76	2.20	2.64	3.08
Basement wall insulation-R11	275	164	82	2,219	11,711	30%	1.91	2.39	2.87	3.35
Boiler temperature modulation	148	88	7	200	11,911	30%	2.12	2.65	3.18	3.71
Seal ducts	34	20	12	315	12,226	31%	2.27	2.84	3.41	3.98
Two zones - hydronic	268	160	10	260	12,486	32%	2.36	2.95	3.55	4.14
Infiltration - .5->.35	105	63	22	595	13,080	33%	2.42	3.03	3.63	4.24
Storage water heater-.65 EF*	55	33	30	797	13,877	35%	2.48	3.10	3.72	4.34
Attic insulation - R5->R30	414	248	17	468	14,345	36%	2.73	3.41	4.09	4.78
Pipe insulation (hydronic)	41	24	1	24	14,369	36%	3.55	4.44	5.32	6.21
Thermostatic steam valves	190	113	2	43	14,411	37%	3.66	4.57	5.48	6.40
Furnace fan/t-stat adj	144	86	49	1,317	15,729	40%	3.91	4.89	5.86	6.84
Retro steam boiler-75%	672	402	4	**	15,729	40%	4.32	5.40	6.49	7.57
Horizontal-axis washing machi	61	37	20	542	16,271	41%	4.70	5.88	7.06	8.23
Basement ceiling insulation-R2	111	67	9	234	16,504	42%	4.73	5.91	7.09	8.27
Furnace - 91% AFUE*	104	62	46	1,247	17,752	45%	4.79	5.99	7.18	8.38
Wall insulation - R13 cellulose	281	168	64	1,723	19,475	49%	4.81	6.01	7.21	8.41
Modulating furnace*	98	58	22	584	20,059	51%	4.97	6.21	7.46	8.70
Attic insulation - R11->R30	184	110	25	684	20,743	53%	5.11	6.39	7.67	8.95
Retro furnace-78% AFUE	376	225	122	**	20,743	53%	5.62	7.03	8.44	9.84
Hydronic boiler - 84%*	58	35	4	100	20,843	53%	5.74	7.18	8.62	10.05
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Gas engine heat pump*	437	261	212	5,715	26,558	***	5.91	7.38	8.86	10.33
Storm windows	179	107	6	173	26,731	***	5.92	7.40	8.88	10.36
Two zones - air	357	213	86	2,332	29,064	***	5.92	7.40	8.88	10.36
Duct insulation - R0->R3	73	43	15	399	29,463	***	7.63	9.53	11.44	13.35
Duct insulation - R3->R6	54	32	19	500	29,962	***	8.50	10.63	12.75	14.88
Retro hydronic boiler - 80%	306	183	11	**	29,962	***	8.97	11.21	13.45	15.70
Instantaneous water heater*	19	12	9	251	30,213	***	10.05	12.57	15.08	17.60
Attic insulation - R19->R30	62	37	13	340	30,553	***	12.17	15.21	18.25	21.29
Basement ceiling insulation-R1	115	69	7	186	30,740	***	14.11	17.63	21.16	24.69
Retro water heater-.54 EF	41	24	15	**	30,740	***	19.01	23.77	28.52	33.28

Notes:

*Measures to be implemented at time of equipment replacement.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings from more expensive application zeroed out to prevent double-counting of savings.

***Measures that will result in some savings, but after more cost-effective measures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceeding text for explanation of each column in this table.

Table 2-40. Savings and Levelized Cost by Measure -- NFG, Wood-frame Townhouse.

	Savings in Homes Implementing Measure (therms) Unadjstd.	Adjustd.	Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs None	25%	50%	75%
MANDATED MEASURES										
Replace water heater-.54 EF	30	19	11	102	102	2%	0.00	0.00	0.00	0.00
Replace steam boiler-75%	285	178	4	32	134	2%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	110	69	6	49	183	3%	0.00	0.00	0.00	0.00
Replace furnace - 78% AFUE	129	81	44	391	574	9%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures					*0*	*0%*				
DHW pipe insulation	25	16	8	70	70	1%	0.98	1.23	1.47	1.72
Setback thermostat- 10	70	44	14	121	191	3%	1.07	1.33	1.60	1.87
Basement wall insulation-R11	116	73	36	323	513	8%	1.79	2.23	2.68	3.13
Setback thermostat - 5	42	26	8	72	585	9%	1.79	2.24	2.69	3.13
Infiltration - 1->.35	171	107	11	95	681	10%	1.84	2.29	2.75	3.21
Furnace - 85% AFUE*	69	43	30	266	947	14%	1.89	2.37	2.84	3.31
Attic insulation - R0->R30	290	181	25	226	1,172	17%	2.06	2.57	3.09	3.60
Low-flow shower & faucet	27	17	12	106	1,278	19%	2.26	2.83	3.39	3.96
Infiltration- .75->.35	107	67	30	178	1,456	22%	2.45	3.06	3.68	4.29
Seal ducts	13	8	5	41	1,497	22%	2.53	3.17	3.80	4.43
Tank wrap - R-6	30	19	13	118	1,615	24%	2.73	3.41	4.09	4.77
Steam boiler - 82%*	97	61	1	11	1,626	24%	2.80	3.50	4.21	4.91
Pipe insulation (steam)	61	38	0	2	1,629	24%	3.00	3.75	4.49	5.24
Storage water heater-.65 EF*	41	26	23	205	1,833	27%	3.18	3.98	4.77	5.57
Attic insulation - R5->R30	147	92	6	57	1,890	28%	3.60	4.50	5.40	6.30
Wall insulation - R13 cell.	223	139	53	471	2,361	35%	3.93	4.91	5.90	6.88
Derate furnace	48	30	17	151	2,513	37%	4.68	5.86	7.03	8.20
Infiltration - .5->.35	40	25	9	78	2,591	38%	5.07	6.34	7.60	8.87
Boiler temp modulation	58	36	3	27	2,618	39%	5.18	6.48	7.77	9.07
Two zones - hydronic	105	66	4	35	2,653	39%	5.77	7.21	8.65	10.09
Horizontal-axis washing machine*	45	28	16	139	2,792	41%	6.04	7.55	9.06	10.57
Attic insulation - R11->R30	70	44	10	89	2,881	43%	6.32	7.90	9.48	11.06
Pipe insulation (hydronic)	16	10	0	4	2,885	43%	7.37	9.21	11.06	12.90
Storm windows	120	75	5	40	2,925	43%	9.49	11.87	14.24	16.62
Modulating furnace*	49	30	12	103	3,028	45%	9.55	11.94	14.33	16.72
Thermostatic steam valves	78	49	1	6	3,034	45%	9.57	11.97	14.36	16.76
Retro steam boiler-75%	285	178	4	**	3,034	45%	9.75	12.19	14.62	17.06
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Furnace fan/t-stat adj	52	32	18	163	3,197	***	10.39	12.99	15.58	18.18
Furnace - 91% AFUE*	38	24	9	78	3,276	***	12.49	15.62	18.74	21.86
Basement ceiling insulation-R19	45	28	6	57	3,333	***	13.60	17.00	20.40	23.80
Hydronic boiler - 84%*	23	14	1	13	3,346	***	13.97	17.46	20.95	24.44
Gas engine heat pump*	174	109	88	784	4,129	***	14.20	17.76	21.31	24.86
Attic insulation - R19->R30	24	15	5	45	4,174	***	14.96	18.70	22.44	26.18
Two zones - air	131	82	33	295	4,469	***	15.45	19.31	23.17	27.03
Retro furnace-78% AFUE	129	81	44	**	4,469	***	15.61	19.51	23.41	27.32
Duct insulation - R0->R3	11	7	2	20	4,489	***	21.82	27.28	32.74	38.19
Duct insulation - R3->R6	8	5	3	27	4,516	***	22.64	28.29	33.95	39.61
Retro hydronic boiler - 80%	110	69	6	**	4,516	***	23.79	29.74	35.69	41.63
Retro water heater-.54 EF	30	19	11	**	4,516	***	24.42	30.52	36.63	42.73
Instantaneous water heater*	14	9	7	64	4,580	***	55.95	69.93	83.92	97.91

Notes:

*Measure to be implemented at time of equipment replacement.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings frm more expensive application zeroed out to prevent double-coding of savings.

***Measures that will result in some savings, but after more cost-effective mreasures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceding text for explanation of each column in this table.

Table 2-41. Savings and Levelized Cost by Measure -- NFG, Low-Rise Apartment.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs			
	Unadjstd.	Adjustd.					None	25%	50%	75%
MANDATED MEASURES										
Replace steam boiler-75%	230	154	0	0	0	0%	0.00	0.00	0.00	0.00
Replace hydronic boiler - 80%	111	74	35	103	103	6%	0.00	0.00	0.00	0.00
Replace water heater-.54 EF	30	20	6	18	121	8%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
--Base for Utility Measures					*0*	*0%*				
Steam boiler - 82%*	78	52	0	0	0	0%	0.21	0.26	0.31	0.36
Main line air vents	109	73	0	0	0	0%	0.25	0.31	0.37	0.43
DHW pipe insulation	25	17	8	25	25	2%	0.38	0.47	0.57	0.66
Boiler temperature modulation	58	39	15	46	71	4%	0.63	0.78	0.94	1.10
Pipe insulation (steam)	51	34	0	0	71	4%	0.79	0.98	1.18	1.37
Setback thermostat - 10	57	38	5	15	85	5%	0.84	1.05	1.26	1.47
Hydronic boiler - 84%*	23	15	13	39	125	8%	0.92	1.15	1.38	1.62
Tank wrap - R-6	50	33	5	15	140	9%	1.07	1.33	1.60	1.87
Setback thermostat - 5	34	23	3	9	148	9%	0.99	1.24	1.48	1.73
Attic insulation - R0->R30	130	87	16	49	197	12%	1.43	1.79	2.15	2.51
Low-flow shower and faucet	27	18	13	38	235	15%	1.46	1.82	2.19	2.55
Retro steam boiler-75%	230	154	0	**	235	15%	1.49	1.86	2.24	2.61
Pipe insulation (hydronic)	16	11	2	7	242	15%	1.56	1.96	2.35	2.74
Storage water heater-.65 EF*	41	28	12	36	278	17%	2.05	2.56	3.07	3.59
Hot water demand control	40	27	14	40	318	20%	2.08	2.61	3.13	3.65
Retro hydronic boiler - 80%	111	74	35	**	318	20%	2.27	2.84	3.41	3.97
Attic insulation - R5->R30	69	46	18	54	372	23%	2.38	2.97	3.57	4.16
Front-end boiler	87	58	44	129	501	31%	2.83	3.53	4.24	4.95
Wall insulation - R13 cellulose	134	90	10	29	531	33%	2.96	3.70	4.44	5.18
Boiler/DHW combination syste	51	34	20	60	591	37%	2.97	3.71	4.46	5.20
Horizontal-axis washing machin	45	30	17	50	641	40%	3.89	4.86	5.84	6.81
Attic insulation - R11->R30	31	21	2	6	646	40%	4.40	5.50	6.60	7.71
ADDITIONAL MEASURES BEYOND CALIBRATION POINT IN THE ANALYSIS										
Slab edge insulation - R5	14	9	4	11	657	***	4.45	5.57	6.68	7.79
Thermostatic steam valves	65	44	0	0	657	***	4.91	6.14	7.37	8.60
Infiltration - 1->.35	101	68	16	48	705	***	5.12	6.40	7.69	8.97
Infiltration- .75->.35	63	42	16	47	753	***	6.46	8.08	9.69	11.31
Instantaneous water heater*	14	10	8	23	776	***	8.31	10.39	12.47	14.55
Storm windows	102	69	4	12	788	***	9.27	11.58	13.90	16.22
Attic insulation - R19->R30	10	7	0	0	788	***	10.57	13.21	15.85	18.49
Infiltration - .5->.35	24	16	6	17	805	***	12.77	15.97	19.16	22.35
Retro water heater-.54 EF	30	20	6	**	805	***	15.72	19.66	23.59	27.52

Notes:

*Measures to be implemented at time of equipment replacement.

**Cases where measures analyzed for both replacement and retrofit applications and for which savings from more expensive application zeroed out to prevent double-counting of savings.

***Measures that will result in some savings, but after more cost-effective measures are implemented first, these measures will generally not be within the predicted range of long-run avoided costs.

See preceeding text for explanation of each column in this table.

Table 2-42. Savings and Levelized Cost by Measure -- NFG, Ranges and Dryers.

	Savings in Homes Implementing Measure (therms)		Savings in Average Home (therms)	Savings in all Homes (1000 DTh)	Cumulative Savings in all Homes (1000 DTh)	Cumulative Savings as % of Bldg Type	Cost of Saved Gas ($/DTh) Program Costs			
	Unadjstd.	Adjustd.					None	25%	50%	75%
MANDATED MEASURES										
Range - elec. ignition	40	27	9	288	288	15%	0.00	0.00	0.00	0.00
Dryer - elec. ignition	30	20	7	175	463	23%	0.00	0.00	0.00	0.00
Dryer - auto terminatn	4	3	1	28	491	25%	0.00	0.00	0.00	0.00
POTENTIAL UTILITY MEASURES										
High spin-speed washer	13	9	9	237	728	37%	4.50	5.63	6.75	3.38

Notes:
*Measures which will be automatically adopted at time of equipment replacement due to NAECA standards.
**Measures to be implemented at time of equipment replacement.

See preceeding text for explanation of each column in this table.

In examining the CSG figures, it is useful to compare these to the marginal and retail cost of gas. As discussed in Chapter 1, the marginal cost of gas has not been firmly established in New York State; however, recent filings by New York gas utilities give some indications of what the marginal cost may be. Based on the discussion in Chapter 1, we estimate that when marginal costs are firmly established, for purposes of residential DSM analysis (meaning winter-only or year-round efficiency measures), marginal costs are likely to be in the $2.50 to 4.00/DTh range. Hence, in the discussion below, these two values are used to indicate the likely range of the economic savings potential from the total resource perspective.

From the consumer perspective, measures are likely to be cost-effective when the CSG is less than the retail price of gas. As discussed in Chapter 1, residential retail gas costs for LILCo, BUG, and NFG are presently approximately $6.50, $8.50, and $6.00/Dth respectively (rounded to the nearest $0.50). In the discussion below, these values are used to indicate the likely economic savings potential from the consumer perspective.

<u>Results by Measure</u>

The savings, cost, and CSG for individual measures vary significantly by prototype and utility; however, the tables show a number of patterns. First, several measures generally have low CSG (less than approximately $2.50/DTh) and are likely to be cost-effective in most applications. The measures in this category include:

- Equipment efficiency upgrades at the time of replacement, up to medium levels of efficiency (e.g. heating system AFUE's in the 80's and water heater EF's in the 60's);

- Clock thermostats;

- Infiltration reduction in all but the tightest homes;

- Low-flow showerheads and faucet aerators;

- Water heater tank and pipe insulation;

- Mainline steam vents in multifamily buildings.

At the other extreme, there are a number of measures with CSG's generally above the retail price of gas (e.g. approximately $7.00/DTh) that are unlikely to be cost-effective in most situations. These measures include:

- Duct insulation (expensive to install as a retrofit);

- Basement ceiling insulation;

- Installing new heating and hot water systems as retrofits (except in some multifamily buildings);

- Storm windows;

- Adding additional insulation to insulated attics (e.g. those already with R-11 or more downstate or R-19 or more upstate);

- Instantaneous water heaters and engine-driven heat pumps (in both cases either efficiency improvements or price cuts are needed to improve the CSG); and

- Zoning warm-air distribution systems.

Measures not listed above generally fall in the mid-range of CSG's and the cost-effectiveness of these measures is likely to depend on the particular application.

To achieve energy savings in a home of 30 percent or more will require packages of many measures, each of which contributes a small amount of savings to the overall package. However, a few measures individually provide a large amount of savings (at least 5 percent savings for a building type). Among the measures with large savings are:

- Replacement heating systems;
- Insulating uninsulated attics;
- Wall insulation (both wood-frame and brick);
- Mainline air vents (for steam systems).

Results by Measure Type

As discussed previously, potential savings fall into several categories -- savings from measures mandated under Federal law, and savings that are potential targets for utility DSM programs. This latter category can be further divided into savings from measures that are implemented at time of equipment replacement and savings from measures that are implemented on a retrofit basis. Table 2-43 divides the potential savings, for the 50 percent program cost scenario, into these three categories.[6] As can be seen, mandated measures will reduce residential gas use by approximately 10 percent, other cost-effective replacement measures can reduce residential gas use by an additional 4 to 14 percent, and retrofit measures can save an additional 10 to 32 percent (the broad ranges are due to differences in assumed avoided gas costs and differences between utilities). Thus, while the savings potential is quite large in each of the three service territories, these savings cannot be quickly achieved. A substantial portion of the savings (approximately one-third) are due to measures that are cost-effective only when existing

[6] Data in Table 2-43, as well as many of the subsequent tables and figures, were calculated by combining the "cumulative savings in all homes" figures from Tables 2-26 through 2-42 in a single database for each utility and dividing cumulative energy savings at each CSG breakpoint by the appropriate existing energy use figure from Tables 2-10 through 2-13.

equipment is replaced. It will take several decades (e.g., approximately 2020) before all of these savings opportunities are available.

Table 2-43. Economic Savings Potential by Utility from Replacement and Retrofit Measures as a Percent of Residential Gas Sales (50% Program Cost Case).

	Mandated Measures	Additional Replacement Measures			Retrofit Measures		
		$2.50/ DTh	$4.00/ DTh	Retail Cost	$2.50/ DTh	$4.00/ DTh	Retail Cost
LILCo	9%	4%	6%	8%	10%	23%	29%
BUG	11%	5%	8%	14%	14%	23%	>26%
NFG	10%	4%	6%	7%	12%	26%	32%

Note: Retail costs are $6.50/DTh for LILCo, $8.50 for BUG, and $6.00 for NFG. ">" sign indicates that calibration point was reached before retail gas cost was reached.

Results by Building Type

To examine results by building type it is useful to simplify the data in Tables 2-26 through 2-42 into one table. Thus, in Table 2-44 the economic savings potential for each building type and each utility are reported for marginal gas costs of $2.50 and 4.00, and average retail gas costs of $6.00-$8.50/DTh. All data in Table 2-44 assume program costs of 50 percent of measure costs.

As table 2-44 shows, the highest savings are possible in the ranch and brownstone, with the lowest savings in the high-rise apartment and wood-frame townhouse. The colonial and low-rise apartment fall in the mid-range of savings potentials.

Savings potential is high in the ranch due to large savings from attic insulation compared to other building types; the ranch loses a larger proportion of heat through the attic. Also, since most ducts and pipes run through the basement, a larger proportion of these can be insulated.

Table 2-44. Summary of Economic Savings Potential as a Percent of Gas Use for Each Building Type (50% Program Cost Case).

ALL MEASURES

	LILCo			BUG			NFG		
Marginal gas cost/DTh	$2.50	$4.00	$6.50	$2.50	$4.00	$8.50	$2.50	$4.00	$6.00
Building Type*									
Colonial	22%	36%	42%	25%	35%	42%	23%	33%	44%
Ranch	27%	43%	53%	30%	41%	56%	28%	45%	50%
Wood-frame	15%	30%	41%	16%	29%	45%	12%	31%	44%
Brownstone	n/a	n/a	n/a	31%	45%	55%	n/a	n/a	n/a
Low-rise apartment	27%	35%	>44%	26%	33%	>44%	23%	31%	48%
High-rise apartment	n/a	n/a	n/a	17%	26%	>26%	n/a	n/a	n/a
Ranges and dryers**	25%	25%	25%	25%	25%	26%	25%	25%	25%

UTILITY MEASURES ONLY

	LILCo			BUG			NFG		
Marginal gas cost/DTh	$2.50	$4.00	$6.50	$2.50	$4.00	$8.50	$2.50	$4.00	$6.00
Building Type*									
Colonial	13%	27%	33%	14%	24%	31%	13%	23%	34%
Ranch	17%	33%	43%	18%	29%	44%	18%	35%	40%
Wood-frame	6%	21%	32%	5%	18%	34%	3%	22%	35%
Brownstone	n/a	n/a	n/a	20%	34%	44%	n/a	n/a	n/a
Low-rise apartment	18%	26%	>35%	17%	24%	>35%	15%	23%	40%
High-rise apartment	n/a	n/a	n/a	12%	21%	>21%	n/a	n/a	n/a
Ranges and dryers**	0%	0%	0%	0%	0%	1%	0%	0%	0%

Notes:
** Savings as a percentage of space and water heating gas usage.*
*** Savings as a percentage of cooking and drying gas usage.*
> sign indicates that the calibration point was reached before the retail gas price.

Savings potential is high in brownstones because most use steam heat, the least efficient type of system examined in this study (baseline distribution efficiency of 61 percent compared to 79 percent for warm-air and 94 percent for hot water—Andrews and Modera 1991). Inefficient heating systems use more gas, increasing opportunities for savings. Also, the masonry construction results in high heat loss through the walls, with higher heating needs than a similarly configured woodframe building. As a result, steam-system upgrades and installing R-4 foam insulation in the walls during building renovation produce dramatic savings.

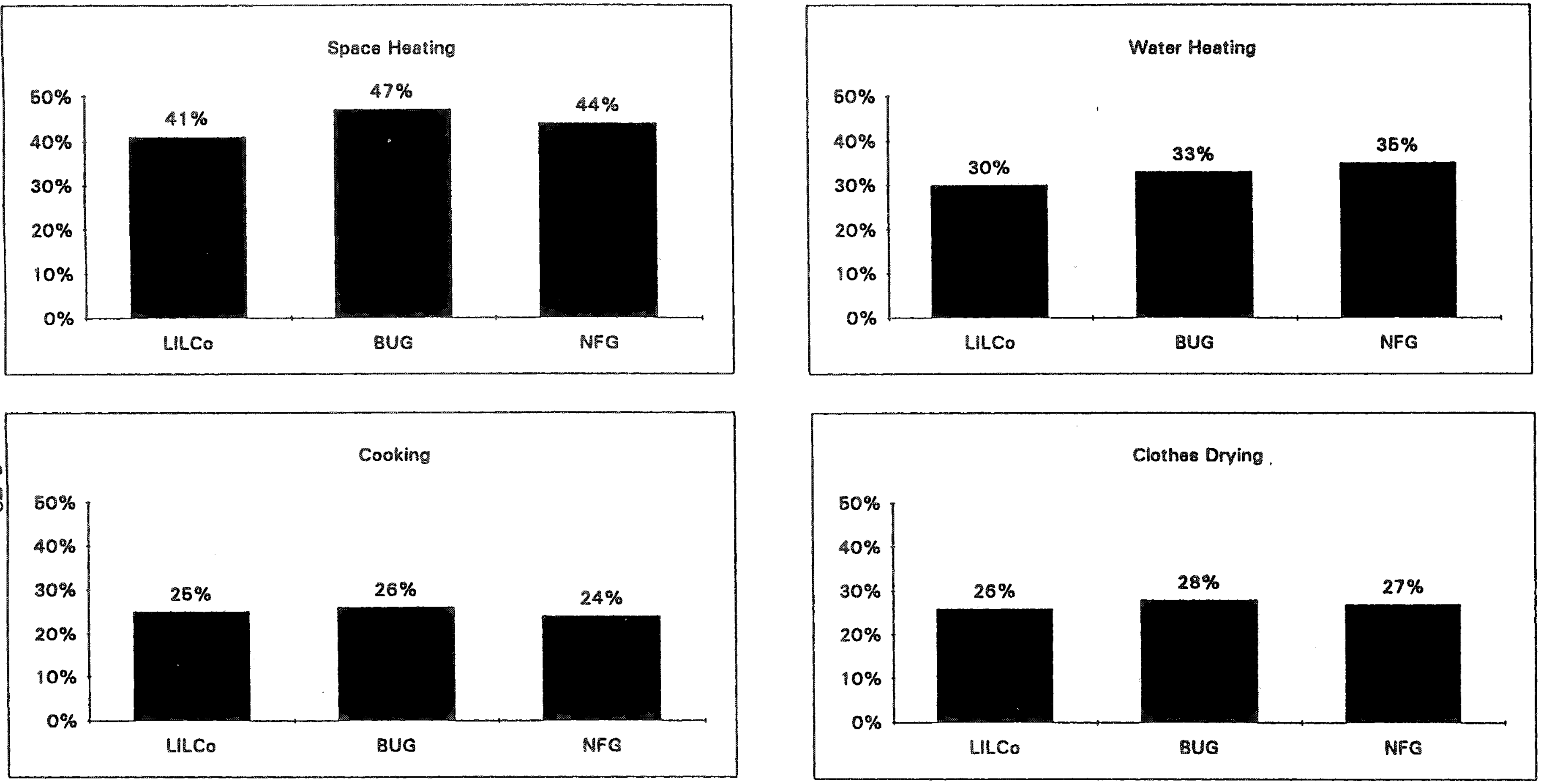
Savings are comparatively low in the high-rise apartment because relative to other building types, a smaller portion of energy use is for space heating, the end-use with the largest savings opportunities. Also, many of the measures that are appropriate for other building types are not appropriate for high-rise buildings. Finally, some measures which are cost-effective for other building types are not cost-effective for the high-rise because the lower energy use of the high-rise means that there are fewer DTh of savings upon which to spread fixed measure costs.

Savings in the woodframe townhouse are relatively low because many measures that are cost-effective in the detached single-family homes are not cost-effective in the townhouse. For many measures such as more efficient heating systems, costs are essentially the same for the single-family detached and townhouse homes, but savings are lower in the townhouse due to the sharing of walls with neighboring units, resulting in less energy use.

Results by End-Use

Savings potentials vary by end use. Opportunities for cost-effective savings are greatest for space heating. At $4.00/DTh, the economic potential for space heating savings (assuming 50 percent program costs) are 41 to 47 percent of present space heating energy use. At the same marginal gas cost, cost-effective measures can reduce water heating energy use by 30 to 35 percent. For cooking and clothes drying, measures costing $4.00/DTh or less can reduce present energy use by 24 to 28 percent. These findings are illustrated in Figure 2-3.

Figure 2-3. Economic Savings Potential by End-Use (% reduction in end-use consumption at marginal gas cost of $4/DTh -- 50% program cost case).



Savings by Avoided Gas Cost

The economic savings potential varies substantially as a function of different avoided gas costs. As shown in Table 2-45, at an avoided gas cost of $2.50 per DTh, the economic savings potential from utility measures (non-mandated measures) ranges from 12 to 25 percent, depending on the utility and the sensitivity case. At $4.00 per DTh, the economic savings potential increases by 10 to 16 percent of current gas use, and at retail gas costs, the economic savings potential increases by an additional 7 to 16 percent of current gas use. As noted previously, when mandated measures are also included, the economic savings potential is appoximately 10 percentage points higher. From the consumer perspective (retail gas prices and no program costs), the economic savings potential is more than 40 percent from utility measures and more than 50 percent from all measures.

Results by Sensitivity Case

Savings potentials also vary substantially from sensitivity case to sensitivity case. These results are also summarized in Table 2-45. Assuming avoided gas costs of $2.50 per DTh, the economic savings potential from utility measures is 19-25 percent at 25 percent program costs, 14-19 percent at 50 percent program costs, and 12-13 percent at 75 percent program costs. Total savings potential (including mandated measures) is approximately 10 percentage points higher for each of the sensitivity cases. Thus, the economic savings potential is approximately 6 percentage points lower at 50 percent program costs than at 25 percent program costs, and approximately 4 percentage points lower at 75 percent program costs than at 50 percent program costs. The percentage point differences are similar at $4.00 per DTh and at retail gas costs, and thus the choice of sensitivity case is much more important at low avoided gas costs than at higher costs.

Table 2-45. Economic Savings Potential by Utility for the Different Sensitivity Cases as a Percent of Residential Gas Sales.

ALL MEASURES

	LILCo			BUG			NFG		
Marginal cost/DTh	**$2.50**	**$4.00**	**$6.50**	**$2.50**	**$4.00**	**$8.50**	**$2.50**	**$4.00**	**$6.00**
Sensitivity Case									
No Program Costs	n/a	n/a	>54%	n/a	n/a	>51%	n/a	n/a	>51%
25% Program Costs	28%	42%	53%	33%	48%	>51%	35%	45%	>51%
50% Program Costs	23%	38%	46%	30%	42%	>51%	26%	42%	49%
75% Program Costs	21%	35%	44%	23%	37%	>51%	23%	37%	45%

UTILITY MEASURES ONLY

	LILCo			BUG			NFG		
Marginal cost/DTh	**$2.50**	**$4.00**	**$6.50**	**$2.50**	**$4.00**	**$8.50**	**$2.50**	**$4.00**	**$6.00**
Sensitivity Case									
No Program Costs	n/a	n/a	>44%	n/a	n/a	>41%	n/a	n/a	>41%
25% Program Costs	19%	33%	44%	22%	37%	>41%	25%	35%	>41%
50% Program Costs	14%	29%	37%	19%	31%	>41%	16%	32%	39%
75% Program Costs	12%	26%	35%	12%	26%	>41%	13%	27%	35%

Note: ">" indicates that calibration point was reached before retail gas cost was reached.

Results by Utility

Table 2-45 also indicates that economic savings potentials are generally similar for the three utilities. For most of the sensitivity cases and avoided gas costs examined, results vary by only a few percentage points from utility to utility.

Overall results by utility can also be summarized in a conservation supply curve, that graphs cumulative savings potential by utility as a function of cost of conserved gas (as shown in Figures 2-4 through 2-6). In these graphs the four sensitivity cases are plotted. These graphs, together with the results summarized in Table 2-45 illustrate an important point: even in a worst case scenario of $2.50 per DTh avoided gas costs and 75 percent program costs, the economic savings potential is still 21-23 percent from all measures and 12-13 percent from potential utility measures.

Savings at Time of System Peak

The analysis discussed above is based entirely on annual energy savings. Annual energy savings are of interest to utilities because every DTh saved means one less DTh that must be purchased by the utility. However, annual energy savings tell only part of the story. Gas utilities are particularly interested in gas consumption and savings at the time of maximum demand, because pipelines and other system components must be sized for the peak demand, not the annual demand. Also, the price of gas to the utility is higher during peak periods than during other periods. In New York State, the peak demand for gas occurs on the coldest days of the year, when gas used for space heating is at its highest. Thus, gas utilities are very interested in knowing which efficiency measures save energy during peak periods, and which primarily save energy during off-peak periods.

The analysis reported here did not examine the issue of peak savings. Still, based on an understanding of the mechanisms by which specific measures save energy, it is possible to make preliminary characterizations of the possible peak impacts of different measures by classifying the measures into four peak-reduction categories: (1) measures whose savings are proportional

Figure 2-4. Supply Curve of Saved Gas, Long Island Lighting, Residential Sector

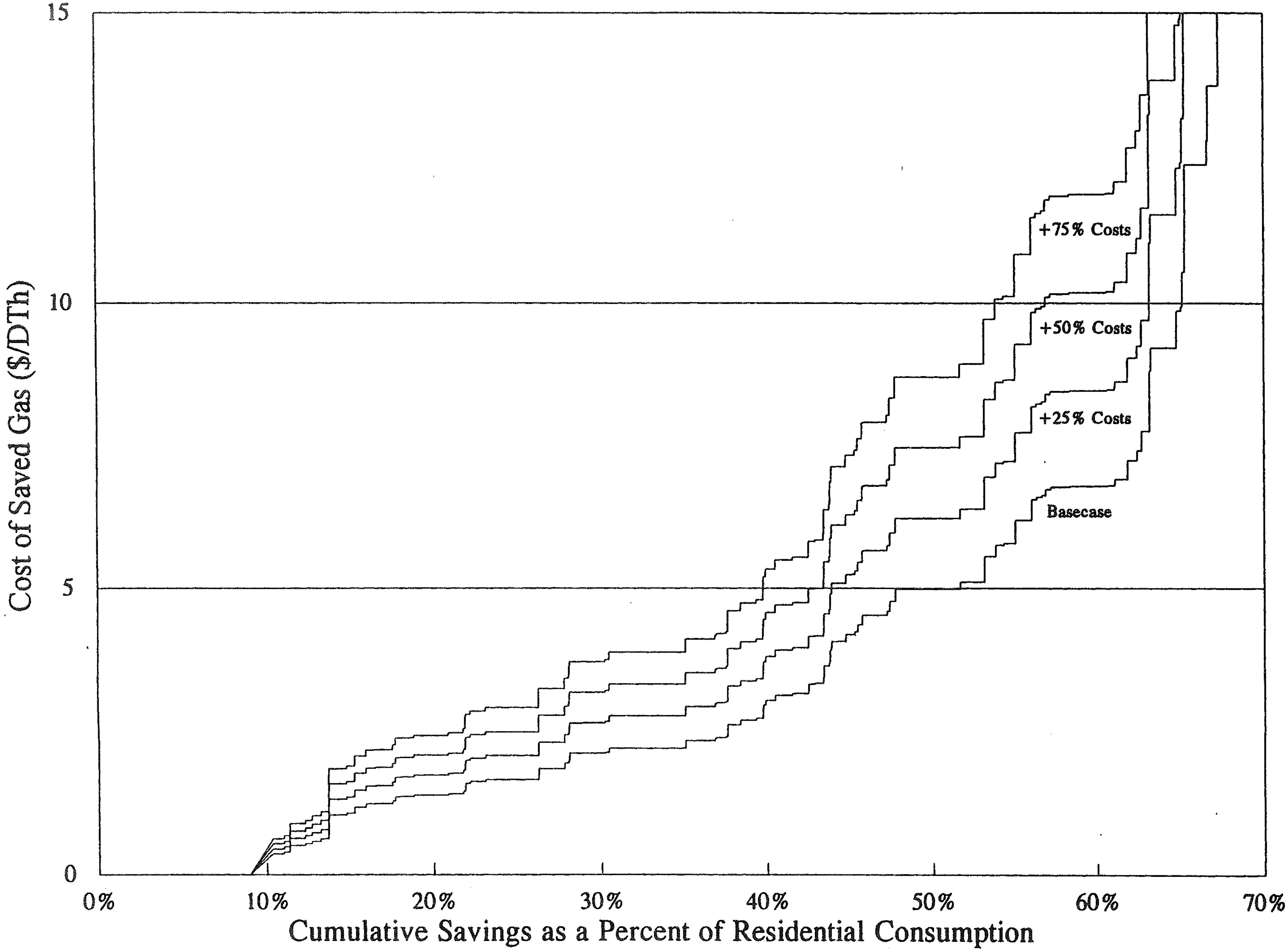


Figure 2-5. Supply Curve of Saved Gas, Brooklyn Union Gas, Residential Sector

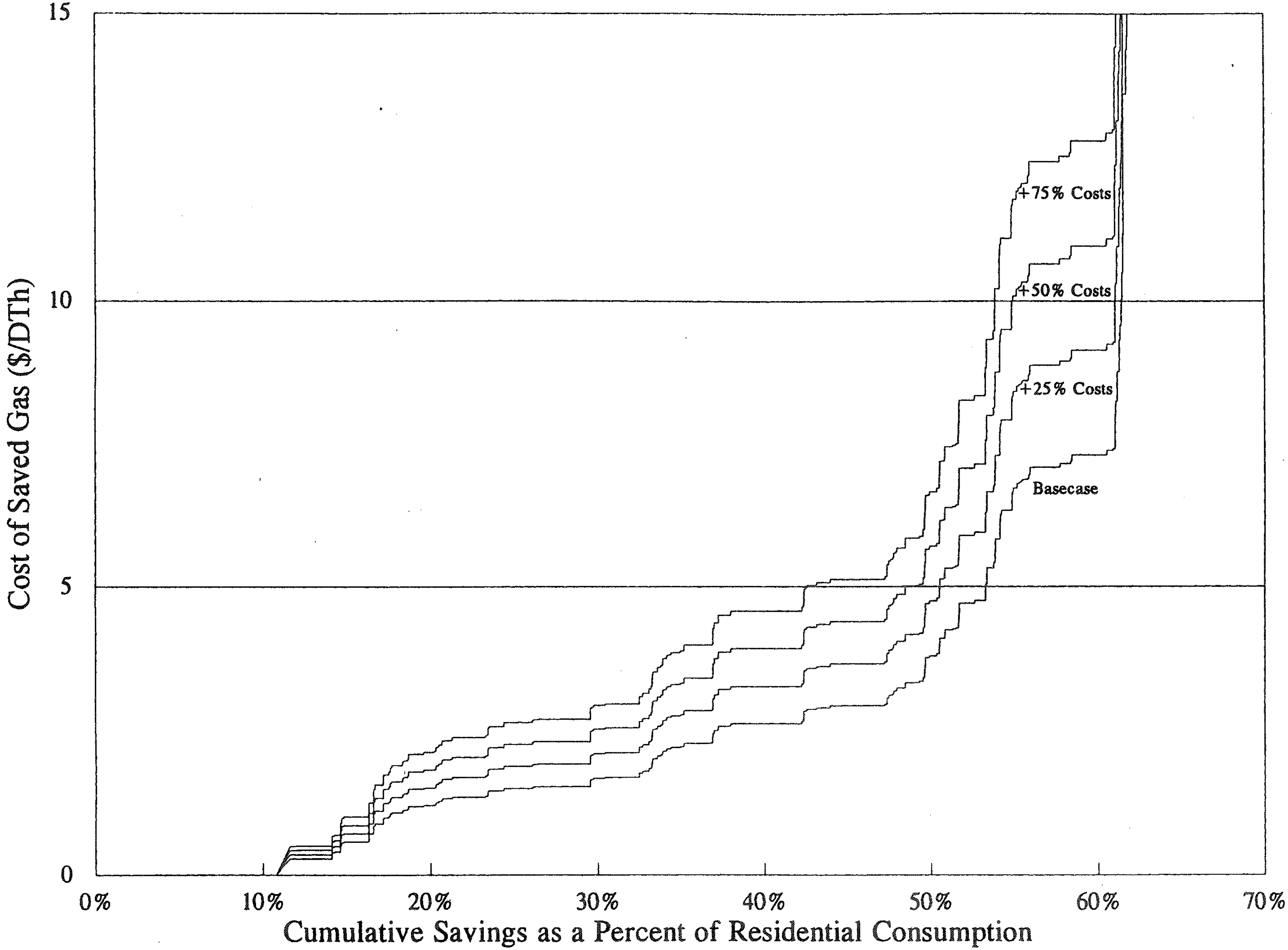
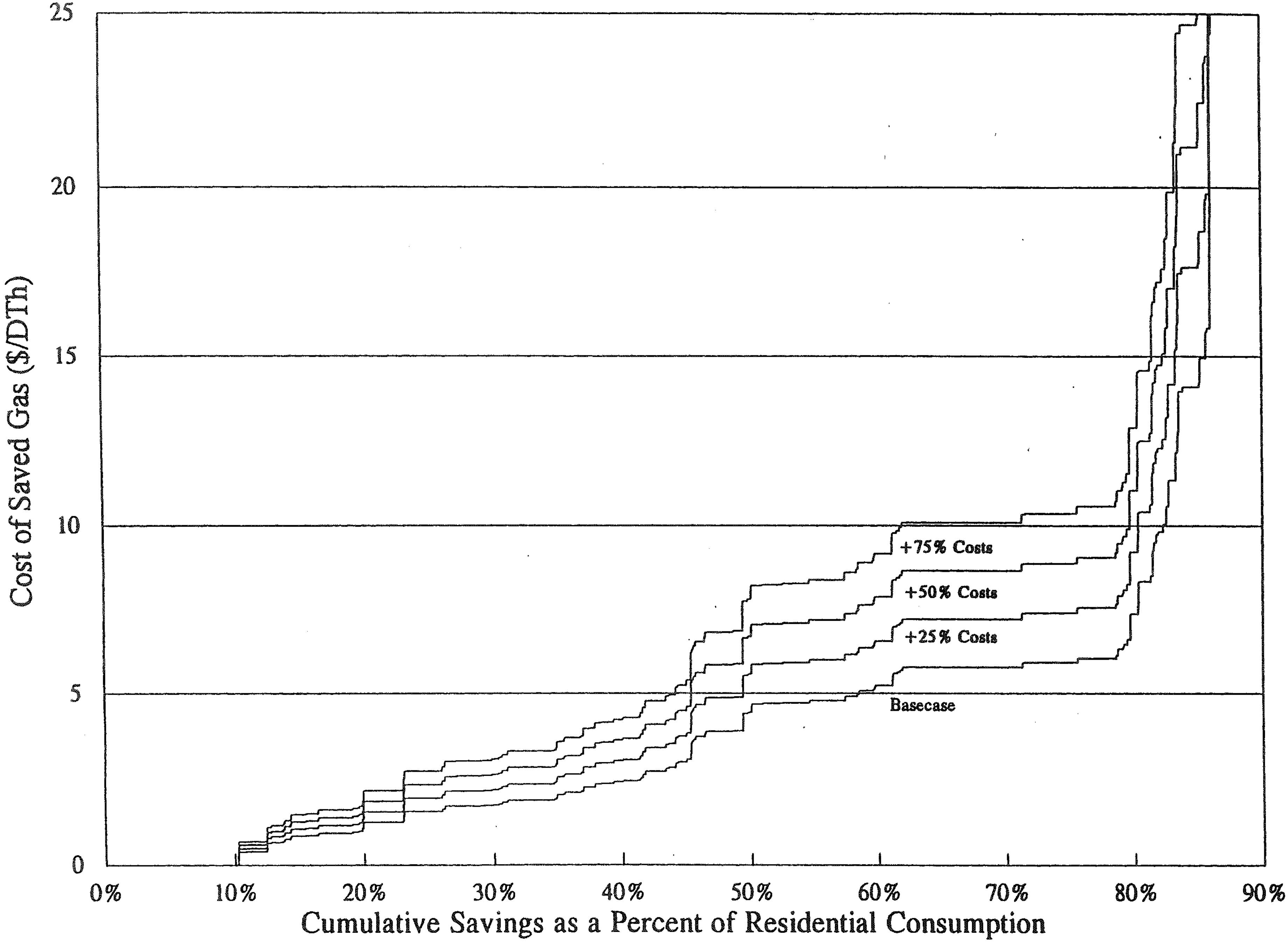


Figure 2-6. Supply Curve of Saved Gas, National Fuel Gas, Residential Sector.



to the outdoor temperature, and hence are likely to be important for reducing peak demand; (2) measures which probably save the same amount of energy during peak and off-peak periods; (3) measures which probably save less energy during peak periods than off-peak periods; and (4) measures whose relative impacts during peak- and off-peak periods are unknown.

The first category of measures covers most building shell measures (e.g. insulation, infiltration reduction, and improved efficiency windows), new high efficiency heating systems, and most distribution system measures such as duct sealing and pipe and duct insulation. The former reduce heat loss from the home, and heat loss is directly proportional to the indoor-outdoor temperature difference. Savings from the other measures are proportional to the demand for heat, which is highest on peak days.

The second category of measures probably includes most non-space heating measures such as water heating, cooking and clothes drying measures. Demand for these energy services tend to be fairly constant throughout the year. Some small increases in water heating and cooking energy can be expected on cold days, but these effects may well be modest compared to the dramatic increase in space heating energy use on the coldest days of the year.

The third category of measures includes controls and retrofits that are specifically designed to reduce energy use during off-peak periods. Examples include boiler water temperature modulation, modulating furnaces, and derating a furnace.

The final category of measures includes measures which achieve energy savings in complex ways, and whose performance under peak conditions needs to be monitored. Examples include gas engine heat pumps (whose performance is likely to degrade at low temperatures), setting back the main thermostat (to what extent do residents raise the set-point on cold days?), zoning of systems (will homeowners be less likely to let the temperature drop in one zone on cold days?), and thermostatic steam valves (will homeowners reset them on cold days?).

Comparison to Field Studies

For this study to have practical meaning, the results of the analysis must compare favorably with the savings that have been achieved from installing packages of measures in homes. In this section the results of this study are compared to the results of two field studies—a study on small single-family homes conducted in the NFG territory in 1988-1989, and on-going studies on steam-heated multifamily buildings conducted by the Center for Neighborhood Technology in Chicago.

The NFG study was conducted by Oak Ridge National Laboratory (Ternes et al. 1991). In the study, 36 homes received energy audits followed by installation of cost-effective efficiency improvements. The energy audits estimated the CSG of 15 efficiency measures on a site-specific basis. Measures with a CSG of $5.79/DTh or less were generally implemented. Pre- and post-retrofit fuel use data were examined for participating homes and a control group of similar non-participating homes. Gas savings were estimated based on a statistical analysis of the data. The retrofit packages generally reduced space heating gas use by 25 percent and water heating gas use by only 2 percent. Combined savings amounted to 20 percent of energy used for space and water heating.

These savings are considerably lower than our estimate of the savings that can be achieved in a typical ranch home, the type most similar to those in the NFG study. At a CSG of $5.79/DTh or less, we estimate an economic savings potential of 63 percent, including both mandated and utility measures. However, of this potential, savings of 21 percent are attributable to measures that are only cost-effective when equipment is replaced and hence would not pass the Oak Ridge screening criteria for retrofit installation. Of the 42 percent savings remaining, some 15 percentage points are due to measures included in our study that were not included in the field study including clock thermostats; hydronic and steam system pipe insulation; furnace derating; duct sealing; boiler temperature modulation; zoning hydronic heating systems; thermostatic steam valves; furnace fan and thermostat adjustments; low-flow showerheads and faucet aerators; and a horizontal-axis clothes washer. When these measures are subtracted from our estimates, the savings potential at $5.79/DTh is reduced to 27 percent of gas used for space and water heating (see Table 2-46).

While this difference is much less significant, it is still higher than we would like. Examination of the Oak Ridge report (Ternes et al. 1991) provides a likely explanation for the difference. Our savings included approximately 9 percentage points of savings from infiltration reduction. This is consistent with a Colorado field study that found savings averaging 8.9 percent from infiltration reduction procedures (Proctor and deKiefer 1988). However, homes in the NFG study achieved an estimated 2 percentage points of savings from infiltration reduction. These savings were substantially lower than had been predicted during the energy audits that predicted savings averaging approximately 6 percentage points.

There are two possible explanations for the difference between our estimates and the NFG results: homes in the NFG study were tighter than we assume in our study and/or the quality or quantity of the infiltration reduction work was more limited in the NFG study. With regard to the first issue, the Oak Ridge data and our estimates are not easily compared because of differences in measurement technique; the Oak Ridge data are reported in terms of cfm at 50 Pascals of pressure using a blower door and our estimates are in terms of air-changes per hour under unpressurized conditions.

With regard to the second issue, the NFG study limited the amount of infiltration reduction work based on a minimum acceptable benefit-cost ratio of 2.0. Furthermore, due to a minimum ventilation guideline (cfm/house), work was stopped in many houses before 0.35 air-changes/hour were achieved (Ternes 1992). Thus the infiltration reduction work was less comprehensive than we modeled in our analysis. In addition, the NFG study used "inexperienced infiltration reduction crews" (p. 77), who, although they received training, were not proficient. The Oak Ridge researchers note (p. 75) that "although [low savings from infiltration reduction work] could indicate that few leakage sites existed in the houses that could be sealed cost effectively, [these results] more likely indicate a lack of crew proficiency." In fact, in the Proctor and deKiefer study cited, the success of the program in saving energy is attributed to extensive, on-going quality control.

Table 2-46. Analysis of Upstate Ranch Savings Potential for All Measures (Mandated and Utility Measures) and Subset of Measures Included in ORNL Study.

	Cumulative Savings as % of Ranch Gas Use	
Measure	All Measures	ORNL Measures
Replace furnace - 78% AFUE *	8%	0%
Replace hydronic boiler - 80% *	9%	0
Replace steam boiler - 75% *	9%	0
Replace water htr. - .54 EF *	10%	0
Setback T-stat - 10 deg. **	12%	0
Setback T-stat - 5 deg. **	14%	0
DHW pipe insulation	15%	1
Infiltration - 1->.35	16%	2
Furnace - 85% AFUE *	20%	2
Infiltration - .75->.35	24%	6
Steam boiler - 82% *	24%	6
Pipe insul. (steam) **	24%	6
Attic insul. - R0->R30	28%	10
Tank wrap - R-6	30%	12
Derate furnace **	33%	12
Low-flow shower & faucet **	34%	12
Basement wall insul. - R11	40%	18
Boiler temp. modulation **	40%	18
Seal ducts **	41%	18
Two zones - hydronic **	42%	18
Infiltration - .5->.35	43%	19
Storage wtr. htr. - .65 EF *	45%	19
Attic insul. - R5->R30	46%	20
Pipe insul. (hydronic) **	46%	20
Thermostatic steam valves **	47%	20
Furnace fan/t-stat adj. **	50%	20
Horiz-axis wash'g mach. **	51%	20
Basement ceiling. insul. - R28	52%	21
Furnace - 91% AFUE *	55%	21
Wall insul. - R13 cell.	59%	25
Modulating furnace *	61%	25
Attic insul. - R11->R30	63%	27
Hydronic boiler - 84% AFUE *	63%	27

Notes:
* Measures to be implemented when equipment is replaced.
** Measures not included in the Oak Ridge study.

Thus, if savings from the NFG study are increased 7 percentage points to account for differences in savings in infiltration reduction work between their study and the Colorado work, the discrepancy between the NFG field study (20 percent + 7 percent = 27 percent savings), and our estimate (27 percent) disappear.

The Center for Neighborhood Technology (CNT) has been providing programs to save energy in steam-heated multifamily buildings for nearly ten years. Based on this work, including numerous measurements of the actual energy savings achieved from retrofit measures, they estimate that energy use in a typical steam-heated multifamily building can be reduced by 29 percent (Katarkis 1989). These savings are achieved at a measure cost (excluding program costs) of approximately $3.50/DTh or less (Biederman and Katrakis 1989). If a cost-effectiveness threshold of 3.50/DTh is assumed, we estimate an economic savings potential of approximately 28 percent in the high-rise apartment. Thus, when program costs are excluded, the CNT field work indicates that our savings estimates are reasonable.[7]

Thus, results from these two field studies indicate that the results reported in this study appear reasonable. However, additional field studies on comprehensive efficiency packages would be useful for further corroboration.

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[7] The comparison becomes much more difficult to make when program costs are included. In recent years CNT has operated their program under contract to People's Gas Light and Coke, the local gas utility. The CNT program has had a low participation rate and high indirect costs per customer served, resulting in a total CSG to the utility substantially in excess of marginal gas costs. Based on a previous program CNT ran that had much lower administrative costs, and based on plans for improved program marketing, CNT believes the program could be restructured to make it cost-effective to the utility. The utility disagrees, and thus the program was canceled (Katrakis 1992).

Chapter 3

RESIDENTIAL FUEL-SWITCHING

INTRODUCTION

An issue that is being extensively debated throughout North America is whether fuel-switching, converting customers from one fuel source to another, should be included among utility DSM offerings. In this chapter the economics of switching residential customers from electricity to natural gas are examined.[1] In all states and provinces, the starting point for fuel-switching discussions has been to identify situations where fuel-switching is likely to be cost-effective from the societal point of view, meaning, are the benefits of fuel-switching to society worth the costs. These analyses can help identify the situations that are the most likely candidates for fuel-switching and also indicate the magnitude of the potential fuel-switching resource. When the magnitude has been identified, discussions can begin if this resource is worth pursuing, and if so, the best approaches to take.

An objective analysis of the economics of fuel-switching is useful because comparative analyses of the economics of different fuels prepared by gas and electric utilities tend to be biased in favor of the fuel each company sells. To note just one example, an analysis prepared by a New England electric utility found that the annual cost of heating with gas or electric resistance heat was equal. However, a close examination of the data, and telephone calls to the utility, revealed that the electric heated home used in the comparison was heavily insulated, according to current building code requirements, but the gas heated home used in the comparison was uninsulated, based on pre-World War II construction practices.

[1] As is discussed in Chapter 1, switching from electricity to other fuels or switching from other fuels to natural gas is beyond the scope of this study.

METHODOLOGY

For this analysis, the same six prototype buildings used in Chapter 2 were employed. These are a single-family colonial, single-family ranch, wood frame townhouse, brownstone townhouse, low-rise apartment, and high-rise apartment. Building parameters are the same as in Chapter 2 except that insulation levels were increased and infiltration levels decreased consistent with typical construction practices for electric-heated dwellings. The air infiltration assumptions were derived from NYSERDA 1989. The other assumptions were based on LILCo energy audit data (LILCo 1991) plus the professional judgement of the project team which led us to increase attic insulation levels upstate. Based on these sources, for the fuel-switching analysis, the following insulation and air infiltration values were assumed:

Parameter	Value	Units
Attic insulation		
Uptate	19	R-value
Downstate	11	R-value
Wall insulation		
Wood frame buildings	8	R-value
Masonry buildings	0	R-value
Windows (double-hung, wood frame)	0.49	U-value
Air infiltration	0.51	ACH

For each prototype, up to seven fuel-switching options were modeled:

1. Electric baseboard heat converted to a gas hydronic boiler with baseboard distribution system;

2. Electric baseboard heat converted to a gas warm-air furnace with a warm-air duct distribution system;

3. A supplemental gas heating coil added to an electric heat pump to displace the electric resistance backup heating coils;

4. Electric heat pump converted to a gas furnace (heat pump remains in place for air conditioning);

5. Electric resistance stand-alone water heater converted to a gas stand-alone water heater;

6. Electric resistance stand-alone water heater converted to an insulated storage tank connected to a gas boiler (for homes that already obtain space heat from a gas boiler); and

7. Electric resistance baseboard heat and stand-alone water heater converted to gas boiler combination system providing both space heat and hot water (using an insulated storage tank as with option #6);

The gas furnace was not examined for the brownstone or the low- and high-rise apartments because in existing buildings like these, it will be difficult to install duct systems. In these situations, a viable option may be to install one or more gas space heaters in heavily used rooms. The electric system is left in place to provide supplemental heat. Gas space heaters can also be used as an inexpensive conversion option in some, but not all, single-family homes. However, the economics and practicality of this approach is highly site-specific and not easy to model for "average" conditions. As a result, gas space heaters were not included in the analysis.

In examining the different types of equipment, typical equipment efficiencies were assumed, not state-of-the-art models. Thus, the gas furnace and boiler options assumed 85% AFUE and not the higher efficiencies possible with condensing furnaces and boilers or the soon-to-be-introduced gas engine-driven heat pump (see Chapter 2 for a discussion of these technologies). Similarly, the electric heat pump analyzed has a seasonal COP of 1.65-1.75, not the approximately 2.5 achieved by the best models on the market (Wilson and Morrill 1992).

Heating and hot water loads for each of the prototypes were estimated using REM Design. For the analysis of heat pump and parasitic energy use (e.g. fans and pumps), the Bin method was employed (ASHRAE 1989). Heat pump calculations assumed a seasonal COP of 1.75 downstate, 1.65 upstate. Each prototype was modeled twice, once with New York City weather data for the LILCo and BUG service areas and once with Buffalo weather data for the NFG service area. As in Chapter 2, space heating loads were then converted into energy use by dividing the loads by the heating system and distribution system efficiencies. Hot water energy use was calculated by dividing the loads by the water heater energy factor. In addition, for the electric baseboard cases, loads were reduced by 19 percent to account for the impacts of zoning. The derivation of this factor is described under distribution system measures in Chapter 2.

The cost of each conversion was estimated by Building Science Engineering based on a detailed study previously prepared for the New England Electric System (Kelly 1991). In some cases these costs were revised based on recent manufacturer's equipment pricing data. These costs assume that gas service is already supplied to the building. When gas service is on the street and not in the building, an additional cost will be incurred. These costs are not included in the primary analysis, but are included in a set of sensitivity cases.

In addition to examining fuel-switching for space and water heating, fuel-switching for cooking and clothes drying were also examined. These analyses were based on simple spreadsheet models. The assumptions used and the calculation procedures followed are summarized in Tables 3-11 and 3-12.

In analyzing the cost-effectiveness of fuel-switching, a total resource cost perspective was used which includes all costs of conversion and not only the utility's share of these costs, and bases the value of electricity and gas use on the long-run marginal costs for each fuel. In New York State, electric long-run avoided costs are well established. Hence, for this analysis, recent long-run marginal costs for LILCo, Consolidated Edison (serving the BUG service area) and Niagara Mohawk (serving the NFG service area) were used. The specific values for each utility are summarized in Table 1-1.

Unfortunately, gas long-run marginal costs are not well established in New York State. Accordingly, the analysis sought to estimate the gas long-run avoided cost at which the costs and benefits of conversion are exactly in balance. If gas long-run avoided costs are less than this value, then conversion will be cost-effective. The detailed methodology is described in Appendix B. The approach is illustrated in Table 3-1 which analyzes the economics of fuel-switching for the downstate colonial. This table also describes other key assumptions in the analysis and their source.

In conducting the initial analysis, only the actual costs of conversion were included and not program costs that will be incurred to encourage customers to convert. Program costs were incorporated during the sensitivity stage of the analysis as summarized below.

SENSITIVITY ANALYSES

The administrative costs of fuel switching programs are largely undocumented. To address these data limitations, we assumed a range of possible administrative costs (25 percent, 50 percent, and 75 percent -- the same values as were used in Chapter 2) and incorporated these into the sensitivity analyses. In addition to capturing program costs, the sensitivity analyses also address other uncertainties including uncertainties regarding conversion costs, energy use of the home prior to conversion, and costs of running a gas line to the home. In total, including the basic no-program-cost case, six sensitivity analyses were conducted:

1. Conversion costs plus 25 percent. This analysis captures the impacts of program administrative costs, assuming fuel switching administrative costs are in line with typical U.S. electric DSM administrative costs. This analysis could also apply if conversion costs are higher than we estimated or if energy use in the electric home is less than in the primary analysis and hence the value of conversion is lower.

Table 3-1. Fuel-Switching Analysis for Colonial - Downstate.

	(FIGURES IN MMBTU)	Electric Baseboard to Gas Hydronic	Electric Heat Pump to Gas Furnace	Electric Heat Pump to Gas Backup	Electric Heat Pump to Gas Furnace	Electric DHW to Gas Storage DHW	Electric DHW to Dual Integrated Appliance	Electric Baseboard/DHW to Dual Integrated Appliance	Notes (#'s refer to row numbers)
1	Annual heat load	67.50	67.50	81.33	81.33	67.50	67.50	67.50	From REM Design runs
2	Annual DHW load	22.90	22.90	22.90	22.90	22.90	22.90	22.90	From REM Design runs
3	Heat + DHW load	22.90	22.90	22.90	22.90	22.90	22.90	22.90	1 + 2
4	Elec. equip. AFUE	100%	100%	175%	175%	100%	100%	100%	BSE estimates.
5	Elec. heat delivery effic.	98%	98%	79%	79%	98%	98%	98%	BSE estimates.
6	Elec. DHW energy factor	84%	84%	84%	84%	84%	84%	84%	BSE estimates.
7	On-site elec consumed-heat	68.88	68.88	58.82	58.82	68.88	68.88	68.88	1/(4*5)
8	On-site elec. consumed-DHW	27.26	27.26	27.26	27.26	27.26	27.26	27.26	2/6
9	Elec. saved w/ switch	68.88	68.88	20.06	58.82	27.26	27.26	96.14	Portion of 7 &/or 8 displaced
10	Site-energy use added	13.83	13.83	0.00	0.00	0.00	0.00	0.00	Loss of savings from zoning
11	Gas equip. efficiency	85% AFUE	85% AFUE	85% AFUE	85% AFUE	54% EF	54% EF	85%/54%	Medium efficiency equipment
12	Gas distribution effic.	94%	79%	79%	79%	N/A	N/A	94%	From chapter 3
13	Added gas use w/ switch	101.78	101.78	41.30	121.11	42.41	35.23	120.21	Based on 1,2,9,10,11, & 12.
14	Parasitic elec. - kWh	700	1100	0	1100	0	0	700	Pumps, fans, transformers and gas valves
15	On-site energy w/ switch	104.17	105.54	41.30	124.87	42.41	35.23	122.60	Assumes 3,413 Btu/kWh.
16	Primary energy w/ switch	126.39	140.45	41.30	159.78	42.41	35.23	144.82	Assumes 33% generation/T&D effic.
17	Primary energy: orig systm	288.42	288.42	258.26	258.26	288.42	288.42	288.42	Assumes 33% generation/T&D effic.
18	Primary energy saved	162.03	147.97	216.96	98.48	246.01	253.19	143.60	17-16
19	Cost of conversion	$6,200.00	$8,500.00	$700.00	$1,850.00	$625.00	$700.00	$6,700.00	From Kelly 1991 and manuf/contractor estimates
20	Elec. marginal cost/kWh	$0.0394	$0.0394	$0.0394	$0.0394	$0.0528	$0.0528	$0.0421	Average of LILCo and Con Ed from Chapter 1. Boiler Combo weights heating 80%, DHW 20%.
21	Value of elec. saved	$768	$752	$232	$636	$422	$422	$1,156	Based on 9, 14, and 20.
22	Breakeven cost/Dth	$3.58	$1.95	$4.51	$4.26	$8.99	$10.68	$5.99	(21-payment on 19)/13; 30 year equip life and 5% real discount assumed

Note: Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.

2. Conversion costs plus 50 percent. This analysis captures the impacts of program administrative costs, assuming fuel switching administrative costs are in line with preliminary data on electric DSM programs in New York State. This analysis could also apply if program administrative costs are 25 percent and either conversion costs are higher than we estimated or energy use in the electric home is less than in the primary analysis and hence the value of conversion is lower.

3. Conversion costs plus 75 percent. This analysis captures a worst-case scenario of a combination of high program administrative costs, high conversion costs, and/or overestimated electricity consumption.

4. Conversion costs plus 0 percent. This is the basecase analysis discussed previously. It reflects a best-case scenario of low program administrative costs (25 percent of conversion costs or less) combined with overestimated conversion costs and/or underestimated electricity consumption.

5. Conversion costs plus 50 percent plus cost of running a gas line to the building. As previously noted, the primary analysis assumes that gas service is already supplied in the building. If service is not in the building but in the street, additional costs must be incurred to run the gas line from the street to the home. In the case of single-family homes, LILCo estimates typical service connection costs of $3200 per home (LILCo 1992). This estimate is used for the analysis. This analysis assumes program administrative costs of 50 percent of basic conversion costs; administrative costs are not added to the service connection cost.

   In the case of multifamily homes, the cost of running a gas line from the street to the building are similar to the single-family case, but since these costs are divided among many units, the increment is negligible and not worth considering. However, in some cases, gas service is not on the street but must be extended from nearby. These costs are highly site-specific, but an analysis by Boston Gas estimates that costs of approximately $765 per apartment for a service line plus extension of the gas main are typical (Cherniack, Goodman and Espenhorst 1989). This estimate is used for the multifamily building analyses.

6. Retail electric rates. All of the preceeding analyses are based on marginal electricity costs. To assess the impact of fuel switching from the consumer perspective, this sensitivity case uses average retail electric costs for high use customers as documented by the Edison Electric Institute (1992). These prices are $0.114 per kWh for LILCo, $0.0991 for Con Edison, and $0.091 for Niagara Mohawk. For the downstate analysis, the simple average of the LILCo and Con Edison rates were used ($0.102 per kWh). Program administrative costs are not included in this analysis.

CAVEATS

Fuel-switching economics are subject to a multitude of factors, many of which are highly site-specific. This analysis attempts to capture much of this variation using six different prototypes that vary substantially in size and electricity use, and through six sensitivity cases. Still, there is substantial variation that is not fully captured. This analysis is intended to represent a reasonable range of situations, but the economics of specific situations may vary from our findings. Accordingly, if fuel-switching programs are offered, site-specific economic analyses should be conducted before conversion proceeds. This report indicates the situations when fuel-switching is or is not likely to be cost-effective, but the absolute economics of fuel-switching can only be determined case by case.

Also, as noted previously, this analysis is based on typical gas and electric equipment. An analysis that compares state-of-the-art gas and electric equipment may yield somewhat different results.

RESULTS

The analyses on the economics of fuel swiching are reported in Tables 3-1 through 3-12 which cover all six prototypes downstate, four prototypes upstate (there are few brownstones and high-rise apartments in the NFG service area), as well as the cooking and clothes drying analyses. Breakeven marginal gas costs for all the analyses, under the no-program-cost scenario, are summarized in Table 3-13. Results of the other scenarios are summarized in Tables 3-14 through 3-18.

To interpret these results one needs to have some indication on actual marginal gas costs. While these costs have not been accurately determined for New York State utilities, recent filings by each of the utilities provide some indication where marginal costs are likely to be. These filings were analyzed by the New York State Energy Office, as summarized in Table 1-1. These results imply that for year-round and winter-only end-uses, long-range gas costs are likely to range from $2.50 to 4.00 per decatherm (1 Dth = 10 therms = 1 million BTUs), with long-run costs near the low end of this range for year-round uses such as water heating, cooking, and clothes drying and at the higher end of this range for winter-only uses such as space heating.

Based on these marginal gas costs, and focusing on the analysis with 50 percent program costs, the analysis indicates that throughout the state fuel switching is likely to be very cost effective from the total resource perspective for water heaters (switching from an electric-storage water heater to either a gas-storage water heater or a gas boiler space/water heating system), somewhat cost-effective for dryers at the time of equipment replacement, and not cost-effective for ranges. For homes with electric baseboard heat, conversion to a gas hydronic system will generally be cost-effective from the total resources perspective upstate for detached homes (e.g. the colonial and the ranch) but not attached homes (townhouses and apartments). Detached homes generally use more energy than attached homes, and thus economic savings with fuel switching are greater in detached homes. Conversion of a ranch to a gas furnace will also often be cost-effective (due to easy access to the entire living area through the basement). Downstate, conversion of electric baseboard systems will generally not be cost-effective, with the possible

Table 3-2. Fuel-Switching Analysis for Colonial - Upstate.

	(FIGURES IN MMBTU)	Electric Baseboard to Gas Hydronic	Electric Heat Pump to Gas Furnace	Electric Heat Pump to Gas Backup	Electric Heat Pump to Gas Furnace	Electric DHW to Gas Storage DHW	Electric DHW to Dual Integrated Appliance	Electric Baseboard/DHW to Dual Integrated Appliance
1	Annual heat load	93.40	93.40	112.53	112.53	93.40	93.40	93.40
2	Annual DHW load	22.90	22.90	22.90	22.90	22.90	22.90	22.90
3	Heat + DHW load	116.30	116.30	135.43	135.43	116.30	116.30	116.30
4	Elec. equip. AFUE	100%	100%	165%	165%	100%	100%	100%
5	Elec. heat delivery effic.	98%	98%	79%	79%	98%	98%	98%
6	Elec. DHW energy factor	84%	84%	84%	84%	84%	84%	84%
7	On-site elec. consumed-heat	95.31	95.31	86.33	86.33	95.31	95.31	95.31
8	On-site elec. consumed-DHW	27.26	27.26	27.26	27.26	27.26	27.26	27.26
9	Elec. saved w/ switch	95.31	95.31	38.85	86.33	27.26	27.26	122.57
10	Site-energy use added	19.13	19.13	0.00	0.00	0.00	0.00	0.00
11	Gas equip. efficiency	85% AFUE	85% AFUE	85% AFUE	85% AFUE	54% EF	65% EF	80% EF
12	Gas distribution effic.	94%	79%	79%	79%	N/A	N/A	94%
13	Added gas use w/ switch	140.84	167.58	75.41	167.58	42.41	35.23	154.65
14	Parasitic elec. - kWh	700	1100	0	1100	0	0	700
15	On-site energy w/ switch	143.23	171.33	75.41	171.33	42.41	35.23	157.04
16	Primary energy w/ switch	165.44	206.25	75.41	206.25	42.41	35.23	179.26
17	Primary energy - orig systm	367.70	367.70	340.77	340.77	367.70	367.70	367.70
18	Primary energy saved	202.26	161.46	265.36	134.53	325.30	332.47	188.44
19	Cost of conversion	$6,200.00	$8,500.00	$700.00	$1,850.00	$625.00	$700.00	$6,700.00
20	Elec. marginal cost/kWh	$0.0514	$0.0514	$0.0514	$0.0514	$0.0530	$0.0530	$0.0517
21	Value of elec. saved	$1,399	$1,379	$585	$1,244	$423	$423	$1,820
22	Breakeven cost/Dth	$7.07	$4.93	$7.15	$6.70	$9.02	$10.72	$8.95

Note: Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.

Table 3-3. Fuel-Switching Analysis for Ranch - Downstate.

	(FIGURES IN MMBTU)	Electric Baseboard to Gas Hydronic	Electric Heat Pump to Gas Furnace	Electric Heat Pump to Gas Backup	Electric Heat Pump to Gas Furnace	Electric DHW to Gas Staged DHW	Electric DHW to Dual Integrated Appliance	Electric Baseboard/DHW to Dual Integrated Appliance
1	Annual heat load	68.00	68.00	81.93	81.93	68.00	68.00	68.00
2	Annual DHW load	22.90	22.90	22.90	22.90	22.90	22.90	22.90
3	Heat+DHW load	90.90	90.90	104.83	104.83	90.90	90.90	90.90
4	Elec. equip. AFUE	100%	100%	175%	175%	100%	100%	100%
5	Elec. heat delivery effic.	98%	98%	79%	79%	98%	98%	98%
6	Elec. DHW energy factor	84%	84%	84%	84%	84%	84%	84%
7	On-site elec consumed-heat	69.39	69.39	59.26	59.26	69.39	69.39	69.39
8	On-site elec. consumed-DHW	27.26	27.26	27.26	27.26	27.26	27.26	27.26
9	Elec. saved w/ switch	69.39	69.39	20.21	59.26	27.26	27.26	96.65
10	Site-energy use added	15.72	31.88	25.26	37.12	12.92	12.92	30.86
11	Gas equip. efficiency	85% AFUE	85% AFUE	85% AFUE	85% AFUE	54% EF	54% EF	85%/54%
12	Gas distribution effic.	94%	79%	79%	79%	N/A	N/A	94%
13	Added gas use w/ switch	103.63	128.62	25.26	96.39	40.19	40.19	127.51
14	Parasitic elec. - kWh	700	1100	0	1100	0	0	700
15	On-site energy w/ switch	106.02	132.37	91.57	127.40	109.57	109.57	129.90
16	Primary energy w/ switch	192.58	221.67	224.20	189.43	248.35	109.57	129.90
17	Primary energy - orig systm	289.95	289.95	259.57	259.57	289.95	289.95	289.95
18	Primary energy saved	97.37	68.28	35.36	70.13	41.60	180.38	160.05
19	Cost of conversion	$6,100.00	$8,500.00	$700.00	$1,850.00	$625.00	$700.00	$6,700.00
20	Elec. marginal cost/kWh	$0.0394	$0.0394	$0.0394	$0.0394	$0.0528	$0.0528	$0.0421
21	Value of elec. saved	$883.37	$865.37	$266.44	$731.84	$359.44	$359.44	$1,242.81
22	Breakeven cost/Dth	$4.25	$1.93	$8.53	$6.20	$7.81	$7.68	$5.93

Note: Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.

Table 3-4. Fuel-Switching Analysis for Ranch - Upstate.

	(FIGURES IN MMBTU)	Electric Baseboard to Gas Hydronic	Electric Heat Pump to Gas Furnace	Electric Heat Pump to Gas Backup	Electric Heat Pump to Gas Furnace	Electric DHW to Gas Storage DHW	Electric DHW to Dual Integrated Appliance	Electric Baseboard/DHW to Dual Integrated Appliance
1	Annual heat load	90.40	90.40	108.92	108.92	90.40	90.40	90.40
2	Annual DHW load	24.50	24.50	24.50	24.50	24.50	24.50	24.50
3	Heat+DHW load	114.90	114.90	133.42	133.42	114.90	114.90	114.90
4	Elec. equip. AFUE	100%	100%	165%	165%	100%	100%	100%
5	Elec. heat delivery effic.	98%	98%	79%	79%	98%	98%	98%
6	Elec. DHW energy factor	84%	84%	84%	84%	84%	84%	84%
7	On-site elec. consumed-heat	92.24	92.24	83.56	83.56	92.24	92.24	92.24
8	On-site elec. consumed-DHW	29.17	29.17	29.17	29.17	29.17	29.17	29.17
9	Elec. saved w/ switch	92.24	92.24	37.60	83.56	29.17	29.17	121.41
10	Site-energy use added	20.90	42.36	47.00	44.58	2.50	2.50	37.10
11	Gas equip. efficiency	85% AFUE	85% AFUE	85% AFUE	85% AFUE	54% EF	54% EF	85%/54%
12	Gas distribution effic.							
13	Added gas use w/ switch	137.76	170.99	47.00	128.14	31.67	31.67	158.51
14	Parasitic elec. - kWh	700	1100	0	1100	0	0	700
15	On-site energy w/ switch	140.15	174.74	122.12	161.06	123.91	123.91	160.90
16	Primary energy w/ switch	232.43	269.75	272.37	226.90	308.40	123.91	160.90
17	Primary energy - orig systm	364.23	364.23	338.17	338.17	364.23	364.23	364.23
18	Primary energy saved	131.80	94.49	65.80	111.27	55.83	240.32	203.33
19	Cost of conversion	$6,100.00	$8,500.00	$700.00	$1,850.00	$625.00	$700.00	$6,700.00
20	Elec. marginal cost/kWh	$0.0514	$0.0514	$0.0514	$0.0514	$0.0530	$0.0530	$0.0517
21	Value of elec. saved	$1,184.74	$1,166.74	$495.76	$1,052.18	$384.56	$384.56	$1,569.30
22	Breakeven cost/Dth	$5.38	$3.21	$9.47	$7.16	$10.71	$10.54	$6.83

Note: Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.

Table 3-5. Fuel-Switching Analysis for Woodframe Townhouse - Downstate.

	(FIGURES IN MMBTU)	Electric Baseboard to Gas Hydronic	Electric Heat Pump to Gas Furnace	Electric Heat Pump to Gas Backup	Electric Heat Pump to Gas Furnace	Electric DHW to Gas Storage DHW	Electric DHW to Dual Integrated Appliance	Electric Baseboard/DHW to Dual Integrated Appliance
1	Annual heat load	43.60	43.60	52.53	52.53	43.60	43.60	43.60
2	Annual DHW load	18.30	18.30	18.30	18.30	18.30	18.30	18.30
3	Heat+DHW load	61.90	61.90	70.83	70.83	61.90	61.90	61.90
4	Elec. equip. AFUE	100%	100%	175%	175%	100%	100%	100%
5	Elec. heat delivery effic.	98%	98%	79%	79%	98%	98%	98%
6	Elec. DHW energy factor	84%	84%	84%	84%	84%	84%	84%
7	On-site elec consumed-heat	44.49	44.49	38.00	38.00	44.49	44.49	44.49
8	On-site elec. consumed-DHW	21.79	21.79	21.79	21.79	21.79	21.79	21.79
9	Elec. saved w/ switch	44.49	44.49	12.96	38.00	21.79	21.79	66.28
10	Site-energy use added	8.93	8.93	0.00	0.00	0.00	0.00	0.00
11	Gas equip. efficiency	85% AFUE	85% AFUE	85% AFUE	85% AFUE	54% EF	65% EF	80% EFF.
12	Gas distribution effic.	94%	79%	79%	79%	N/A	N/A	94%
13	Added gas use w/ switch	65.74	78.23	26.68	78.23	33.89	28.15	82.31
14	Parasitic elec. - kWh	700	1100	0	1100	0	0	700
15	On-site energy w/ switch	68.13	81.98	26.68	81.98	33.89	28.15	84.70
16	Primary energy w/ switch	90.35	116.89	26.68	116.89	33.89	28.15	106.92
17	Primary energy - orig systm	198.83	198.83	179.35	179.35	198.83	198.83	198.83
18	Primary energy saved	108.48	81.93	152.67	62.45	164.94	170.67	91.91
19	Cost of conversion	$6,000.00	$8,500.00	$700.00	$1,850.00	$625.00	$700.00	$6,500.00
20	Elec. marginal cost/kWh	$0.0394	$0.0394	$0.0394	$0.0394	$0.0528	$0.0528	$0.0421
21	Value of elec. saved	$486.00	$470.00	$150.00	$395.00	$337.00	$337.00	$788.00
22	Breakeven cost/Dth	$1.46	($1.06)	$3.90	$3.51	$8.75	$10.35	$4.44

Note: Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.

Table 3-6. Fuel-Switching Analysis for Wood-frame Townhouse - Upstate.

	(FIGURES IN MMBTU)	Electric Baseboard to Gas Hydronic	Electric Heat Pump to Gas Furnace	Electric Heat Pump to Gas Backup	Electric Heat Pump to Gas Furnace	Electric DHW to Gas Storage DHW	Electric DHW to Dual Integrated Appliance	Electric Baseboard/DHW to Dual Integrated Appliance
1	Annual heat load	61.40	61.40	73.98	73.98	61.40	61.40	61.40
2	Annual DHW load	19.60	19.60	19.60	19.60	19.60	19.60	19.60
3	Heat+DHW load	81.00	81.00	93.58	93.58	81.00	81.00	81.00
4	Elec. equip. AFUE	100%	100%	165%	165%	100%	100%	100%
5	Elec. heat delivery effic.	98%	98%	79%	79%	98%	98%	98%
6	Elec. DHW energy factor	84%	84%	84%	84%	84%	84%	84%
7	On-site elec consumed-heat	62.65	62.65	56.75	56.75	62.65	62.65	62.65
8	On-site elec. consumed-DHW	23.33	23.33	23.33	23.33	23.33	23.33	23.33
9	Elec. saved w/ switch	62.65	62.65	25.54	56.75	23.33	23.33	85.99
10	Site-energy use added	12.58	12.58	0.00	0.00	0.00	0.00	0.00
11	Gas equip. efficiency	85% AFUE	85% AFUE	85% AFUE	85% AFUE	54% EF	65% EF	80% EFF.
12	Gas distribution effic.	94%	79%	79%	79%	NA	NA	94%
13	Added gas use w/ switch	92.59	110.17	49.57	110.17	36.30	30.15	107.71
14	Parasitic elec. - kWh	700	1100	0	1100	0	0	700
15	On-site energy w/ switch	94.97	113.92	49.57	113.92	36.30	30.15	110.10
16	Primary energy w/ switch	117.19	148.83	49.57	148.83	36.30	30.15	132.32
17	Primary energy - orig systm	257.96	257.96	240.26	240.26	257.96	257.96	257.96
18	Primary energy saved	140.77	109.13	190.68	91.42	221.66	227.81	125.64
19	Cost of conversion	$6,000.00	$8,500.00	$700.00	$1,850.00	$625.00	$700.00	$6,500.00
20	Elec. marginal cost/kWh	$0.0514	$0.0514	$0.0514	$0.0514	$0.0530	$0.0530	$0.0517
21	Value of elec. saved	$908.00	$887.00	$385.00	$798.00	$362.00	$362.00	$1,266.00
22	Breakeven cost/Dth	$5.59	$3.03	$6.84	$6.15	$8.86	$10.51	$7.83

Note: Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.

Table 3-7. Fuel-Switching Analysis for Brownstone Townhouse - Downstate.

	(FIGURES IN MMBTU)	Electric Baseboard to Gas Hydronic	Electric Heat Pump to Gas Backup	Electric Heat Pump to Gas Furnace	Electric DHW to Gas Storage DHW	Electric DHW to Dual Integrated Appliance	Electric Baseboard/DHW to Dual Integrated Appliance
1	Annual heat load	103.60	124.82	124.82	103.60	103.60	103.60
2	Annual DHW load	18.30	18.30	18.30	18.30	18.30	18.30
3	Heat + DHW load	121.90	143.12	143.12	121.90	121.90	121.90
4	Elec. equip. AFUE	100%	175%	175%	100%	100%	100%
5	Elec. heat delivery effic.	98%	79%	79%	98%	98%	98%
6	Elec. DHW energy factor	84%	84%	84%	84%	84%	84%
7	On-site elec consumed-heat	105.71	90.29	90.29	105.71	105.71	105.71
8	On-site elec. consumed-DHW	21.79	21.79	21.79	21.79	21.79	21.79
9	Elec. saved w/ switch	105.71	30.79	90.29	21.79	21.79	127.50
10	Site-energy use added	21.22	0.00	0.00	0.00	0.00	0.00
11	Gas equip. efficiency	85% AFUE	85% AFUE	85% AFUE	54% EF	65% EF	80% EFF.
12	Gas distribution effic.	94%	79%	79%	N/A	N/A	94%
13	Added gas use w/ switch	156.22	63.39	185.88	33.89	28.15	162.10
14	Parasitic elec. - kWh	700	0	1100	0	0	700
15	On-site energy w/ switch	158.61	63.39	189.64	33.89	28.15	164.49
16	Primary energy w/ switch	180.83	963.39	224.55	33.89	28.15	186.71
17	Primary energy - orig systm	382.50	336.21	336.21	382.50	382.50	382.50
18	Primary energy saved	201.67	272.83	111.66	348.61	354.35	195.79
19	Cost of conversion	$7,000.00	$700.00	$1,850.00	$625.00	$700.00	$7,500.00
20	Elec. marginal cost/kWh	$0.0394	$0.0394	$0.0394	$0.0528	$0.0528	$0.0421
21	Value of elec. saved	$1,193	$355	$999	$337	$337	$1,543
22	Breakeven cost/Dth	$4.72	$4.89	$4.73	$8.75	$10.35	$6.51

Note: Marginal gas cost must be less than value listed for fuel-switching to be cost-effective.

Table 3-8. Fuel-Switching Analysis for Low-Rise Apartment - Downstate.

	(FIGURES IN MMBTU)	Electric Baseboard to Gas Hydronic	Electric Heat Pump to Gas Backup	Electric Heat Pump to Gas Furnace	Electric DHW to Gas Storage DHW	Electric DHW to Dual Integrated Appliance	Electric Baseboard/DHW to Dual Integrated Appliance
1	Annual heat load	25.10	30.24	30.24	25.10	25.10	25.10
2	Annual DHW load	13.80	13.80	13.80	13.80	13.80	13.80
3	Heat+DHW load	38.90	44.04	44.04	38.90	38.90	38.90
4	Elec. equip. AFUE	100%	175%	175%	100%	100%	100%
5	Elec. heat delivery effic.	98%	79%	79%	98%	98%	98%
6	Elec. DHW energy factor	84%	84%	84%	84%	84%	84%
7	On-site elec consumed-heat	25.61	21.87	21.87	25.61	25.61	25.61
8	On-site elec. consumed-DHW	16.43	16.43	16.43	16.43	16.43	16.43
9	Elec. saved w/ switch	25.61	7.46	21.87	16.43	16.43	42.04
10	Site-energy use added	5.14	0.00	0.00	0.00	0.00	0.00
11	Gas equip. efficiency	85% EFF.	85% EFF.	85% EFF.	54% EF	65% EF	80% EFF.
12	Gas distribution effic.	94%	79%	79%	N/A	N/A	94%
13	Added gas use w/ switch	37.85	15.36	45.03	25.56	21.23	51.73
14	Parasitic elec. - kWh	700	0	1100	0	0	700
15	On-site energy w/ switch	40.24	15.36	48.79	25.56	21.23	54.12
16	Primary energy w/ switch	62.45	15.36	83.70	25.56	21.23	76.33
17	Primary energy - orig systm	126.12	114.91	114.91	126.12	126.12	126.12
18	Primary energy saved	63.67	99.55	31.21	100.57	104.89	49.79
19	Cost of conversion	$4,000.00	$900.00	$1,850.00	$500.00	$500.00	$4,500.00
20	Elec. marginal cost/kWh	$0.0394	$0.0394	$0.0394	$0.0528	$0.0528	$0.0421
21	Value of elec. saved	$268.00	$86.00	$209.00	$254.00	$254.00	$489.00
22	Breakeven cost/Dth	$0.21	$2.64	$1.97	$8.67	$10.44	$3.80

Note: Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.

Table 3-9. Fuel-Switching Analysis for Low-Rise Apartment - Upstate.

	(FIGURES IN MMBTU)	Electric Baseboard to Gas Hydronic	Electric Heat Pump to Gas Backup	Electric Heat Pump to Gas Furnace	Electric DHW to Gas Storage DHW	Electric DHW to Dual Integrated Appliance	Electric Baseboard/DHW to Dual Integrated Appliance
1	Annual heat load	31.60	38.07	38.07	31.60	31.60	31.60
2	Annual DHW load	14.60	14.60	14.60	14.60	14.60	14.60
3	Heat+DHW load	46.20	52.67	52.67	46.20	46.20	46.20
4	Elec. equip. AFUE	100%	165%	165%	100%	100%	100%
5	Elec. heat delivery effic.	98%	79%	79%	98%	98%	98%
6	Elec. DHW energy factor	84%	84%	84%	84%	84%	84%
7	On-site elec consumed-heat	32.24	29.21	29.21	32.24	32.24	32.24
8	On-site elec. consumed-DHW	17.38	17.38	17.38	17.38	17.38	17.38
9	Elec. saved w/ switch	32.24	13.14	29.21	17.38	17.38	49.63
10	Site-energy use added	6.47	0.00	0.00	0.00	0.00	0.00
11	Gas equip. efficiency	85% AFUE	85% AFUE	85% AFUE	54% EF	65% EF	80 EFF.
12	Gas distribution effic.	94%	79%	79%	N/A	N/A	94%
13	Added gas use w/ switch	47.65	25.51	56.70	27.04	22.46	61.44
14	Parasitic elec. - kWh	700	0	1100	0	0	700
15	On-site energy w/ switch	50.04	25.51	60.45	27.04	22.46	63.83
16	Primary energy w/ switch	72.26	25.51	95.36	27.04	22.46	86.04
17	Primary energy - orig systm	148.88	139.77	139.77	148.88	148.88	148.88
18	Primary energy saved	76.62	114.25	44.40	121.84	126.42	62.84
19	Cost of conversion	$4,000.00	$700.00	$1,850.00	$500.00	$500.00	$4,500.00
20	Elec. marginal cost/kWh	$0.0514	$0.0514	$0.0514	$0.0530	$0.0530	$0.0517
21	Value of elec. saved	$450.00	$198.00	$383.00	$270.00	$270.00	$716.00
22	Breakeven cost/Dth	$3.98	$5.97	$4.64	$8.78	$10.57	$6.88

Note: Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.

Table 3-10. Fuel-Switching Analysis for High-Rise Apartment - Downstate.

	(FIGURES IN MMBTU)	Electric Baseboard to Gas Hydronic	Electric Heat Pump to Gas Backup	Electric Heat Pump to Gas Furnace	Electric DHW to Gas Storage DHW	Electric DHW to Dual Integrated Appliance	Electric Baseboard/DHW to Dual Integrated Appliance
1	Annual heat load	33.70	40.60	40.60	33.70	33.70	33.70
2	Annual DHW load	13.80	13.80	13.80	13.80	13.80	13.80
3	Heat + DHW load	47.50	54.40	54.40	47.50	47.50	47.50
4	Elec. equip. AFUE	100%	175%	175%	100%	100%	100%
5	Elec. heat delivery effic.	98%	79%	79%	98%	98%	98%
6	Elec. DHW energy factor	84%	84%	84%	84%	84%	84%
7	On-site elec consumed-heat	34.39	29.37	29.37	34.39	34.39	34.39
8	On-site elec. consumed-DHW	16.43	16.43	16.43	16.43	16.43	16.43
9	Elec. saved w/ switch	34.39	10.01	29.37	16.43	16.43	50.82
10	Site-energy use added	6.90	0.00	0.00	0.00	0.00	0.00
11	Gas equip. efficiency	85% EFF.	85% EFF.	85% EFF.	54% EF	65% EF	80% EFF.
12	Gas distribution effic.	94%	79%	79%	N/A	N/A	94%
13	Added gas use w/ switch	50.82	20.62	60.47	25.56	21.23	63.16
14	Parasitic elec. - kWh	700	0	1100	0	0	700
15	On-site energy w/ switch	53.21	20.62	64.22	25.56	21.23	65.55
16	Primary energy w/ switch	75.42	20.62	99.13	25.56	21.23	87.77
17	Primary energy - orig systm	152.45	137.39	137.39	152.45	152.45	152.45
18	Primary energy saved	77.03	116.77	38.26	126.89	131.22	64.68
19	Cost of conversion	$2,500.00	$700.00	$1,850.00	$500.00	$500.00	$3,000.00
20	Elec. marginal cost/kWh	$0.0394	$0.0394	$0.0394	$0.0528	$0.0528	$0.0421
21	Value of elec. saved	$369.00	$116.00	$296.00	$254.00	$254.00	$597.00
22	Breakeven cost/Dth	$4.07	$3.40	$2.90	$8.67	$10.44	$6.37

Note: Marginal gas cost must be less than value listed for fuel-switching to be cost-effective.

Table 3-11. Fuel-Switching Analysis for Ranges.

Variable	Value	Notes/Source
1. Avg. consumption new electric appliance (kWh)	740	Levine et al. 1992 (LBL).
2. Avg. consumption existing electric appliance	770	Levine et al. 1992 (LBL).
3. Avg. consumption new gas appliance (therms)	40	Gas DSM analysis for this project
4. Kwh used by IID	40	ACEEE estimate based on discussion w/ LBL
Value of annual electric savings		
5. Marginal electric cost	$0.0529	from Table 1-1; avg. of 3 utilities listed.
6. Relative to new appliance	$37.03	(Row #1-Row #4)*Row #5
7. Relative to existing appliance	$38.62	(Row #2-Row #4)*Row #5
8. Equipment life (years)	18	Wilson and Morrill 1991.
Conversion costs:		
9. A. At time of replacement - natural gas	$316	Krause et al., 1988 (LBL) and Chernick et al., 1989 (Boston Gas).
10 B. Early replacement - natural gas	$741	$550 new range cost - $125 trade-in on old range plus line above (ACEEE estimate).
Breakeven gas cost ($/DTh):		
11 Option A	$2.50	
12 Option B	($6.19)	

Note: Marginal gas cost must be less than value listed for fuel-switching to be cost-effective.

Table 3-12. Fuel-Switching Analysis for Dryers.

	Variable	Value	Source
1.	Avg. consumption new electric appliance (kWh)	805	DOE 1990. Assumes 1994 std.
2.	Avg. consumption existing electric appliance	892	DOE 1990.
3.	Avg. consumption new gas appliance (therms)	33	DOE 1990. Assumes 1994 std.
4.	Kwh used by IID	40	ACEEE estimate based on Rosenquist 1992.
	Value of annual electric savings:		
5.	Marginal electric cost	$0.0529	from Table 1-1; avg. of 3 utilities listed.
6.	Relative to new appliance	$40.47	(Row #1-Row #4)*Row #5.
7.	Relative to existing appliance	$45.07	(Row #2-Row #4)*Row #5.
8.	Equipment life (years)	17	DOE 1990.
	Conversion costs:		
9.	A. At time of replacement - natural gas	$226	Krause et al., 1988 (LBL) and Chernick et al., 1989 (Boston Gas).
10	B. Early replacement - natural gas	$551	$400 new dryer cost - $75 trade-in on old dryer plus line above (ACEEE estimate).
	Breakeven gas cost ($/DTh):		
11	Option A	$6.19	
12	Option B	($1.15)	

Note: Marginal gas cost must be less than value listed for fuel-switching to be cost-effective.

Table 3-13. Summary of Residential Fuel-Switching Analysis - No Program Costs.

	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
DOWNSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise	High-Rise
EL BB > GAS HYDRONIC	$3.58	$5.32	$1.46	$4.72	$0.21	$4.07
EL BB > GAS FURNACE	$1.95	$3.27	($1.06)	N/A	N/A	N/A
EL HP + GAS BACKUP	$4.50	$4.51	$3.90	$4.89	$2.64	$3.40
EL HP > GAS FURNACE	$4.26	$4.27	$3.51	$4.73	$1.97	$2.90
EL DHW > GAS STG DHW	$8.99	$8.99	$8.75	$8.75	$8.67	$8.67
EL DHW>BOILER/DHW COMBO	$10.68	$10.68	$10.35	$10.35	$10.44	$10.44
EL BB&DHW>BOILR COMBO	$5.99	$7.47	$4.44	$6.51	$3.80	$6.37
RANGE - at time of replacement	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50
RANGE - retrofit	($6.19)	($6.19)	($6.19)	($6.19)	($6.19)	($6.19)
DRYER - at time of replacement	$6.19	$6.19	$6.19	$6.19	$6.19	$6.19
DRYER - retrofit	($1.15)	($1.15)	($1.15)	($1.15)	($1.15)	($1.15)
	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
UPSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise	High-Rise
EL BB > GAS HYDRONIC	$7.07	$8.26	$5.59	N/A	$3.98	N/A
EL BB > GAS FURNACE	$5.86	$6.67	$3.03	N/A	N/A	N/A
EL HP + GAS BACKUP	$7.15	$7.13	$6.84	N/A	$5.97	N/A
EL HP > GAS FURNACE	$6.70	$6.67	$6.15	N/A	$4.64	N/A
EL DHW > GAS STG DHW	$9.02	$9.09	$8.86	N/A	$8.78	N/A
EL DHW>BOILER/DHW COMBO	$10.72	$10.81	$10.51	N/A	$10.57	N/A
EL BB&DHW>BOILR COMBO	$8.95	$10.10	$7.83	N/A	$6.88	N/A
RANGE - at time of replacement	$2.50	$2.50	$2.50	$2.50	$2.50	$2.50
RANGE - retrofit	($6.19)	($6.19)	($6.19)	($6.19)	($6.19)	($6.19)
DRYER - at time of replacement	$6.19	$6.19	$6.19	$6.19	$6.19	$6.19
DRYER - retrofit	($1.15)	($1.15)	($1.15)	($1.15)	($1.15)	($1.15)

** Retail gas costs must be less than value listed for fuel-switching to be cost-effective.*

Table 3-14. Summary of Residential Fuel-Switching Analysis - 25% Increase.

	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
DOWNSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise	High-Rise
EL BB > GAS HYDRONIC	2.59	$4.77	($0.03)	$3.99	($1.51)	$3.27
EL BB > GAS FURNACE	0.60	$2.23	($2.82)	N/A	N/A	N/A
EL HP + GAS BACKUP	4.23	$4.24	$3.47	$4.71	$1.90	$2.85
EL HP > GAS FURNACE	4.01	$4.02	$3.13	$4.56	$1.30	$2.40
EL DHW > GAS STG DHW	8.75	$8.75	$8.45	$8.45	$8.35	$8.35
EL DHW>BOILER/DHW COMBO	10.36	$10.36	$9.95	$9.95	$10.06	$10.06
EL BB&DHW>BOILR COMBO	5.09	$6.93	$3.15	$5.76	$2.38	$5.60
RANGE - at time of replacement	$0.81	$0.81	$0.81	$0.81	$0.81	$0.81
RANGE - retrofit	($10.16)	($10.16)	($10.16)	($10.16)	($10.16)	($10.16)
DRYER - at time of replacement	$4.67	$4.67	$4.67	$4.67	$4.67	$4.67
DRYER - retrofit	($4.85)	($4.85)	($4.85)	($4.85)	($4.85)	($4.85)
	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
UPSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise	High-Rise
EL BB > GAS HYDRONIC	6.36	$7.84	4.53	N/A	2.61	N/A
EL BB > GAS FURNACE	4.88	$5.90	1.78	N/A	N/A	N/A
EL HP + GAS BACKUP	7.00	$6.98	6.61	N/A	5.53	N/A
EL HP > GAS FURNACE	6.52	$6.48	5.88	N/A	4.11	N/A
EL DHW > GAS STG DHW	8.78	$8.86	8.58	N/A	8.48	N/A
EL DHW>BOILER/DHW COMBO	10.40	$10.51	10.13	N/A	10.21	N/A
EL BB&DHW>BOILR COMBO	8.25	$9.67	6.85	N/A	5.69	N/A
RANGE - at time of replacement	$0.81	$0.81	$0.81	$0.81	$0.81	$0.81
RANGE - retrofit	($10.16)	($10.16)	($10.16)	($10.16)	($10.16)	($10.16)
DRYER - at time of replacement	$4.67	$4.67	$4.67	$4.67	$4.67	$4.67
DRYER - retrofit	($4.85)	($4.85)	($4.85)	($4.85)	($4.85)	($4.85)

** Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.*

Table 3-15. Summary of Residential Fuel-Switching Analysis - 50% Increase.

	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
DOWNSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise	High-Rise
EL BB > GAS HYDRONIC	$1.60	$4.21	($1.51)	$3.26	($3.23)	$2.47
EL BB > GAS FURNACE	($0.76)	$1.20	($4.59)	N/A	N/A	N/A
EL HP + GAS BACKUP	$3.95	$3.97	$3.05	$4.53	$1.16	$2.29
EL HP > GAS FURNACE	$3.76	$3.77	$2.75	$4.40	$0.64	$1.90
EL DHW > GAS STG DHW	$8.51	$8.51	$8.15	$8.15	$8.04	$8.04
EL DHW>BOILER/DHW COMBO	$10.03	$10.03	$9.54	$9.54	$9.67	$9.67
EL BB&DHW>BOILR COMBO	$4.18	$6.39	$1.87	$5.01	$0.97	$4.82
RANGE - at time of replacement	($0.88)	($0.88)	($0.88)	($0.88)	($0.88)	($0.88)
RANGE - retrofit	($14.12)	($14.12)	($14.12)	($14.12)	($14.12)	($14.12)
DRYER - at time of replacement	$3.15	$3.15	$3.15	$3.15	$3.15	$3.15
DRYER - retrofit	($8.56)	($8.56)	($8.56)	($8.56)	($8.56)	($8.56)
	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
UPSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise	High-Rise
EL BB > GAS HYDRONIC	$5.64	$7.42	$3.48	N/A	$1.24	N/A
EL BB > GAS FURNACE	$3.90	$5.12	$0.52	N/A	N/A	N/A
EL HP + GAS BACKUP	$6.85	$6.82	$6.38	N/A	$5.08	N/A
EL HP > GAS FURNACE	$6.34	$6.30	$5.61	N/A	$3.58	N/A
EL DHW > GAS STG DHW	$8.54	$8.64	$8.30	N/A	$8.18	N/A
EL DHW>BOILER/DHW COMBO	$10.08	$10.20	$9.75	N/A	$9.84	N/A
EL BB&DHW>BOILR COMBO	$7.54	$9.25	$5.87	N/A	$4.50	N/A
RANGE - at time of replacement	($0.88)	($0.88)	($0.88)	($0.88)	($0.88)	($0.88)
RANGE - retrofit	($14.12)	($14.12)	($14.12)	($14.12)	($14.12)	($14.12)
DRYER - at time of replacement	$3.15	$3.15	$3.15	$3.15	$3.15	$3.15
DRYER - retrofit	($8.56)	($8.56)	($8.56)	($8.56)	($8.56)	($8.56)

** Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.*

Table 3-16. Summary of Residential Fuel-Switching Analysis - 75% Increase

	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
DOWNSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise**	High-Rise**
EL BB > GAS HYDRONIC	$0.61	$3.66	($3.00)	$2.53	($4.95)	$1.67
EL BB > GAS FURNACE	($2.12)	$0.17	($6.36)	N/A	N/A	N/A
EL HP + GAS BACKUP	$3.68	$3.69	$2.62	$4.35	$0.42	$1.74
EL HP > GAS FURNACE	$3.51	$3.53	$2.36	$4.24	($0.03)	$1.41
EL DHW > GAS STG DHW	$8.27	$8.27	$7.85	$7.85	$7.72	$7.72
EL DHW>BOILER/DHW COMBO	$9.71	$9.71	$9.14	$9.14	$9.29	$9.29
EL BB&DHW>BOILR COMBO	$3.28	$5.85	$0.58	$4.25	($0.45)	$4.05
RANGE - at time of replacement	($2.57)	($2.57)	($2.57)	($2.57)	($2.57)	($2.57)
RANGE - retrofit	($18.08)	($18.08)	($18.08)	($18.08)	($18.08)	($18.08)
DRYER - at time of replacement	$1.63	$1.63	$1.63	$1.63	$1.63	$1.63
DRYER - retrofit	($12.26)	($12.26)	($12.26)	($12.26)	($12.26)	($12.26)
	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
UPSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise**	High-Rise**
EL BB > GAS HYDRONIC	$4.92	$7.00	$2.43	N/A	($0.12)	N/A
EL BB > GAS FURNACE	$2.92	$4.35	($0.73)	N/A	N/A	N/A
EL HP + GAS BACKUP	$6.70	$6.67	$6.15	N/A	$4.63	N/A
EL HP > GAS FURNACE	$6.16	$6.11	$5.33	N/A	$3.05	N/A
EL DHW > GAS STG DHW	$8.31	$8.41	$8.02	N/A	$7.88	N/A
EL DHW>BOILER/DHW COMBO	$9.75	$9.90	$9.37	N/A	$9.48	N/A
EL BB&DHW>BOILR COMBO	$6.84	$8.82	$4.89	N/A	$3.31	N/A
RANGE - at time of replacement	($2.57)	($2.57)	($2.57)	($2.57)	($2.57)	($2.57)
RANGE - retrofit	($18.08)	($18.08)	($18.08)	($18.08)	($18.08)	($18.08)
DRYER - at time of replacement	$1.63	$1.63	$1.63	$1.63	$1.63	$1.63
DRYER - retrofit	($12.26)	($12.26)	($12.26)	($12.26)	($12.26)	($12.26)

* *Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.*

** *Service connection is estimated at $765 for multi-family, $3200 for all other cases.*

Table 3-17. Summary of Residential Fuel-Switching Analysis - 50% Plus Service Connection Cost.

	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
DOWNSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise**	High-Rise**
EL BB > GAS HYDRONIC	($0.45)	$2.18	($4.68)	$1.93	($4.54)	$1.49
EL BB > GAS FURNACE	($2.81)	($0.83)	($7.25)	N/A	N/A	N/A
EL HP + GAS BACKUP	($1.09)	($1.04)	($4.76)	$1.25	($2.08)	($0.12)
EL HP > GAS FURNACE	$2.04	$2.07	$0.08	$3.28	($0.47)	$1.08
EL DHW > GAS STG DHW	$3.60	$3.60	$2.00	$2.00	$6.09	$6.09
EL DHW>BOILER/DHW COMBO	$4.12	$4.12	$2.15	$2.15	$7.33	$7.33
EL BB&DHW>BOILR COMBO	$2.45	$4.67	($0.66)	$3.72	$0.00	$4.03
RANGE - at time of replacement	($69.32)	($69.32)	($69.32)	($69.32)	($69.32)	($69.32)
RANGE - retrofit	($82.55)	($82.55)	($82.55)	($82.55)	($82.55)	($82.55)
DRYER - at time of replacement	($82.86)	($82.86)	($82.86)	($82.86)	($82.86)	($82.86)
DRYER - retrofit	($94.57)	($94.57)	($94.57)	($94.57)	($94.57)	($94.57)
	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
UPSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise**	High-Rise**
EL BB > GAS HYDRONIC	$4.16	$5.89	$1.23	N/A	$0.20	N/A
EL BB > GAS FURNACE	$2.42	$3.60	($1.37)	N/A	N/A	N/A
EL HP + GAS BACKUP	$4.09	$3.97	$2.18	N/A	$3.13	N/A
EL HP > GAS FURNACE	$5.10	$5.01	$3.72	N/A	$2.70	N/A
EL DHW > GAS STG DHW	$3.64	$4.05	$2.57	N/A	$6.34	N/A
EL DHW>BOILER/DHW COMBO	$4.17	$4.68	$2.85	N/A	$7.63	N/A
EL BB&DHW>BOILR COMBO	$6.20	$7.88	$3.94	N/A	$3.69	N/A
RANGE - at time of replacement	($69.32)	($69.32)	($69.32)	($69.32)	($69.32)	($69.32)
RANGE - retrofit	($82.55)	($82.55)	($82.55)	($82.55)	($82.55)	($82.55)
DRYER - at time of replacement	($82.86)	($82.86)	($82.86)	($82.86)	($82.86)	($82.86)
DRYER - retrofit	($94.57)	($94.57)	($94.57)	($94.57)	($94.57)	($94.57)

* *Marginal gas costs must be less than value listed for fuel-switching to be cost-effective.*

** *Service connection is estimated at $765 for multi-family, $3200 for all other cases.*

Table 3-18. Summary of Residential Fuel-Switching Analysis - Retail Electric Costs.

	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
DOWNSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise	High-Rise
EL BB > GAS HYDRONIC	$15.56	$17.31	$13.20	$16.85	$11.46	$15.62
EL BB > GAS FURNACE	$13.69	$15.01	$8.49	N/A	N/A	N/A
EL HP + GAS BACKUP	$4.50	$13.42	$12.81	$13.80	$11.55	$12.31
EL HP > GAS FURNACE	$12.60	$12.61	$11.54	$13.26	$9.35	$10.67
EL DHW > GAS STG DHW	$18.25	$18.25	$18.01	$18.01	$17.94	$17.94
EL DHW>BOILER/DHW COMBO	$21.83	$21.83	$21.51	$21.51	$21.59	$21.59
EL BB&DHW>BOILR COMBO	$19.68	$21.15	$18.06	$20.06	$17.25	$19.82
RANGE - at time of replacement	$10.17	$10.17	$10.17	$10.17	$10.17	$10.17
RANGE - retrofit	$1.81	$1.81	$1.81	$1.81	$1.81	$1.81
DRYER - at time of replacement	$16.35	$16.35	$16.35	$16.35	$16.35	$16.35
DRYER - retrofit	$10.17	$10.17	$10.17	$10.17	$10.17	$10.17
	Breakeven Levelized Gas Cost for Cost-Effective Fuel-Switching*					
UPSTATE:	Colonial	Ranch	Townhouse	Brownstone	Low-Rise	High-Rise
EL BB > GAS HYDRONIC	$14.73	$15.91	$13.14	N/A	$11.25	N/A
EL BB > GAS FURNACE	$13.41	$14.21	$9.24	N/A	N/A	N/A
EL HP + GAS BACKUP	$13.13	$13.11	$12.82	N/A	$11.95	N/A
EL HP > GAS FURNACE	$12.42	$12.38	$11.73	N/A	$9.85	N/A
EL DHW > GAS STG DHW	$16.18	$16.24	$16.02	N/A	$15.94	N/A
EL DHW>BOILER/DHW COMBO	$19.34	$19.42	$19.12	N/A	$19.18	N/A
EL BB&DHW>BOILR COMBO	$17.90	$19.07	$16.77	N/A	$15.74	N/A
RANGE - at time of replacement	$10.17	$10.17	$10.17	$10.17	$10.17	$10.17
RANGE - retrofit	$1.81	$1.81	$1.81	$1.81	$1.81	$1.81
DRYER - at time of replacement	$16.35	$16.35	$16.35	$16.35	$16.35	$16.35
DRYER - retrofit	$10.17	$10.17	$10.17	$10.17	$10.17	$10.17

** Retail gas costs must be less than value listed for fuel-switching to be cost-effective.*

exception of a hydronic conversion in the ranch. For homes with electric heat pumps, conversion to a primary or backup gas furnace will generally be cost-effective upstate, and is of borderline cost-effectiveness downstate in the detached homes and townhouses (woodframe and brownstone).

At 25 percent program costs, results are generally similar except that electric baseboard to hydronic conversions become cost-effective for the upstate woodframe townhouse and the downstate brownstone. Likewise, an electric baseboard to gas furnace conversion will often be cost-effective in the upstate colonial.

With no program costs, from the total resource perspective, results are very similar to the previous case, except that converting a range at time of equipment replacement is of borderline cost-effectiveness throughout the state, and electric baseboard to gas hydronic conversions become cost-effective for the downstate high-rise and the upstate low-rise.

At 75 percent program costs (or the equivalent), results are similar to the 50 percent program cost case except that none of the electric baseboard conversions are cost-effective from the total resource perspective downstate.

For the scenario with 50 program costs plus a service connection cost, most of the water heater conversions are cost-effective from the total resource perspective as are most of the electric heat pump to gas furnace conversions and the upstate electric baseboard to gas hydronic conversions in detached homes.

From the consumer perspective (using retail rates and assuming no program costs), most conversions are cost-effective throughout the state for most building types, including converting to gas from electric baseboard heat, electric heat pumps, electric resistance water heaters, electric dryers, and electric ranges. However, the dryer and range conversions are cost-effective only at the time of equipment replacement.

SIZE OF THE RESOURCE

Based on the economic analysis, we estimated the size of the fuel-switching resource in the three electric service areas most closely corresponding to the three gas utilities included in this study. In making these estimates we looked at total electric sales for each end-use for which fuel-switching is an option (space and water heating, cooking and drying); the proportion of homes that now use electric equipment that have gas service available in the home; and the proportion of homes for which fuel-switching is likely to be cost-effective. The product of these three variables is the size of the available resource. Specific assumptions and calculations are summarized in Table 3-19. These assumptions generally come from data supplied by the New York State Energy Office. However, the proportion of homes for which fuel-switching is likely to be cost-effective was estimated by ACEEE based on the breakeven gas cost for the most cost-effective fuel-switching option for each end-use.[2] The estimates in Table 3-19 are based on the 50 percent program cost scenario. For ranges and dryers, potential savings estimates assume fuel switching at time of equipment replacement.

Many assumptions used to develop this resource estimate are imprecise, and this estimate provides only a rough approximation of the size of the actual resource. Given the many uncertainties involved, we estimate that the actual resource available may deviate upwards or downwards by about 25 percent from the values presented in Table 3-19.

The bottom line result is that if fuel-switching occurs in all cost-effective situations, LILCo, Consolidated Edison, and Niagara Mohawk can reduce residential electric sales by approximately 3 percent, 4 percent, and 10 percent respectively. For LILCo the savings are primarily in water heating and clothes drying. For Con Edison the savings are primarily in

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[2] Specifically, we used a simple protocol that increased the values for lines 5, 13, 22, and 29 in Table 3-19 as the breakeven gas cost increased. The specific figures used are not highly scientific estimates but instead are based on discussions with several HVAC experts combined with comments we received on review drafts of the report. Under the protocol, if the breakeven gas price is negative, we assume no cost-effective potential. At breakeven gas costs of $2.50, $4.00, $8.00, and $12,00 per DTh we assume fuel-switching is appropriate for 25, 50 75, and 90 percent of the applications. For breakeven gas costs in between these values, the cost-effective potential was interpolated.

Table 3-19. Rough Estimate of Electricity Savings Available from Cost-Effective Fuel Switching in the Service Areas of Three New York State Electric Utilities.

		LILCo	Con Ed	NMPC	Notes/Sources (#'s are row #'s)
1	% of homes with gas in house	60%	95%	79%	NYSEO 1990.
	SPACE HEATING				
2	Gas share	30%	42%	57%	NYSEO 1990.
3	Electric share	7%	7%	12%	NYSEO 1990.
4	Use - GWh (1992)	324	879	1,500	NYSEO 1991a.
5	Cost-effective potential (% elec.)	30%	10%	60%	ACEEE estimate based on Table 3-15 & allowances for outliers.
6	% electric with available gas	29%	61%	34%	((1 - 2)/(100% - 2))*67%
7	Savings potential (GWh)	28	54	309	(4 * 5 * 6)
8	Ratio M DTh/GWh	5.41	5.41	5.30	Based on efficiencies in Table 3-1; assumes 67% baseboard heat, 33% heat pumps.
9	Added gas sales (M DTh)	151	291	1,635	(7 * 8)
	WATER HEATING				
10	Gas share	41%	51%	56%	NYSEO 1991a.
11	Electric share	13%	7%	35%	NYSEO 1991a.
12	Use - GWh (1992)	349	628	1636	NYSEO 1991a.
13	Cost-effective potential (% elec)	90%	90%	90%	ACEEE estimate based on Table 3-15 & allowances for outliers.
14	% electric with available gas	22%	60%	35%	((1 - 10)/(100% - 10))*67%
15	Savings potential (GWh)	68	340	516	(12 * 13 * 14).
16	Ratio M DTh/GWh	5.31	5.31	5.31	Based on effic. in Table 3-1.
17	Added gas sales (M DTh)	360	1,805	2,737	(15 * 16)
	COOKING				
18	Gas share	42%	83%	34%	NYSEO 1991a.
19	Electric share	50%	13%	55%	NYSEO 1991a.
20	Use - GWh (1992)	355	360	596	NYSEO 1991a.
21	Cost-effective potential (% elec)	0%	0%	0%	ACEEE estimate based on Table 3-15 & allowances for outliers.
22	% electric with available gas	21%	47%	46%	((1 - 18)/(100% - 18))*67%
23	Savings potential (GWh)	0	0	0	(20 * 21 * 22).
24	Ratio M DTh/GWh	2.84	2.84	2.84	Based on values in Table 3-11.
25	Added gas sales (M DTh)	0	0	0	(23 * 24)
	CLOTHES DRYING				
26	Gas share	25%	15%	54%	Smolenski 1992, Gobris 1992, Pijacki 1992.
27	Electric share	55%	11%	52%	Miller et al. 1989.
28	Use - GWh (1992)	442	252	698	Miller et al. 1989 + growth in residual from NYSEO 1991a.
29	Cost-effective potential (% elec)	50%	50%	50%	ACEEE estimate based on Table 3-15 & allowances for outliers.
30	% electric with available gas	31%	63%	36%	((1 - 26)/(100% - 26))*67%
31	Savings potential (GWh)	69	80	127	(28 * 29 * 30).
32	Ratio M DTh/GWh	2.84	2.84	2.84	Based on values in Table 3-12.
33	Added gas sales (M DTh)	196	226	361	(31 * 32)
34	**Total savings potential (GWh)**	**165**	**473**	**951**	(7 + 15 + 23 + 31)
35	% of residential electric sales	3%	4%	10%	(34 / Elec sales: NYSEO 1991c).
36	**Total sales added (M DTh)**	**707**	**2,322**	**4,733**	(9 + 17 + 25 + 33)
37	% of residential gas sales	2%	1%	4%	(36 / Gas sales: NYSEO 1991c).

water heating. For Niagara Mohawk the savings are primarily in water and space heating. Differences between utilities in how savings are allocated among the different end-uses are primarily due to differences in the current saturation of electric equipment for the different end-uses.

Savings are highest for Niagara Mohawk because electric market shares for each of the end-uses studied are generally higher than at the other utilities. Also, in the cold upstate climate, the economics of fuel-switching are more favorable than downstate.

These results show that the fuel-switching resource is extensive and it is worthwhile for New York State utilities and regulators to consider how best to tap it. On the other hand, the resource is not nearly as large as the resource for residential efficiency improvements -- a resource that Miller, Eto and Geller (1989) estimated could reduce LILCo, Con Ed, and Niagara Mohawk residential sales by 32 percent, 39 percent and 33 percent respectively if all measures that are cost-effective considering the total resource cost are implemented. Thus, efforts to consider how best to implement fuel-switching programs should not diminish efforts to implement electric-efficiency programs. In deciding how to pursue fuel-switching opportunities, experience with different policies and programs described in Chapter 7 that have been tried in the U.S. and Canada may be useful.

Chapter 4

THE POTENTIAL FOR COMMERCIAL GAS ENERGY EFFICIENCY

This chapter describes the technical and economic potential for gas space heating, water heating, and cooking energy-efficiency measures in the LILCo, BUG, and NFG commercial sectors. It begins by describing the prototypical buildings used to assess the potential for efficiency improvements in the use of gas for space heating, including the calibration of these prototypes using information on end-use energy consumption by commercial buildings in New York State[1]. Next, the energy-efficiency measures are described. Following these descriptions, the results of the analysis are presented separately by utility service territory. The presentation of results is followed by a limited review of existing measured data on the energy performance of retrofits in commercial buildings.

METHODOLOGY

A two-part methodology was used to estimate the technical and economic potential for gas energy efficiency in the commercial sector. For those measures affecting space heating energy use, detailed simulations of six prototypical buildings were performed using the DOE-2 building energy-analysis program (the DOE-2 program is the building energy analysis industry's reference hourly energy simulation model). For those measures affecting gas water heating and cooking, two spreadsheet models were developed.

For the DOE-2 analysis of gas space heating energy-efficiency measures, the absence of comparably detailed data on building characteristics and operation for each of the three gas utility service territories led to our developing a common set of prototypical building descriptions. Differences in end-use energy use were estimated by simulating the prototypes

[1] The prototypical buildings developed for analysis of gas space heating energy-efficiency measures are also used to assess the cost-effectiveness of fuel-switching (Chapter 5).

separately for an upstate and downstate climate. The upstate climate was represented using hourly weather data typical for Buffalo; the downstate climate was represented using typical hourly weather data for New York City.

Each prototype was calibrated separately for upstate and downstate conditions using utility-specific end-use data developed for the New York Power Pool (NYPP).

Following calibration, the impacts of gas space heating energy-efficiency measures were estimated using additional simulations. Interactive effects were captured by sequentially simulating the cumulative effects of the energy-efficiency measures. That is, the order of simulation was designed to follow the approximate order of decreasing cost-effectiveness (the most cost-effective measures were simulated first; the least cost-effective measures were simulated last, assuming the presence of the more cost-effective measures). Through this process interactive effects between measures were captured automatically and in the appropriate order. The cost of saved gas for each measure and building type was then calculated using measure cost and lifetime information and the results of the energy simulations. For the remaining building types (i.e., those not represented by six prototypes), we make a simple extrapolation of our results from the detailed analysis of the prototypes.

For the analysis of gas water heating and cooking energy efficiency measures, two spreadsheet models were developed. For these analyses, the energy impacts of the measures were estimated by applying savings fractions from engineering calculations directly to the energy-use estimates developed for the NYPP for each utility service territory. As with the analysis of gas space-heating measures, the cost-effectiveness of the gas water heating and cooking energy-efficiency measures is reported using the cost of saved gas.

Commercial Building Types

The number and types of buildings selected for analysis were intended to ensure that the results could be reliably extrapolated to the population of commercial buildings in each of the gas utility service territories. Based on a review of end-use information developed for the NYPP for forecasting, six commercial building types were selected for detailed analysis: office, retail, hospital, supermarket, restaurant, and warehouse. For the gas space-heating analysis, which involved DOE-2 simulations, two additional prototypes for the office and retail building types were analyzed to capture differences in energy use between buildings with central compared to packaged HVAC equipment. Taken together, the forecasting data imply that the gas consumption of these six building types represents 87, 78, and 63 percent of total commercial sector gas consumption in the LILCo, BUG, and NFG service territories, respectively (see Table 4-1).[2]

The forecasting data used in this analysis (floorspace, end-use fuel saturation, and energy-use intensity), and presented in Table 4-1, were developed primarily by J. Jackson for the NYPP (Jackson 1992a and Jackson 1992b). These data, however, were developed only for New York State *electric* utility service territories. For LILCo, the gas and electric service territories were assumed to be identical. For NFG, the floorspace and fuel saturation estimates were developed in consultation with NFG staff (Pijacki 1992b, Narayannan 1992), but the Energy Use Intensities or EUIs (expressed in kBtu/sqft.yr) of end-uses by fuel type were assumed equal to the NYPP estimate for Niagara Mohawk Power Corporation (NMPC). For BUG, floorspace by building type was derived from information supplied by Consolidated Edison (ConEd) on floorspace by borough (Griffo 1991). BUG saturations were developed by ACEEE, after discussions with New York State Energy Office forecasting staff (Bowman 1992). However, as with NFG, the EUIs of end-uses by fuel type for the BUG service territory were assumed equal to those developed for NYPP for the ConEd service territory.

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[2] In reviewing the percentages of total commercial sector gas consumption by the six building types analyzed in this study, it is useful to note that the miscellaneous building category represents 6,14, and 24 percent of total commercial sector gas consumption for LILCo, BUG and NFG, respectively. In other words, with the exception of this extremely heterogeneous building type for which there is little comprehensive information on building or operating characteristics, only 7, 8, and 13 percent of total commercial sector gas consumption is unaddressed by the prototypes for the LILCo, BUG, and NFG service territories, respectively. The unaddressed categories include schools, colleges, and lodging, in addition to the miscellaneous category of commercial customers.

Table 4-1. Commercial Sector Sales Profile

	Office	Retail	Health	Supermkt	Restrnt	Warehse	Source
Fl. Area (mil. sf)							
LILCo	205.4	96.7	28.8	15.2	14.0	25.3	Jackson 1992b
NFG	67.7	22.3	17.8	13.5	2.3	42.3	NFG 1992
BUG	91.5	63.0	32.4	14.6	12.3	60.6	Con Ed 1991, ACEEE
Fuel Saturation %							
LILCo							Jackson
sp heat	45.8	48.7	25.0	42.5	50.3	40.4	1992b
a/c	2.5	0.3	2.9	0.0	0.0	1.1	
wt heat	20.7	34.8	19.0	35.9	54.6	21.3	
cooking	8.1	4.2	12.8	15.0	48.6	0.7	
misc	100.0	100.0	100.0	100.0	100.0	100.0	
NFG							
sp heat	94.0	80.0	94.0	84.0	84.0	78.0	NFG 1992,
a/c	0.0	0.0	0.0	0.0	0.0	0.0	Jackson
wt heat	72.0	62.0	85.0	80.0	80.0	64.0	1992b
cooking	86.0	25.0	48.0	90.0	90.0	100.0	
misc	100.0	100.0	100.0	100.0	100.0	100.0	
BUG							
sp heat	50.0	62.5	40.9	87.8	69.6	62.5	Jackson
a/c	0.9	0.0	17.4	0.0	0.0	0.0	1992b,
wt heat	28.5	76.2	42.0	41.5	65.0	76.2	ACEEE
cooking	8.1	4.2	12.8	15.0	48.6	0.7	
misc	100.0	100.0	100.0	100.0	100.0	100.0	
EUI (kBtu/sf)							
LILCo	59.6	55.6	69.4	104.7	119.4	76.6	Jackson
sp heat	24.0	27.1	62.7	37.0	45.2	26.0	1992a
a/c	6.7	5.9	15.2	14.7	41.0	1.1	
wt heat	9.0	11.9	12.8	58.5	125.3	6.6	
cooking	0.2	2.7	1.1	3.1	3.6	0.7	
misc							
NFG (=NMPC)							
sp heat	77.4	66.7	121.3	116.8	107.3	14.1	Jackson
a/c	0.0	0.0	0.0	0.0	0.0	0.0	1992a
wt heat	6.7	5.9	15.2	14.7	41.0	1.1	
cooking	9.0	11.9	12.8	58.5	125.3	6.6	
misc	0.2	2.7	1.1	3.1	3.6	0.7	
BUG (ConEd)							
sp heat	37.8	50.9	117.7	51.2	70.4	16.8	Jackson
a/c	30.2	15.5	72.7	26.4	36.7	7.8	1992a
wt heat	6.7	5.9	15.2	14.7	41.0	1.1	
cooking	9.0	11.9	12.8	58.5	125.3	6.6	
misc	0.2	2.7	1.1	3.1	3.6	0.7	
Total Gas Consumption (% of Total Commercial Gas Sales)							6 Bldg. types
LILCo	39	20	5	6	13	5	87
NFG	32	8	13	3	3	4	63
BUG	15	19	17	7	13	6	78

Prototype Simulation with DOE-2

For the analysis of gas space heating energy-efficiency measures, detailed prototypical buildings were developed for simulation with the DOE-2 building energy analysis program. The prototypes used in this study were based on earlier prototypes developed by the Lawrence Berkeley Laboratory (LBL). All but the warehouse prototype were originally developed and calibrated to be broadly representative of buildings in the Northeast region, as defined by the Energy Information Administration (EIA) Commercial Buildings Energy Consumption Survey (Huang, et. al. 1991). The warehouse prototype was originally developed for Southern California (Akbari, et. al. 1989). For this present study, the most important features of the prototypes (including the warehouse) were modified using data unique for the specific New York State utility service areas.[3] Finally, the calibration of each of the prototypes (leading to additional re-specification of the building descriptions) was done using end-use energy-use information unique in each service territory.

The prototypes were specified using several modeling conventions that may initially seem unnatural. These conventions were developed to create an accurate thermodynamic model for prototype energy performance, but may result in building descriptions that are architecturally unrealistic. For example, the number of distinct HVAC zones was reduced wherever possible. Zone floor areas were expressed as a percentage of the total floor area of the building, as were the numbers of exterior walls, windows, and interior walls adjoining other zones. Instead of developing arbitrary building geometries, average aspect ratios (exterior wall length to width ratios) and surface area-to-volume ratios were defined based on reviewing typical buildings. Wall area was further divided into attached or enclosed exterior and free-standing exterior walls. The total free-standing exterior wall area for each zone was then equally distributed in four directions to avoid directional bias. Finally, envelope thermal integrity features such as roof and

[3] Specific prototype building characteristics will sometimes differ considerably from those now required by New York State building codes or observed in current building practice. The reason is that the prototypes are intended to be broadly representative of the entire stock of New York State buildings, which may consist of buildings that span many generations of building construction and practices. Current building practices and applicable codes affect only the most recent vintages of buildings within the stock.

wall insulation, and window R-values and shading coefficients were modeled calculating a saturation-weighted measure for the entire building component. For example, if 50 percent of a given building type has R-9 roof insulation, the prototype was modeled with the entire roof having an insulation value equivalent to having R-9 insulation for 50 percent of the roof area and R-0 insulation for the remaining area, resulting in an average roof R-value of 4.

Two main sources of utility-specific data were used to update inputs from the original LBL prototypes. The first was Niagara Mohawk's commercial sector characterization (Xenergy 1988). The second was LILCo's commercial building equipment inventory (Xenergy 1990). Wherever possible, information from these two studies was used to replace inputs from the original LBL prototypes.

The Niagara Mohawk commercial sector characterization reports several important physical and operating characteristics for commercial buildings. The following information from the Niagara Mohawk report replaced characteristics in the original LBL prototypes:

whether the building is free-standing, attached, or enclosed;
number of stories;
presence of ceiling insulation;
presence of wall insulation;
window to wall ratio;
window type (number of panes and if treated);
lighting equipment intensity (W/sqft);
saturation of packaged versus central HVAC equipment (affects only office and retail prototype).

The Niagara Mohawk data often report categorical features; that is, categories indicating the presence or absence of a feature (e.g., does the building have wall insulation?), but, if present, not the quantity (e.g., the amount of insulation). Categorical information was converted by assigning mean values to categories and calculating a weighted average. For example, the percent of buildings reporting wall insulation is multiplied by the minimum wall insulation called for by the New York State energy code (R-9) and a resulting, average R-value is estimated.

Review of both the NMPC and LILCo data confirmed the presence of substantial numbers of packaged and central HVAC systems in office and retail buildings (i.e., central HVAC systems in excess of 15 percent of the stock). Accordingly, two prototypes were developed for these building types, each with identical physical and operating characteristics but with different HVAC systems. Central HVAC systems were modeled for the hospital and packaged HVAC systems were modeled for the remaining building types (supermarket, restaurant, and warehouse).[4]

Two additional sources of information were used to modify the original LBL prototypes. The first was direction from the review committee for the project, which recommended that the office building prototype be a two-story building with a floor area of 75,000 square feet, and that the retail building prototype be a single-story building with 5,000 square feet of floor area.

The second was modifications that arose from calibrating the prototypes to existing EUIs. Lighting and miscellaneous equipment energy-use intensities (i.e., watts per square foot) were adjusted to ensure calibration with existing EUIs.[5] In addition, calibration to existing heating, cooling, and ventilation EUIs resulted in some re-specification of HVAC design and control characteristics from those used in the original LBL prototypes. In general, these characteristics

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[4] Other HVAC systems were also documented in the NMPC and LILCO survey data, but represented a much smaller proportion of the stock than central and packaged HVAC systems. Through our calibrations, we are implicitly assuming that the energy use of these non-explicitly represented systems is captured by the energy performance of the prototypes.

[5] The original values from the Niagara Mohawk data are also specified in Tables 4-2 to 4-7 for comparison.

(such as design ventilation rate or temperature control strategy) are rarely reported in any survey. [6]

The prototype features influencing heating and cooling energy use are summarized in six separate tables, 4-2 to 4-7, one for each prototype. The hospital and supermarket have the most complicated zoning; five distinct building functions were specified and zoned separately. Other building types have multiple zones intended primarily to reflect typical HVAC zoning practices (e.g., core versus perimeter zones) rather than functional differences between zones.

Calibration of Prototypes to End-Use EUIs

The original characteristics of the prototype buildings were modified by extensive calibration efforts to ensure that the analysis of energy-efficiency and fuel-switching measures accurately reflected their potential for New York State. The data used in the calibrations were end-use energy-use intensities or EUIs expressed in kWh/sqft (for electric end uses) or kBtu/sqft (for gas end uses).[7]

As described previously, separate EUIs for each electric service territory in New York were developed by J. Jackson for the NYPP (Jackson 1992a). The EUIs were based on work performed originally by Xenergy, but include additional adjustments, primarily to gas space heat, required for reconciliation with utility records on actual gas sales.

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[6] In the case of minimum outside air ventilation, for example, two issues are being addressed. First, as noted previously, the prototypes are intended to be broadly representative of all generations of New York commercial buildings. Hence, current industry practice (e.g., ASHRAE Standard 62-1989) does not strictly apply. Second, to the extent these practices do apply, actual building occupancies (as specified for the prototypes) are typically lower than those used in design outside air ventilation calculations, resulting in apparently higher outside air ventilation rates on a per person basis than might be recommended in Standards.

[7] Each building is assumed to be heated with natural gas and cooled with electricity. The actual saturations for these fuels, which are required to extrapolate the simulation results to buildings within a given service territory are treated separately.

Table 4-2. Office Prototype Characteristics.

Characteristic	Value	Source/Comment
Size (sqft)	75,000	review comm.
Floors	2	review comm.
No. of Exterior Walls - Height	3.3 - 10 ft	NMPC (Xenergy 1988)
Wall Insulation (R-value)	0.8	NMPC (Xenergy 1988)
Ceiling Insulation (R-value)	2.6	NMPC (Xenergy 1988)
Window/Wall Ratio	0.24	NMPC (Xenergy 1988)
Window Conductance	0.86	NMPC (Xenergy 1988)
Weekday Start/Stop	7 am - 6 pm	Huang 1988
Weekend Start/Stop	8 am - 12 pm	Huang 1988
Occupancy (sqft/person)	420	Huang 1988
Lighting Intensity (watt/sqft)	1.7	calibration (NMPC = 1.8)
Misc. Eqp. Intensity (watt/sqft)	1.1	calibration
Heating Setpoint (F)	72	calibration
Cooling Setpoint (F)	74	calibration
HVAC Zoning	4 perimeter; 1 core	Huang 1988
HVAC System Type	1 Reheat Fan System or 5 Package Single Zones	Huang 1988
Design Air (CFM/sqft)	0.7	calibration
Min. Outside Air (CFM/person)	20/40	calibration
Central Plant	2 Hot-Water Boilers; 2 Hermetic Centrifugal Chillers w/cooling tower	Huang 1988

Table 4-3. Retail Prototype Characteristics.

Chacteristic	Value	Source/Comment
Size (sqft)	5,000	review comm.
Floors	1	review comm.
No. of Exterior Walls - (Height)	3.2 (15 ft)	NMPC (Xenergy 1988)
Wall Insulation (R-value)	0.9	NMPC (Xenergy 1988)
Ceiling Insulation (R-value)	3.2	NMPC (Xenergy 1988)
Window/Wall Ratio	0.16	NMPC (Xenergy 1988)
Window Conductance	1.13	NMPC (Xenergy 1988)
Weekday Start/Stop	9 am - 9 pm	Huang 1988
Weekend Start/Stop	11 am - 6 pm	Huang 1988
Occupancy (sqft/person)	135	Huang 1988
Lighting Intensity (watt/sqft)	1.1	calibration (NMPC = 1.8)
Misc. Eqp. Intensity (watt/sqft)	0.6	calibration
Heating Setpoint (F)	68	calibration
Cooling Setpoint (F)	72	calibration
HVAC Zoning	1 zone	Huang 1988
HVAC System Type	1 Reheat Fan System or 1 Package Single Zone	Huang 1988
Design Air (CFM/sqft)	1.0	calibration
Min. Outside Air (CFM/person)	10	calibration
Central Plant	2 Hot-Water Boilers; 2 Hermetic Centrifugal Chillers w/cooling tower	Huang 1988

Table 4-4. Hospital Prototype Characteristics.

Chacteristic	Value	Source/Comment
Size (sqft)	386,900	Huang 1988
Floors	6	Huang 1988
No. of Exterior Walls - (Height)	3.9 (10 ft)	NMPC (Xenergy 1988)
Wall Insulation (R-value)	0.8	NMPC (Xenergy 1988)
Ceiling Insulation (R-value)	6.1	NMPC (Xenergy 1988)
Window/Wall Ratio	0.27	NMPC (Xenergy 1988)
Window Conductance	0.93	NMPC (Xenergy 1988)
Weekday Start/Stop	24 hour operation	Huang 1988
Weekend Start/Stop	24 hour operation	Huang 1988
Occupancy (sqft/person)	150 - 700	Huang 1988
Lighting Intensity (watt/sqft)	0.4 - 1.0	calibration (NMPC = 1.8)
Misc. Eqp. Intensity (watt/sqft)	0.0 - 4.1	calibration
Heating Setpoint (F)	70	calibration
Cooling Setpoint (F)	74	calibration
HVAC Zoning	Perimeter, Core/Public & Hallway, Kitchen, Clinic	Huang 1988
HVAC System Type (follows order of zones)	Four-pipe fan coil, Reheat fan system, Reheat fan system, Dual-duct system	Huang 1988
Design Air (AC/hr)	2.5 - 9	calibration
Min. Outside Air (%)	50 - 100	calibration
Central Plant	2 Hot-Water Boilers; 2 Hermetic Centrifugal Chillers w/cooling tower	Huang 1988

Table 4-5. Supermarket Prototype Characteristics.

Chacteristic	Value	Source/Comment
Size (sqft)	21,300	Huang 1988
Floors	1	Huang 1988
No. of Exterior Walls - (Height)	2.8 (20 ft)	NMPC (Xenergy 1988)
Wall Insulation (R-value)	0.3	NMPC (Xenergy 1988)
Ceiling Insulation (R-value)	1.0	NMPC (Xenergy 1988)
Window/Wall Ratio	0.14	NMPC (Xenergy 1988)
Window Conductance	0.93	NMPC (Xenergy 1988)
Weekday Start/Stop	6 am - 11 pm	Huang 1988
Weekend Start/Stop	6 am - 11 pm	Huang 1988
Occupancy (sqft/person)	100	Huang 1988
Lighting Intensity (watt/sqft)	1.8	calibration (NMPC = 1.9)
Misc. Eqp. Intensity (watt/sqft)	0.6 - 10.0	calibration
Heating Setpoint (F)	70	calibration
Cooling Setpoint (F)	70	calibration
HVAC Zoning	Office, Bakery, Deli, Dry-storage, Sales	Huang 1988
HVAC System Type	5 package single zone	Huang 1988
Design Air (CFM/sqft)	1.0	calibration
Min. Outside Air (CFM/person)	50	calibration
Central Plant	n/a	

Table 4-6. Restaurant Prototype Characteristics.

Chacteristic	Value	Source/Comment
Size (sqft)	3,084	Huang 1988
Floors	1	Huang 1988
No. of Exterior Walls - (Height)	3.4 (10 ft)	NMPC (Xenergy 1988)
Wall Insulation (R-value)	1.0	NMPC (Xenergy 1988)
Ceiling Insulation (R-value)	2.9	NMPC (Xenergy 1988)
Window/Wall Ratio	0.16	NMPC (Xenergy 1988)
Window Conductance	0.97	NMPC (Xenergy 1988)
Weekday Start/Stop	7 am - 12 am	Huang 1988
Weekend Start/Stop	7 am - 12 am	Huang 1988
Occupancy (sqft/person)	50	Huang 1988
Lighting Intensity (watt/sqft)	0.8	calibration (NMPC = 1.6)
Misc. Eqp. Intensity (watt/sqft)	0.0 - 9.0	calibration
Heating Setpoint (F)	65	calibration
Cooling Setpoint (F)	75	calibration
HVAC Zoning	Kitchen & Dinning	Huang 1988
HVAC System Type	2 package single zone	Huang 1988
Design Air (CFM/sqft)	0.7	calibration
Min. Outside Air (CFM/person)	20	calibration
Central Plant	n/a	

Table 4-7. Warehouse Prototype Characteristics.

Characteristic	Value	Source/Comment
Size (sqft)	25,700	Akbari 1989
Floors	1	Akbari 1989
No. of Exterior Walls - (Height)	3.8 (15 ft)	NMPC (Xenergy 1988)
Wall Insulation (R-value)	0.3	NMPC (Xenergy 1988)
Ceiling Insulation (R-value)	5.3	NMPC (Xenergy 1988)
Window/Wall Ratio	0.21	NMPC (Xenergy 1988)
Window Conductance	1.04	NMPC (Xenergy 1988)
Weekday Start/Stop	9 am - 5 pm	Akbari 1989
Weekend Start/Stop	11 am - 5 pm	Akbari 1989
Occupancy (sqft/person)	1370	Akbari 1989
Lighting Intensity (watt/sqft)	0.7	calibration (NMPC = 1.8)
Misc. Eqp. Intensity (watt/sqft)	0.5	calibration
Heating Setpoint (F)	68	calibration
Cooling Setpoint (F)	70	calibration
HVAC Zoning	1 zone	Akbari 1989
HVAC System Type	1 package single zone	Akbari 1989
Design Air (CFM/sqft)	1.0	calibration
Min. Outside Air (CFM/person)	50	calibration
Central Plant	n/a	

The following assignments of electric service territory EUIs were made in order to calibrate upstate and downstate prototypes. The upstate prototype (used for NFG) is calibrated to the EUIs developed for the NMPC service territory. The downstate prototype (used for LILCo and BUG) is calibrated to the simple average of the EUIs developed for the ConEd and LILCo service territories. See Table 4-1 for the original EUIs.

The results of the calibrations are presented in Table 4-8 which includes information on the calibration to EUIs for electric ventilation, lighting, and miscellaneous (e.g. office information processing equipment), and to gas space and water heating. Calibration to the EUIs for electric lighting and miscellaneous is important because these end uses contribute to internal gains, that in turn affect space heating and cooling-energy-use. Ventilation is related to space heating and cooling in an even more direct fashion since air is the primary means for transporting mechanical heating and cooling into and out of buildings.

Table 4-8 indicates reasonable overall but imperfect individual calibration to data currently being used by the NYPP. Since calibration for electric lighting and miscellaneous, and gas water heating EUIs result from direct modifications to DOE-2 inputs, excellent calibration results were guaranteed for these end uses. For the space conditioning end uses, except ventilation, acceptable but less precise calibrations were achieved.

The gas space heating EUIs for retail, health, and grocery were within 15 percent of the values used by the NYPP. Both the office EUIs were consistently lower than the NYPP values, i.e., the upstate EUI was higher than the downstate EUI. The restaurant EUIs were within 15 percent; but, in this case, the downstate EUI was lower, while the upstate EUI was higher than the NYPP value. The warehouse EUI was within 15 percent of the downstate NYPP EUI, but significantly higher than the upstate NYPP EUI. Since the upstate NYPP EUI is considerably lower than the downstate NYPP EUI (which is counter to expectations, since upstate New York is colder than downstate), the NYPP EUIs suggest that there are significant structural or operational differences between upstate and downstate warehouses that cannot be captured simply by simulating the same prototype with different weather data.[8]

[8] On the other hand, absent the presence of these differences, it remains an open question, outside the scope of the present study, as to why the NYPP data, themselves, are inconsistent

Table 4-8 Calibration Results.

	Downstate			Upstate		
	ACEEE (kBtu/ft2)	NYPP (kBtu/ft2)	(%diff)	ACEEE (kBtu/ft2)	NYPP (kBtu/ft2)	(%diff)
Office:						
gas heat	44.4	48.7	-9	59.2	77.4	-24
elec cool	9.6	9.9	-3	8.5	9.4	-9
elec vent	11.7	9.2	26	11.8	6.0	98
elec lght	21.4	21.5	-0	21.4	21.5	-0
elec misc	14.9	15.2	-2	15.0	15.2	-1
gas dhw	6.6	6.7	-0	6.6	6.7	-0
Retail:						
gas heat	57.1	53.2	7	73.7	66.7	10
elec cool	9.7	9.1	7	6.4	7.4	-13
elec vent	8.9	5.6	59	8.9	2.7	229
elec lght	16.6	16.6	-0	16.6	16.6	-0
elec misc	7.8	8.0	-3	8.4	8.0	3
gas dhw	5.8	5.9	-1	5.8	5.9	-1
Health:						
gas heat	97.3	93.6	4	131.4	121.3	8
elec cool	14.1	22.1	-36	9.8	5.0	96
elec vent	6.4	11.0	-42	6.5	6.3	3
elec lght	16.1	16.0	1	16.1	16.0	1
elec misc	16.1	16.0	1	15.7	16.0	-2
gas dhw	15.3	15.2	1	15.3	15.2	1

with one another for this end use and building type.

Table 4-8 Calibration Results (continued).

	Downstate			Upstate		
	ACEEE (kBtu/ft2)	NYPP (kBtu/ft2)	(% diff)	ACEEE (kBtu/ft2)	NYPP (kBtu/ft2)	(%diff)
Grocery:						
gas heat	84.4	78.0	8	134.6	116.8	15
elec cool	11.4	11.7	-3	7.2	9.1	-22
elec vent	19.9	5.6	257	20.4	6.8	201
elec lght	45.1	44.1	2	45.1	44.1	2
elec misc	107.9	113.9	-5	106.9	113.9	-6
gas dhw	14.4	14.7	-2	14.4	14.7	-2
Restaur:						
gas heat	99.0	94.9	4	143.9	107.3	34
elec cool	11.5	14.0	-18	7.1	6.5	9
elec vent	12.1	7.7	57	12.3	2.8	338
elec lght	18.7	19.0	-2	18.7	19.0	-2
elec misc	11.8	11.7	1	11.8	11.7	1
gas dhw	40.5	41.0	-1	40.5	41.0	-1
Warehse:						
gas heat	42.7	46.7	-9	56.7	14.1	304
elec cool	4.5	5.9	-24	2.8	6.2	-54
elec vent	6.1	2.8	122	6.3	1.7	263
elec lght	8.3	8.3	0	8.3	8.3	0
elec misc	6.4	6.2	2	6.4	6.2	2
gas dhw	2.9	2.8	2	2.9	2.8	2

The electric space-cooling EUIs for only office and retail were within 15 percent of the NYPP EUIs. For health and restaurant, due to differences between the upstate and downstate NYPP values (see previous comment regarding warehouse space heating), the prototype EUIs fell in the middle of the range of NYPP EUIs, but in a consistent pattern (i.e., the upstate EUI is higher than the downstate EUI). For the grocery, both upstate and downstate EUIs were lower than the NYPP EUIs, with the upstate EUI significantly lower than the NYPP EUI. For the warehouse, the prototype EUIs were consistently lower than the NYPP EUIs. Since the upstate NYPP EUI for cooling was higher than the downstate EUI, there may be important differences between upstate and downstate warehouses that cannot be captured using only weather data.

The poorest area of calibration was ventilation. For all building types, the prototype EUIs were rarely within 20 percent of the NYPP EUIs. However, concerns regarding the calibration for this end use are mitigated somewhat by two considerations. First, the present study is concerned primarily with the impacts of DSM on gas space heating and of fuel-switching on electric space cooling; ventilation energy use is a secondary concern. Second, conversations with energy analysts confirm that the empirical basis for ventilation EUIs is probably the weakest of all end uses. The end use is often not well-defined and can be difficult to estimate separately from heating and cooling energy use. That is, the poor calibration observed for this end use may be the result of reliance on possibly un-realistically low (and certainly un-verified by, for example, end-use metering) EUIs developed for NYPP.

The cumulative effect of the EUIs developed in the calibration process is summarized in Table 4-9. The Table presents both 1991 commercial sector gas sales for each utility service territory and the gas consumption resulting from the calibrated end-use gas EUIs for the six prototypes, adjusted for saturation, times the floor area represented by each building type (see Table 4-1).

Table 4-9. Reconciliation of Prototype Energy Use to 1991 Commercial Sector Gas Sales.

	1991 Utility Commercial Sector Gas Sales (thousands DTh)	Gas Consumption of Six ACEEE Prototypes (thousands DTh)	Ratio of 1991 Gas Sales to Prototype Gas Consumption
LILCo	14,629	12,068	1.212
BUG	12,208	12,141	1.006
NFG	20,282	12,235	1.658

Total gas consumption by the six prototypes is less than total utility commercial sector gas sales due to several reasons. First and most importantly, gas is consumed in building types other than those for which prototypes were developed (e.g., schools, lodging, and miscellaneous). Second, the calibrated EUIs do not exactly match the EUIs developed for NYPP to forecast gas sales; as mentioned previously, the downstate prototype is calibrated to the simple average of the EUIs developed for LILCo and ConEd.

If we correct for the first factor by using the NYPP EUIs to include building types not explicitly considered in this study, the model results are 8 percent higher, 6 percent higher and 10 percent lower than reported 1991 commercial sector sales by LILCo, BUG, and NFG respectively. This comparison suggests our data are quite consistent with actual utility sales. That is, forecast data are intended to represent typical consumption patterns, whereas 1991 gas sales result from the particular economic and climatic conditions influencing gas use in 1991. Since 1991 was a warm year compared to historical averages (Schultz 1992), lower than average gas sales should result (leading to ACEEE over-estimates of gas sales). Indeed, warmer weather in 1991 appears to be a plausible explanation for ACEEE's over-estimates for LILCo and BUG. The under-estimate for NFG, however, cannot be explained by weather. In this case, we believe the under-estimate results from a combination of errors introduced by the floor areas and EUIs assumed in the analysis. Nevertheless, the cumulative effect of these errors is tolerable (only a 10 percent under-estimate), although we believe that this is a worthy area for future research.

The simple ratio of utility 1991 commercial sector gas sales to the gas consumption of the six prototypes is used to scale the energy efficiency results for the six ACEEE prototypes for the building types for which prototypes were not developed and to calibrate energy efficiency results to 1991 utility commercial sector gas sales.

COMMERCIAL SECTOR ENERGY EFFICIENCY MEASURES

To determine the technical and economic potential for improvements to commercial sector gas energy-efficiency, the energy savings and cost-effectiveness of ten gas space heating, seven gas hot water heating, and five gas cooking energy efficiency measures were evaluated. After defining each measure, the cost of measures and the applicability of the measures to the building types considered is discussed.

Ten gas space-heating energy-efficiency measures were analyzed. The energy effects of each measure were simulated using the DOE-2 building energy analysis program for each applicable building prototype. Interactive effects were treated explicitly by simulating the measures cumulatively in the order of cost-effectiveness. That is, the order of simulation was designed to follow the approximate order of decreasing cost-effectiveness (the most cost-effective measures were simulated first; the least cost-effective measures were simulated last, assuming the presence of the more cost-effective measures). Through this process interactive effects between measures were captured automatically and in the appropriate order.[9] The cost of saved gas for each measure and building type was then calculated using measure cost and lifetime information and the results of the energy simulations.

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[9] This procedure follows that used in the residential sector analysis (Chapter 2) with one exception. In the analysis of energy efficiency measures for the residential sector, energy savings from the sum of a package of cost-effective measures are re-allocated among individual measures; the effect is to increase the energy savings attributed to the more expensive measures within the group of cost-effective measures and decrease the savings of the less expensive measures. No such reallocation was performed for the analysis of energy efficiency measures in the commercial sector, primarily because of the difficulty of determining the appropriate threshold for cost-effectiveness. Instead, the savings attributable to each measure are taken directly from the simulations as increments assuming the presence of more cost-effective measures. These savings are referred to as "interactive savings" in the example given of this method in Chapter 2.

The ten space heating measures are:

1. Reset HVAC Supply Air Temperature ("Reset SA Temp") for central HVAC systems (office, retail, and health) re-sets the temperatures in the main supply air ducts hourly to satisfy heating load of the coldest zone. Operation of central HVAC systems without this measure requires manually setting hot deck temperatures to a high temperature (105 degrees F) to ensure the highest expected load will be met during the heating season. Re-setting this temperature lower on an hourly basis to just meet the actual heating load of the coldest zone results in significant gas heating energy savings.[10] This measure is modeled within DOE-2 using an algorithm that compares, each hour, the heating demands of all zones and the minimum hot deck temperature required to satisfy the highest heating load.

2. Boiler Tune-up ("Boiler Tune") refers to general improvements to gas boilers in central HVAC systems (office, retail, health) to improve combustion efficiency by 5 percent (Zoellick 1992). Examples of these improvements include system balancing, duct sealing, thermostat calibration and checking damper operation. The base level of boiler efficiency used in the calibration is 75 percent. This measure is modeled by re-specification of boiler efficiency input to DOE-2.

3. Time Clocks/Temperature Set-back ("Temp Set-Back") are measures to control more precisely the operating hours of the gas heating system in a building. By lowering space temperatures during non-occupied hours, gas energy use for heating is reduced. The measure is modeled by lowering heating temperature set-points to 55 degrees F during non-business hours. This measure is modeled by re-specification of the hourly schedule of temperature set-points input to DOE-2.

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[10] Due to the interaction of this measure with cooling and ventilation energy, electricity consumption may be increased. The cost of saved gas for this measure was calculated with an additional cost-penalty to account for the increase in electricity use. The penalty was calculated by multiplying the increase in electricity use by the avoided cost of electricity (see Table 1-1). No other measure resulted in an increase in electricity use of more than 2%.

4. HVAC Heat Recovery ("HVAC Heat Rec") recovers heat that would normally be exhausted in the return air of a central HVAC system to preheat supply air. It saves gas by reducing the amount of gas that would otherwise be required to preheat supply air. This measure is modeled within DOE-2 using an algorithm that calculates the amount of recoverable heat available in the return air to be exhausted.

5. Higher-Efficiency Boilers ("Hi-Eff Boiler") are forced draft, four pass firetube boilers with rotary damper, characterized fuel valve, and high velocity gas burner for precise fuel to air mixture and high combustion efficiency. These measures increase boiler efficiency to 85 percent (Zoellick 1992). The efficiency of a standard, forced draft, gas fired, watertube boiler is 80 percent. This measure is modeled by re-specifying boiler efficiency input to DOE-2.

6. Higher-Efficiency Furnaces ("Hi-Eff Furnace") rely on similar advanced designs and control techniques to increase furnace efficiency by 6 percent. The efficiency of a standard furnace is 74 percent. This measure is modeled by re-specification of furnace efficiency input to DOE-2.[11]

7. Double-Pane Windows ("Dbl Pane") reduce heating loads by improving the thermal integrity of windows to a center of glass U-value of 0.53, excluding outside air film coefficient and the window frame. This measure is modeled by re-specifying of the window U-value and shading coefficient input to DOE-2.

8. Low-Emissivity Windows ("Low-E Glass") reduce heating loads by improving the thermal integrity of windows to a center of glass U-value of 0.24, excluding outside air film coefficient and the window frame. This measure is modeled by re-specifying the window U-value and shading coefficient input to DOE-2.

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[11] High-efficiency furnaces will soon be mandated by recent Federal standards for minimum appliance energy efficiency. For this reason, we will note the contribution of this measure to total savings separately in discussing our findings.

9. Roof Insulation ("Roof Ins") reduces heating loads by improving the thermal integrity of the roof. The measure is modeled by increasing the level of insulation input to DOE-2 to R-19, using either rigid board insulation under built-up roofing or fiberglass insulation under the roof deck.[12]

10. HVAC System Maintenance ("HVAC Maint") refers to general improvements to HVAC distribution systems to reduce wasted gas heat by 5 percent (Zoellick 1992). Examples of these improvements include system balancing, duct sealing, thermostat calibration and checking damper operation. This measure is modeled by re-specifying the base level of either the gas boiler or gas furnace efficiency input to DOE-2.

Seven gas water heating energy-efficiency measures were analyzed based on preliminary engineering estimates developed by Xenergy for this study (Zoellick 1992). The preliminary estimates were re-calibrated to NYPP gas water heating EUIs by service territory. The measures included:

1. Lower DHW Temperature ("Lower Temp") reduces gas use through a one-time reduction of hot water temperature from between 130° and 140° F to 120° F. This measure is modeled by reducing the energy required to heat water from an assumed ground water temperature of 60° F to 120° F instead of 130° or 140° F, and by reducing the energy lost through the walls of the tank due to the lower temperature of water.

2. High-Efficiency Boiler ("Hi-Eff Boiler") is based on a 12-hp pulse combustion gas fired boiler that increases efficiency to 85 percent (Zoellick 1992). The efficiency of a standard, forced draft, gas fired, watertube boiler is 80 percent. This measure is modeled by increasing the overall efficiency of gas boiler in meeting hot water loads and maintaining hot water temperatures in the tank.

[12] In contrast to the residential energy efficiency analysis, we did not consider wall insulation as an energy efficiency option for the commercial sector. This decision stems the reduced need for heating in the commercial sector because commercial buildings have: (1) higher internal gains when occupied; and (2) reduced or no occupancy during the late evening and early morning hours when heating needs are greatest.

3. High-Efficiency Stand-Alone Water Heater ("Hi-Eff Stdaln") is a stand-alone water heater that also includes increased insulation, an intermittent ignition device, and a power burner. It increases overall efficiency to 72 percent compared to the efficiency of standard stand-alone, atmospheric, gas fired water heater of 54 percent (Zoellick 1992). This measure is modeled by increasing the overall efficiency of the standalone water heater in meeting hot water loads and maintaining hot water temperatures in the tank.

4. Boiler Tune-up ("Boiler Tune") refers to general improvements to gas boilers to improve combustion efficiency by about 5 percent.

5. Tank Insulation ("Tank Ins") increases tank insulation from R-5 to R-12 thereby reducing heat losses through the tank walls in proportion to the increase in R-values.

6. Pipe Insulation ("Pipe Ins") adds pipe insulation to exposed pipe runs nearest the hot water heater or boiler. This measure is modeled by reducing heat losses for an assumed exposed bare pipe run of four feet to that for R-3 insulation over the same exposed area.

7. Auto Temperature Reset ("Auto Reset") uses a time-clock to lower hot water temperatures during off-hours. This measure is modeled by calculating the reduction in tank wall heat loss during off-hours resulting from a lower hot water temperature.

Five gas cooking energy-efficiency measures were analyzed. The analysis was performed with a spreadsheet model developed by ACEEE based on data developed by Lobenstein and Hewett (1992) in a study prepared for Minnegasco. A single analysis was performed for all building types and then extrapolated to each building type using building and service territory specific EUIs. The measures are listed below. All savings estimates come from the Minnegasco study.

1. Standard to Direct Convection Oven ("Std-Dir Conv"). Convection ovens use fans located in the rear of the oven compartment to circulate heated air over and around the food

being cooked, accelerating heat absorption. Compared to a conventional oven, gas savings average approximately 50 percent.

2. Indirect to Direct Convection Oven ("Ind-Dir Conv"). Convection ovens come in two configurations -- direct and indirect. Indirect convection ovens circulate air heated from the walls of the oven compartment while direct convection ovens circulate hot flue gases. Direct convection ovens are more efficient because the flue gases they circulate are hotter. Compared to indirect ovens, direct ovens reduce gas use by approximately 30 percent.

3. Catalytic Infrared Fryer ("Cat IR Fry"). Infrared fryers use ceramic plate burners to increase combustion temperatures to 1650° F or higher. Increasing temperatures to these levels creates electromagnetic energy which vibrates the atoms in the absorbing object, in this case the frying oil, causing its temperature to rise. In this way heat is delivered directly to the product, without relying on convective or conductive heat transfer. Relative to conventional fryers, energy use is reduced approximately 35 percent. So-called "catalytic" infrared fryers have improved ceramic plates relative to standard infrared fryers, increasing the energy savings compared to conventional fryers to approximately 43 percent.

4. Infrared Griddle ("IR Griddle"). Infrared griddles operate similarly to infrared fryers, except the griddle plate is heated instead of the frying oil. Relative to conventional griddles, infrared griddles reduce gas use by approximately 27 percent.

5. Power Burner Range ("Pwr BurnR"). Power burners fully mix the gas and combustion air in the burner (as opposed to incomplete mixing when secondary combustion air is drawn from around the burner, as in a conventional burner), reducing energy use approximately 24 percent.

The Cost and Life Expectancy of Commercial Sector Gas Energy Efficiency Measures

In addition to energy use, the lifecycle cost of gas energy-efficiency measures depends on two inputs: the capital and operating (not excluding energy) costs[13] of the measures, and their life expectancy. Cost and life expectancy data were developed based on either the most recent estimates available in the literature or information developed specifically for the New York State region.

Generally speaking, costs are developed for retrofit applications of measures. For the measures involving equipment up-grades (to higher efficiency or new technologies) for space heating, water heating, and cooking, however, only incremental costs are considered beyond a base technology. Accordingly, these measures would only be considered at time of replacement, while the remaining measures (all retrofits) could be considered at any time.

Three primary sources of information were used to develop measure costs and lifetimes for the gas energy-efficiency measures. The first was an analysis of commercial sector conservation measures performed for the Bonneville Power Administration (UIC 1988). This source was used extensively to develop cost and lifetime information for the gas space heating energy-efficiency measures. The second was data developed by Xenergy specifically for use in this study (Zoellick 1992). These data were used in the analyses of several gas space heating measures and all the gas water heating energy efficiency measures. The third was Lobenstein and Hewett (1992), which was used for the analysis of all the gas cooking energy-efficiency measures.

The measure cost and lifetime information developed for each measure and its source is summarized in Tables 4-10 through 4-12 for the gas space heating, water heating, and cooking measures, respectively. To facilitate comparisons, the costs presented are normalized to a

[13] This analysis assumes that the energy-efficiency measures do not increase non-energy operating costs, such as changes in maintenance costs. The issue of increased or decreased operating costs for the gas energy-efficiency measures is treated implicitly through the sensitivity analysis which examines the impact of higher and lower measure costs on the findings.

Table 4-10. Summary of Gas Space Heating Energy-Efficiency Measure Costs and Lifetimes.

Measure	Cost	Units ($1991)	Lifetime	Source/Notes
Reset SA Temp	0.03	$/sqft	11	UIC 1988
Boiler Tune	0.30	$/kBtuh	5	Zoellick 1992; lifetime - eng. judgement
Temp Set-back	0.09	$/sqft	10	UIC 1988
HVAC Heat Rec	0.35	$/sqft	14	UIC 1988
Hi-Eff Boiler	2.00	$/kBtuh	15	Zoellick 1992; incr. cost
Hi-Eff Furnace	1.90	$/kBtuh	15	SRC 1990; incr. cost
Dbl Pane	21.00	$/sqft window	20	Reed 1992b
Low-E Glass	24.40	$/sqft window	20	Reed 1992b
Roof Insulation	0.77	$/sqft roof	20	UIC 1988; retrofit
HVAC Maint - central	0.50	$/sqft	5	Zoellick 1992; lifetime - eng. judgement
HVAC Maint - packaged	0.25	$/sqft	5	Zoellick 1992; lifetime - eng. judgement

Table 4-11. Gas Hot Water Energy-Efficiency Measure Cost, Lifetime.

	1991 Cost	$/unit	Lifetime
Lower Temp	$0.00	tank	20
Hi-Eff Boiler	900.00	boiler	15
Hi-Eff Stdaln	166.00	tank	10
Boiler Tune	300.00	boiler	5
Tank Insulation	5.40	sq ft	10
Pipe Insulation	3.74	ft pipe	10
Auto Reset	71.21	tank	10

Source: Zoellick 1992, UIC 1988.

Table 4-12. Gas Cooking Energy-Efficiency Measure Cost, Performance, Lifetime.

Measure	Cost	Avg. (ccf) Saved	Savings	Lifetime
Std-Dir Convection Oven	$1338	720	50%	20
Ind-Dir Convection Oven	0	282	28	20
Catalytic IR Fryer	1253	674	43	15
IR Griddle	1048	292	27	20
Power-Burner Range	870	248	24	20

Source: Lobenstein and Hewett 1992.

common metric, such as $/sqft of floor area, $/kBtuh of heating capacity, or $/unit (in the case of cooking), as appropriate. For the analysis of cost-effectiveness, these costs are then scaled by the specific characteristics of the prototypes examined (i.e., by floor area or by peak heating requirements). Measure lives for cooking are capped at 20 years to allow for equipment change-out during remodeling.

The Applicability of Gas Energy-Efficiency Measures

Two steps determine the applicability of gas energy-efficiency measures in commercial buildings in New York State. The first is to determine technical feasibility, which requires mapping each measure to appropriate commercial building types. The second is remaining potential by estimating the proportion of commercial buildings of each type that have not yet installed each measure.

The mapping required by the first step is summarized in Tables 4-13 to 4-15 for the gas space heating, water heating, and cooking measures, respectively. Tables 4-13 and 4-14 calculate applicability as a fraction of the building floor area in the service territory where the measure could be applied. The values were derived from the saturation of measures in the NMPC service territory (Xenergy 1988), which, in the absence of more saturation data for each service territory, was assumed to be identical for all three service territories. The NMPC survey data did not report saturations for high-efficiency gas boilers and furnaces and low-E windows; the existing saturation of the high-efficiency heating equipment is assumed to be ten percent and that for low-E windows is assumed to be zero. Table 4-14 separately reports technical feasibility and existing penetration for gas water-heating measures.

Table 4-15 gives the applicability and technical feasibility of gas cooking energy-efficiency measures in a slightly different format. In this table, applicability and existing penetration is expressed on a technology-specific basis with the assumption that the distribution of cooking technologies is constant across all building types, apparently a reasonable assumption without survey information that would permit a more accurate mapping of specific types of cooking equipment for particular buildings.

Table 4-13. Applicability of Gas Space Heating Energy-Efficiency Measures to Commercial Building Prototypes (%).

Measure	Office Cnt	Office Pkg	Retail Cnt	Retail Pkg	Hospital	Super-market	Restau-rant	Ware-house
Reset SA Temp	95.4		94.7		87.4			
Boiler Tune	74.8		82.1		0.0			
Temp Set-back	69.6	69.6	73.8	73.8	59.0	83.1	85.7	87.7
HVAC Heat Rec	95.6		99.4		73.0			
Hi-Eff Boiler	90.0		90.0		90.0			
Hi-Eff Furnace		90.0		90.0		90.0	90.0	90.0
Double-Pane	21.0	21.0	37.0	37.0	25.0	27.0	20.0	36.0
Low-E Glass	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Roof Insulation	42.0	42.0	36.0	36.0	13.0	71.0	39.0	18.0
HVAC System Maint. - central	66.2		85.6		43.5			
HVAC System Maint. - packaged		66.2		85.6		86.9	93.8	93.7

Source: Xenergy 1988.

Table 4-14. Gas Hot Water Energy-Efficiency Measure Applicability (%).

Technical Feasibility

	Office	Retail	Hospital	Supermkt	Restrnt	Warehse
Lower Temp	100	100	0	100	0	100
Auto Reset	100	100	98	100	98	100
Pipe Ins	100	100	98	100	98	100
Tank Ins	100	100	98	100	98	100
Boiler Tune	8	1	87	0	2	18
Hi-Eff Boiler	8	1	87	0	2	18
Hi-Eff Stdaln	92	98	12	67	96	81

Existing Penetration

	Office	Retail	Hospital	Supermkt	Restrnt	Warehse
Lower Temp	5.3	2.9	17.3	2.4	8.3	0.0
Auto Reset	3.3	4.2	16.1	4.1	1.7	0.0
Pipe Ins	36.7	17.8	71.0	62.9	13.5	11.3
Tank Ins	12.7	18.5	65.0	7.0	17.7	12.4
Boiler Tune	25.2	17.9	100.0	90.3	12.1	5.7
Hi-Eff Boiler	0.0	0.0	0.0	0.0	0.0	0.0
Hi-Eff Stdaln	0.0	0.0	0.0	0.0	0.0	0.0

Source: Xenergy 1988.

Table 4-15. Gas Cooking Energy-Efficiency Measure Applicability (%).

	Equip. Type as % of Total Cooking	Technical Feasibility	Existing Penetration	Applicability Factor
	(a)	(b)	(c)	(d)
Ind-Dir. Conv. Oven	20	50	38	3
Std-Dir. Conv. Oven	20	60	50	2
Catalytic IR Fryer	19	90	10	15
IR Griddle	20	90	10	16
Power Burner Range	26	23	1	9

Applicability factor = [a]*([b]-[c]).
Source: ACEEE estimates based on Lobenstein and Hewett 1991.

The second step is to determine how many commercial buildings have gas space heating, water heating, or cooking in each of the three service territories (LILCo, BUG, and NFG). Table 4-1 (in the Methodology sub-section), summarizes floorspace estimates and end-use fuel saturations for gas space heating, water heating, and cooking for each of the three utility service territories.

As described in the Methodology sub-section, two additional prototypes were developed for the office and retail building types to capture important differences in energy use in central and packaged HVAC systems and the large relative saturations of both system types in these buildings. Table 4-16 presents the results of our analysis of LILCo and NMPC survey data (Xenergy 1988 and Xenergy 1990) which were used to develop relative saturations for these system types for downstate and upstate respectively.

Table 4-16. Relative Saturation of Central and Package HVAC for Office and Retail.

	Downstate (LILCo, BUG)	Upstate (NFG)
Office-central HVAC	0.27	0.67
Office-package HVAC	0.73	0.33
Retail-central HVAC	0.23	0.11
Retail-package HVAC	0.77	0.89

Source: Xenergy 1988, Xenergy 1990.

THE COST-EFFECTIVE TECHNICAL POTENTIAL FOR GAS ENERGY-EFFICIENCY

The results of the simulations or spreadsheet analyses, combined with the cost and lifetime of the measures, adjusted for their applicability, the existing penetration of measures, the fuel saturation of the each end use, and a real discount rate of 5 percent, yield a cost of saved gas (in $/DTh) for each energy-efficiency measure in each building type.

The results are discussed from both a commercial gas customer perspective (represented by the average retail price of gas) and a gas utility perspective (represented by an avoided cost for gas). The average gas price used to evaluate technical potential from a commercial gas customer perspective are $6.00/DTh, $8.50/DTh, and $5.00/DTh for LILCo, BUG, and NFG, respectively, which are based on values in Table 1-2, rounded to the nearest half dollar. Since there is no consensus on gas avoided costs, the results from the gas utility perspective are described with reference to a range of possible avoided costs from $2.50 and $4.00/DTh, which is based on the preliminary estimates of avoided costs for year-round and winter-only energy use, as discussed in Chapter 1, and summarized in Table 1-1.

Four sets of results are presented in order to capture the potential effects of both the additional program costs required to deliver measures through utility DSM programs and pessimism regarding measure cost and performance. The first case presents results based only on the installed gas energy efficiency technology costs (or measure costs) documented above. The second case presents results based on adding 25 percent to the measure cost assumed in the first case. The third case adds 50 percent to the measure cost and the fourth case adds 75 percent to the measure cost.

Adding costs over and above the direct installation costs of the gas energy efficiency technologies addresses several concerns. First, added costs would be a natural consequence of utility-sponsored activities promoting the adoption of these technologies. In this regard, the additional costs can be thought of as proxies for the likely administrative, marketing, and evaluation costs that would be incurred by a utility running a DSM program for these technologies. For this reason, when describing results from the utility cost perspective (using a range of gas avoided costs), we will refer to results from the third case in which the total cost has been increased by 50 percent over the measure costs developed for the first case.

Second, the various cases can also be thought of as sensitivities on the direct cost and performance of the energy efficiency measures. For example, considering costs 25 percent higher than those assumed in the first case can be thought of either as direct-cost sensitivity or as a sensitivity on the estimated energy savings. In this case, costs 25 percent higher could also result from energy savings 33 percent lower than that modeled in the first case.

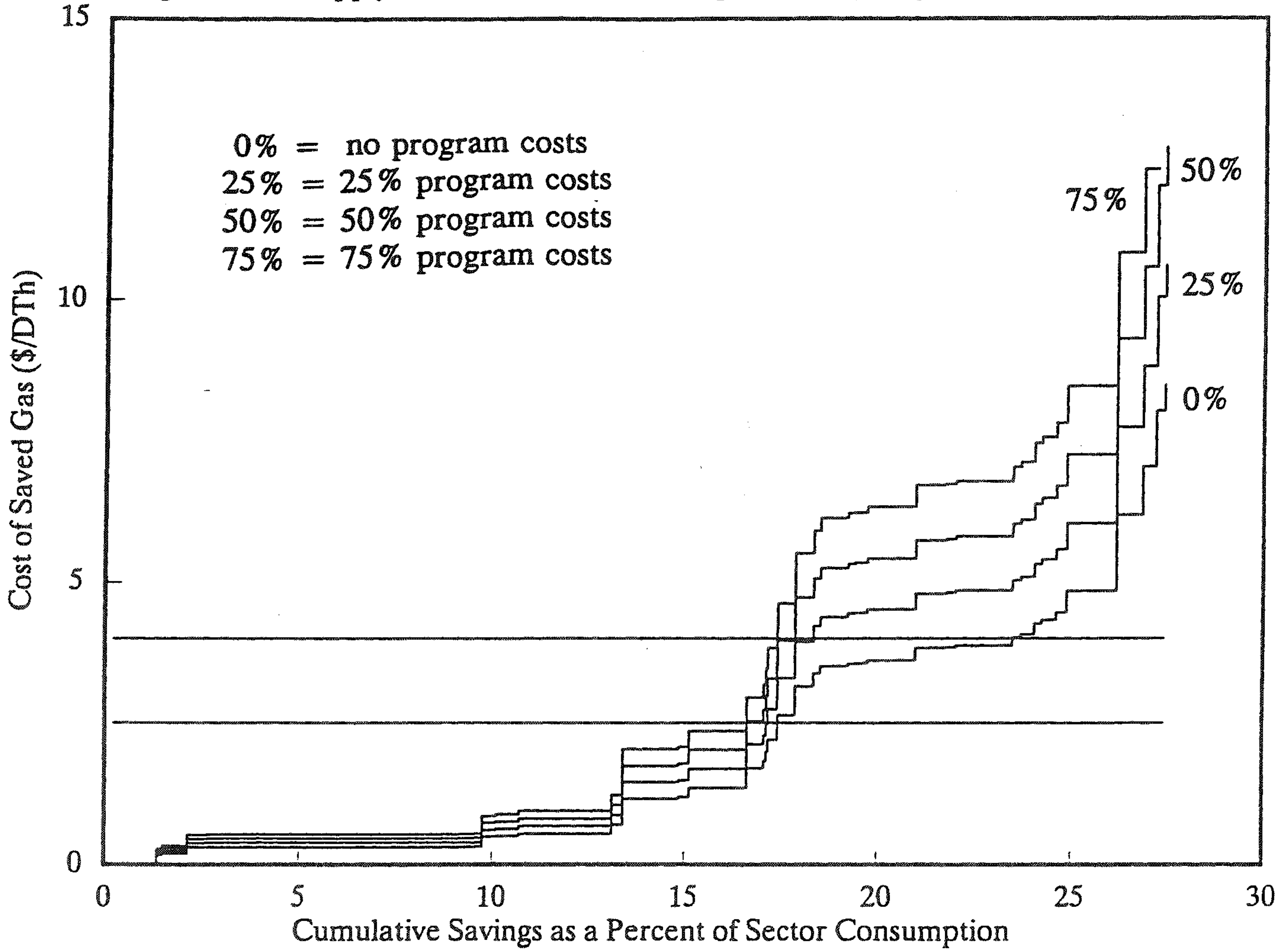
For each utility service territory, results are first summarized on an aggregated basis, considering both the various cost-effectiveness thresholds and the various sensitivities considered. Next, the results are summarized by end use and building type, considering only the results from the third case in which measure costs are increased by 50 percent over those developed for the first case. Finally, the results for individual measures are discussed. All results are discussed from the perspective of some future date (e.g., 2020) at which time it is reasonable to expect that sufficient time has elapsed to allow widespread retrofit activity and to ensure turnover of most of the existing equipment stock. This perspective acknowleges that equipment turnover and retrofitting will not take place instantaneously.

The presentation of detailed results, by measure, follows a common order: The results for each measure are presented in order of increasing cost; measures with the lowest cost are presented first, while those with the highest cost are presented last. The amount of gas that could be saved annually is presented in thousands of decatherms, which is also equal to thousands of MMBtu. Gas savings from the prototype analyses have been adjusted upwards to extrapolate our results to the building types not examined (schools, hotels, and miscellaneous). We also present the cumulative amount of saved gas, expressed as the fraction of total annual gas sales for the commercial sector of each utility. An arbitrary ceiling of $10/DTh is used to limit the number of measures presented in each table.

The Potential For Commercial Sector Gas Energy-Efficiency For The LILCo Service Territory

Table 4-17 summarizes the economic potential for commercial sector gas energy efficiency measures for each of the perspectives and sensitivities considered. Figure 4-1 presents the results graphically. Considering the case in which measure costs are increased by 50 percent, the results suggest that 17 percent or 2.4 million DTh to 18 percent or 2.6 million DTh of the gas consumed annually by the commercial sector could be saved with energy efficiency measures costing less than $2.50/Dth and $4.00/DTh, respectively. From the customer perspective ($6.00/DTh), this case indicates that 24 percent or 3.4 million DTh could be saved cost-effectively. Replacement measures (or all higher efficiency equipment) account for a small fraction of these savings, totalling 4, 6, and 15 percent of the cost-effective savings potential in each perspective, respectively. Among these replacement measures, savings due to high-efficiency gas furnaces (now covered by Federal law) contribute only 0, 1, and 8 percent to the total cost-effective savings potential in each perspective, respectively.

Figure 4–1. Supply Curve of Saved Gas, Long Island Lighting Co., Commercial Sector.



(Includes both mandated measures and measures that may be the target of utility DSM programs.)

Table 4-17. Summary of Commercial Sector Economic Gas Savings Potential - LILCo.

Perspective	Measure Cost + 0%	Measure Cost +25%	Measure Cost +50%	Measure Cost +75%
Utility - $2.50/DTh	n/a	17	17	17
Utility - $4.00/DTh	n/a	18	18	17
Customer - $6.00/DTh	26	25	24	19

The results appear to be robust with respect to the cost and performance sensitivities considered. Considering only the utility perspective, for example, if the cost of the energy efficiency measures is only 25 percent higher than the direct installed cost of the gas energy efficiency technologies (also corresponding to energy savings 33 percent lower), the cost-effective energy-efficiency potential does not change at the utility cost-effectiveness thresholds of $2.50/DTh and $4.00/DTh, respectively. If the cost of the energy efficiency measures is 75 percent higher than the measure costs, the cost-effective energy-efficiency potential decreases very slightly (to 17 percent) only at the higher cost-effectiveness threshold $4.00/DTh.

Table 4-18 summarizes our findings from the third case (measure costs + 50%) by end use. Savings are expressed both as percentages of annual gas consumption by the end use, as well as a percentage of total commercial sector gas consumption. The percentage of total sectoral sales accounted for by each end use is also indicated.

Table 4-18. Summary of Commercial Sector Economic Gas Savings Potential by End Use - LILCo. - Measure Cost + 50%

Perspective	Space Heat (77%)		Water Heat (8%)		Cooking (10%)	
	% of end use	% of sector	% of end use	% of sector	% of end use	% of sector
Utility - $2.50/DTh	19	14	23	2	15	2
Utility - $4.00/DTh	20	16	24	2	15	2
Customer - $6.00/DTh	28	21	28	2	15	2

Table 4-18 highlights the importance of energy efficiency measures to reduce gas used for space heating. Space heating accounts for the majority of gas consumption in the commercial sector (77 percent). Significant cost-effective savings are achievable from each perspective considered and these savings would have a major impact on commercial sector gas consumption. Despite the cost-effectiveness of measures directed toward reducing gas water heating and cooking energy use, the savings from these end uses account for only a modest portion of total commercial sector gas sales, although the results indicate that the majority of cost-effective savings for these end uses are highly cost-effective, costing less than the lowest cost-effectiveness threshold considered ($2.50/DTh). For example, all five cooking measures were found to be cost-effective under any scenario of gas avoided cost or cost/performance sensitivity.

Table 4-19 summarizes our primary findings separately by building type. The results are expressed both as a percentage of gas consumed by the building type and as a percentage of total commercial sector sales.

Table 4-19. Summary of Commercial Sector Economic Gas Savings Potential by Building Type - LILCo. - Measure Cost +50%

	Perspective					
	Utility-$2.50/DTh		Utility-$4.00/DTh		Customer-$6.00/DTh	
Building Type	% of Bldg	% of Sector	% of Bldg.	% of Sector	% of Bldg.	% of Sector
Office	25	10	25	10	31	12
Retail	13	3	13	3	22	6
Hospital	18	1	19	1	25	2
Grocery	27	2	28	2	32	2
Restaurant	0	0	5	1	7	1
Warehouse	0	0	0	0	5	0

Table 4-19 indicates that the greatest source of cost-effective commercial sector gas savings lies in the office sector. Offices account for the largest share of gas consumption (65 percent) and offer significant gas savings, under each perspective considered. There are also significant cost-effective savings available in the retail, hospital, and grocery sectors, yet the cumulative effect of savings from these buildings is modest as a percentage of total commercial sector gas sales.

The changes in cost-effective potential as a function of perspective provides insight into the cost-effectiveness of measures by building type. For example, the majority of savings for the office and supermarket and most of the savings for hospitals are highly cost-effective; only modest additional savings result from considering higher cost-effectiveness thresholds. The majority of (albeit modest) savings for restaurants and warehouses become cost-effective only at the higher thresholds.

Table 4-20 summarizes the individual results for the measures costing less than $10/Dth. The energy-efficiency measures contributing most to the cost-effective energy efficiency potential improve the control of HVAC systems, including the reset of supply air temperatures in central HVAC systems, and the night set-back of temperatures in both central and packaged HVAC systems. Significant energy savings also result from lowering hot water temperatures. Shell measures (double pane windows, low-e glass, and roof insulation) only appear to be cost-effective for some building types, notably hospitals. However, where cost-effective, they offer large energy savings.

Higher-efficiency equipment for space heating and water heating is generally cost-effective, but sometimes only marginally. Boiler tune-ups for space heating are highly cost-effective for offices and retail with central HVAC systems.

Table 4-20. Cost of Saved Gas - LILCO Commercial Sector.

End Use	Measure	Bldg	Savings 1000 DTh	Cum Savings 1000 DTh	Cum as % of Sector	CSG + 0% $/DTh	CSG +25% $/Dth	CSG +50% $/Dth	CSG +75% $/Dth
water heating	Lower temperature	supermarket	34	34	0.2	0.00	0.00	0.00	0.00
water heating	Lower temperature	office	88	122	0.8	0.00	0.00	0.00	0.00
water heating	Lower temperature	retail	64	186	1.3	0.00	0.00	0.00	0.00
water heating	Lower temperature	warehouse	2	188	1.3	0.00	0.00	0.00	0.00
cooking	Ind.-dir. conv.	all buildings	9	197	1.3	0.00	0.00	0.00	0.00
water heating	High-efficiency boiler	hospital	8	206	1.4	0.15	0.18	0.22	0.26
cooking	Std.-dir. conv.	all buildings	14	220	1.5	0.16	0.20	0.24	0.28
cooking	Cat. IR fry	all buildings	92	312	2.1	0.19	0.24	0.29	0.33
space heating	Double pane windows	hospital	79	391	2.7	0.30	0.38	0.45	0.53
cooking	Power burner	all buildings	33	424	2.9	0.31	0.38	0.46	0.54
space heating	Reset sa temperature	off cnt	941	1365	9.3	0.31	0.38	0.46	0.54
cooking	IR griddle	all buildings	61	1426	9.8	0.31	0.39	0.47	0.55
water heating	High-efficiency stand-alone un	office	52	1479	10.1	0.49	0.61	0.73	0.85
space heating	Tune boiler	off cnt	85	1564	10.7	0.50	0.63	0.75	0.88
space heating	Reset sa temperature	ret cnt	357	1921	13.1	0.54	0.68	0.81	0.95
space heating	Tune boiler	ret cnt	40	1961	13.4	0.70	0.87	1.04	1.22
space heating	Temperature set-back	off cnt	212	2173	14.9	1.16	1.45	1.73	2.02
space heating	High-efficiency boiler	hospital	39	2212	15.1	1.18	1.48	1.78	2.07
space heating	Roof insulation	supermarket	219	2431	16.6	1.34	1.68	2.01	2.35
space heating	Low-E glass	hospital	66	2497	17.1	1.69	2.11	2.53	2.95
water heating	High-efficiency stand-alone un	supermarket	9	2507	17.1	1.82	2.27	2.73	3.18
space heating	Roof insulation	hospital	5	2512	17.2	1.98	2.48	2.97	3.47
space heating	High-efficiency furnace	restaurant	38	2550	17.4	2.19	2.74	3.28	3.83
water heating	High-efficiency boiler	office	2	2552	17.4	2.35	2.94	3.53	4.11
space heating	Roof insulation	restaurant	66	2619	17.9	2.64	3.30	3.96	4.62
space heating	HVAC heat recovery	hospital	68	2686	18.4	3.15	3.94	4.72	5.51
space heating	High-efficiency boiler	ret cnt	25	2711	18.5	3.38	4.22	5.06	5.91
space heating	High-efficiency furnace	ret pkg	102	2813	19.2	3.50	4.38	5.26	6.13
space heating	High-efficiency furnace	warehouse	25	2838	19.4	3.55	4.44	5.33	6.22
water heating	High-efficiency stand-alone un	restaurant	49	2887	19.7	3.56	4.45	5.34	6.23
space heating	Temperature set-back	off pkg	181	3068	21.0	3.62	4.52	5.42	6.33
space heating	High-efficiency furnace	off pkg	114	3182	21.7	3.83	4.79	5.75	6.71
space heating	High-efficiency boiler	off cnt	37	3219	22.0	3.85	4.81	5.77	6.73
space heating	Roof insulation	ret pkg	214	3433	23.5	3.88	4.85	5.82	6.78
water heating	Tune boiler	office	1	3434	23.5	3.93	4.91	5.89	6.87
space heating	High-efficiency furnace	supermarket	31	3464	23.7	4.02	5.03	6.03	7.04
space heating	Double pane windows	off cnt	51	3515	24.0	4.07	5.09	6.11	7.13
space heating	Roof insulation	warehouse	27	3543	24.2	4.26	5.32	6.39	7.45
space heating	Roof insulation	ret cnt	56	3598	24.6	4.32	5.40	6.49	7.57
water heating	High-efficiency stand-alone un	retail	36	3635	24.8	4.47	5.58	6.70	7.82
water heating	High-efficiency stand-alone un	warehouse	1	3636	24.9	4.47	5.58	6.70	7.82
space heating	Roof insulation	off pkg	191	3827	26.2	4.84	6.05	7.26	8.47
water heating	Tank insulation	restaurant	10	3836	26.2	6.20	7.74	9.29	10.84
space heating	Double pane windows	off pkg	89	3926	26.8	6.20	7.75	9.29	10.84
space heating	Roof insulation	off cnt	49	3975	27.2	7.05	8.81	10.58	12.34
space heating	Double pane windows	restaurant	32	4007	27.4	8.03	10.04	12.05	14.05
water heating	Tank insulation	supermarket	1	4008	27.4	8.49	10.61	12.74	14.86
water heating	Tank insulation	warehouse	0	4008	27.4	9.55	11.93	14.32	16.71
water heating	Tank insulation	retail	6	4014	27.4	9.55	11.93	14.32	16.71
water heating	Tank insulation	office	1	4015	27.4	9.55	11.94	14.33	16.72
water heating	High-efficiency boiler	restaurant	0	4016	27.5	11.45	14.31	17.18	20.04
space heating	Double pane windows	ret pkg	243	4259	29.1	11.48	14.35	17.22	20.09
water heating	Tank insulation	hospital	0	4259	29.1	11.51	14.38	17.26	20.14
water heating	Pipe insulation	hospital	1	4259	29.1	11.81	14.77	17.72	20.67
space heating	Double pane windows	supermarket	14	4274	29.2	12.55	15.69	18.83	21.97
space heating	HVAC maintenance	restaurant	35	4308	29.5	12.57	15.72	18.86	22.01
space heating	Double pane windows	ret cnt	64	4372	29.9	12.72	15.90	19.08	22.26
water heating	Pipe insulation	supermarket	0	4372	29.9	13.29	16.61	19.93	23.26
space heating	Double pane windows	warehouse	38	4410	30.1	13.80	17.25	20.70	24.16
space heating	HVAC maintenance	supermarket	25	4435	30.3	14.62	18.27	21.93	25.58
water heating	Pipe insulation	restaurant	1	4436	30.3	16.34	20.42	24.51	28.59
water heating	Pipe insulation	warehouse	0	4436	30.3	17.07	21.34	25.60	29.87
water heating	Pipe insulation	retail	1	4437	30.3	17.07	21.34	25.60	29.87
water heating	Pipe insulation	office	0	4437	30.3	17.12	21.40	25.68	29.96
water heating	Tune boiler	restaurant	0	4437	30.3	19.13	23.91	28.69	33.47
space heating	HVAC heat recovery	off cnt	50	4487	30.7	19.93	24.91	29.89	34.88
water heating	Auto reset	retail	3	4490	30.7	21.93	27.41	32.89	38.37
water heating	Auto reset	warehouse	0	4490	30.7	21.93	27.41	32.89	38.37
water heating	Auto reset	office	1	4491	30.7	21.93	27.41	32.90	38.38
space heating	HVAC maintenance	ret pkg	86	4576	31.3	24.08	30.10	36.12	42.14
space heating	Low-E glass	off cnt	46	4623	31.6	25.34	31.68	38.01	44.35
space heating	HVAC maintenance	hospital	16	4638	31.7	26.40	33.00	39.60	46.21
space heating	HVAC maintenance	warehouse	22	4660	31.9	28.70	35.87	43.05	50.22
water heating	Auto reset	restaurant	2	4663	31.9	32.01	40.01	48.01	56.01
space heating	HVAC maintenance	ret cnt	36	4699	32.1	33.08	41.35	49.62	57.89
space heating	HVAC maintenance	off cnt	64	4763	32.6	34.88	43.60	52.32	61.04
space heating	HVAC maintenance	off pkg	83	4846	33.1	36.16	45.20	54.24	63.28
space heating	Low-E glass	off pkg	80	4926	33.7	39.29	49.11	58.94	68.76
water heating	High-efficiency boiler	retail	0	4926	33.7	43.10	53.87	64.65	75.42
water heating	High-efficiency boiler	warehouse	0	4926	33.7	43.10	53.88	64.65	75.43
water heating	Auto reset	supermarket	0	4926	33.7	43.86	54.83	65.79	76.76
space heating	Low-E glass	restaurant	22	4948	33.8	70.83	88.53	106.24	123.94
space heating	Low-E glass	ret pkg	124	5072	34.7	71.72	89.65	107.58	125.51
water heating	Tune boiler	retail	0	5072	34.7	71.98	89.98	107.97	125.97
water heating	Tune boiler	warehouse	0	5072	34.7	71.99	89.98	107.98	125.98
space heating	Low-E glass	supermarket	11	5082	34.7	73.40	91.75	110.09	128.44
space heating	Low-E glass	ret cnt	32	5114	35.0	80.80	100.99	121.19	141.39
space heating	Low-E glass	warehouse	21	5135	35.1	82.13	102.66	123.20	143.73

The Potential For Commercial Sector Gas Energy Efficiency For The BUG Service Territory

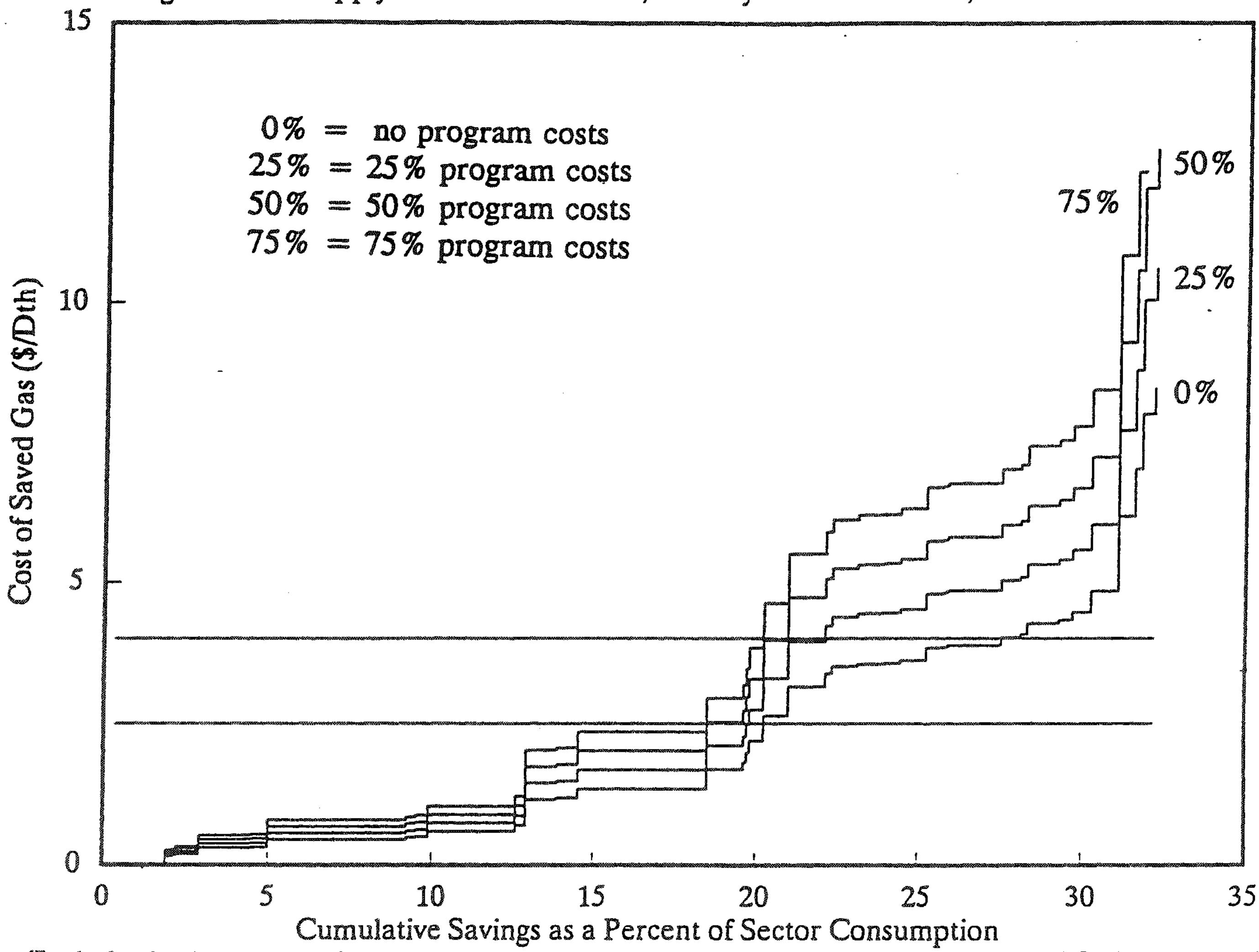
Table 4-21 summarizes the economic potential for commercial sector gas energy efficiency measures for each of the perspectives and sensitivities considered. Figure 4-2 presents the results graphically. Generally speaking, the cost-effectiveness results for the BUG service territory parallel those developed for the LILCo service territory since the same prototypes were analyzed using identical cost assumptions. The differences between the findings for the two utilities stem only from the differing amounts of gas consumption affected by the measures, as defined by differences in the population or building type between BUG and LILCo.

Considering the case in which measure costs are increased by 50 percent, the results suggest that 17 percent or 2.3 million DTh to 21 percent or 2.6 million DTh of the gas consumed annually by the commercial sector could be saved with energy efficiency measures costing less than \$2.50/Dth and \$4.00/DTh, respectively. From the customer perspective (\$8.50/DTh), this case indicates that 28 percent or 3.4 million DTh could be saved cost-effectively. Replacement measures (or all higher efficiency equipment) account for a small fraction of these savings, totalling 6, 8, and 16 percent of the cost-effective savings potential in each perspective, respectively. Among these replacement measures, savings due to high-efficiency gas furnaces (now covered by Federal law) contribute only 0, 2, and 9 percent to the total cost-effective savings potential in each perspective, respectively.

Table 4-21. Summary of Commercial Sector Economic Gas Savings Potential - BUG

Perspective	Measure Cost + 0%	Measure Cost +25%	Measure Cost +50%	Measure Cost +75%
Utility - \$2.50/DTh	n/a	20	19	19
Utility - \$4.00/DTh	n/a	22	21	20
Customer - \$8.50/DTh	32	32	31	31

Figure 4–2. Supply Curve of Saved Gas, Brooklyn Union Gas Co., Commercial Sector.



(Includes both mandated measures and measures that may be the target of utility DSM programs.)

The results appear to be robust with respect to the cost and performance sensitivities considered. Considering only the utility perspective, for example, if the cost of the energy efficiency measures is only 25 percent higher than the direct installed cost of the gas energy efficiency technologies (also corresponding to energy savings 33 percent lower), the cost-effective energy-efficiency potential increases by only one percent at the utility cost-effectiveness thresholds of $2.50/DTh and $4.00/DTh, respectively. If the cost of the energy efficiency measures is 75 percent higher than the measure costs, the cost-effective energy-efficiency potential decreases by only one percent at the higher cost-effectiveness threshold of $4.00/DTh.

Table 4-22 summarizes our findings from the third case (measure costs + 50%) by end use. Savings are expressed both as percentages of annual gas consumption by the end use, as well as a percentage of total commercial sector gas consumption. The percentage of total sectoral sales accounted for by each end use is also indicated.

Table 4-22. Summary of Commercial Sector Economic Gas Savings Potential by End Use - BUG - Measure Costs +50%

Perspective	Space Heat (75%)		Water Heat (10%)		Cooking (9%)	
	% of end use	% of sector	% of end use	% of sector	% of end use	% of sector
Utility - $2.50/DTh	17	13	25	2	15	2
Utility - $4.00/DTh	21	17	26	2	15	2
Customer - $8.50/DTh	30	24	29	2	15	2

Table 4-22 highlights the importance of energy efficiency measures to reduce gas used for space heating. As was found for LILCO, space heating accounts for the majority of gas consumption in the commercial sector (75%). Significant cost-effective savings are achievable from each perspective considered and these savings would have a major impact on commercial gas consumption. Despite the cost-effectiveness of measures directed toward reducing gas water heating and cooking energy use, the savings from these end uses account for only a modest portion of total commercial sector gas sales, although the results indicate that the majority of cost-effective savings for these end uses are highly cost-effective, costing less than the lowest cost-effectiveness threshold considered ($2.50/DTh). For example, all five cooking measures were found to be cost-effective under any scenario of gas avoided cost or cost/performance sensitivity.

Table 4-23 summarizes our primary findings separately by building type. The results are expressed both as a percentage of gas consumed by the building type and as a percentage of total commercial sector sales. The percentage of gas consumption accounted for by each building type is also indicated.

Table 4-23. Summary of Commercial Sector Economic Gas Savigns Potential by Building Type - BUG - Measure Cost +50%

	Perspective					
	Utility-$2.50/DTh		Utility-$4.00/DTh		Customer-$8.50/DTh	
Building Type	% of Bldg	% of Sector	% of Bldg.	% of Sector	% of Bldg.	% of Sector
Office	25	10	25	10	38	14
Retail	2	0	11	1	19	2
Hospital	19	4	29	6	29	6
Grocery	22	1	23	1	26	1
Restaurant	2	0	6	0	9	0
Warehouse	0	0	0	0	9	2

Table 4-23 indicates that, like LILCO, the greatest source of cost-effective commercial sector gas savings remains the office sector. Significant cost-effective savings are also available in the hospital and grocery sectors, but the overall contribution to total sales by these sectors is smaller.

The changes in cost-effective potential as a function of perspective provides insight into the cost-effectiveness of measures by building type. For example, the majority of savings for the office and supermarket and, to a lesser degree, for retail and hospital are highly cost-effective; only modest additional savings result from considering higher cost-effectiveness thresholds. The majority of (albeit modest) savings for restaurants and warehouses again become cost-effective only at the higher thresholds.

Table 4-24 summarizes the individual results for the measures costing less than $10/Dth. The energy-efficiency measures contributing most to the cost-effective energy efficiency potential improve the control of HVAC systems, including the reset of supply air temperatures in central HVAC systems, and the night set-back of temperatures in both central and packaged HVAC systems. Significant energy savings also result from lowering hot water temperatures. Shell measures (double pane windows, low-e glass, and roof insulation) only appear to be cost-effective for some building types, notably hospitals. However, where cost-effective, they offer large energy savings.

Higher-efficiency equipment for space heating and water heating is generally cost-effective, but sometimes only marginally. Boiler tune-ups for space heating are highly cost-effective for offices and retail with central HVAC systems.

Table 4-24. Cost of Saved Gas - BUG Commercial Sector.

End Use	Measure	Bldg	Savings 1000 DTh	Cum Savings 1000 DTh	Cum as % of Sector	CSG + 0% $/DTh	CSG +25% $/Dth	CSG +50% $/Dth	CSG +75% $/Dth
water heating	Lower temperature	supermarket	42	42	0.3	0.00	0.00	0.00	0.00
water heating	Lower temperature	warehouse	20	62	0.5	0.00	0.00	0.00	0.00
water heating	Lower temperature	office	60	122	1.0	0.00	0.00	0.00	0.00
cooking	Ind.-dir. conv.	all buildings	9	131	1.1	0.00	0.00	0.00	0.00
water heating	Lower temperature	retail	102	234	1.9	0.00	0.00	0.00	0.00
water heating	High efficiency boiler	hospital	23	257	2.1	0.15	0.18	0.22	0.26
cooking	Std.-dir. conv.	all buildings	13	270	2.2	0.16	0.20	0.24	0.28
cooking	Cat IR fry	all buildings	87	357	2.9	0.19	0.24	0.29	0.33
space heating	Double pane windows	hospital	164	520	4.3	0.30	0.38	0.45	0.53
cooking	Power burner	all buildings	31	551	4.5	0.31	0.38	0.46	0.54
cooking	IR griddle	all buildings	57	608	5.0	0.31	0.39	0.47	0.55
space heating	Reset sa temperature	off cnt	513	1121	9.2	0.45	0.57	0.68	0.79
water heating	High-efficiency stand-alone un	office	36	1157	9.5	0.49	0.61	0.73	0.85
space heating	Tune boiler	off cnt	46	1203	9.9	0.50	0.63	0.75	0.88
space heating	Reset sa temperature	ret cnt	335	1538	12.6	0.59	0.74	0.89	1.03
space heating	Tune boiler	ret cnt	37	1575	12.9	0.70	0.87	1.04	1.22
space heating	Temperature set-back	off cnt	115	1691	13.9	1.16	1.45	1.73	2.02
space heating	Hgh-efficiency boiler	hospital	81	1772	14.5	1.18	1.48	1.78	2.07
space heating	Roof insulation	supermarket	487	2259	18.5	1.34	1.68	2.01	2.35
space heating	Low-E glass	hospital	136	2395	19.6	1.69	2.11	2.53	2.95
water heating	High-efficiency stand-alone un	supermarket	12	2407	19.7	1.82	2.27	2.73	3.18
space heating	Roof insulation	hospital	11	2417	19.8	1.98	2.48	2.97	3.47
space heating	High-efficiency furnace	restaurant	52	2470	20.2	2.19	2.74	3.28	3.83
water heating	High efficiency boiler	office	1	2471	20.2	2.35	2.94	3.53	4.11
space heating	Roof insulation	restaurant	91	2562	21.0	2.64	3.30	3.96	4.62
space heating	HVAC heat recovery	hospital	139	2701	22.1	3.15	3.94	4.72	5.51
space heating	High efficiency boiler	ret cnt	24	2724	22.3	3.38	4.22	5.06	5.91
space heating	High-efficiency furnace	ret pkg	96	2820	23.1	3.50	4.38	5.26	6.13
space heating	High-efficiency furnace	warehouse	103	2923	23.9	3.55	4.44	5.33	6.22
water heating	High-efficiency stand-alone un	restaurant	58	2981	24.4	3.56	4.45	5.34	6.23
space heating	Temperature set-back	off pkg	98	3079	25.2	3.62	4.52	5.42	6.33
space heating	High-efficiency furnace	off pkg	62	3142	25.7	3.83	4.79	5.75	6.71
space heating	High efficiency boiler	off cnt	20	3162	25.9	3.85	4.81	5.77	6.73
space heating	Roof insulation	ret pkg	201	3362	27.5	3.88	4.85	5.82	6.78
water heating	Tune boiler	office	0	3363	27.5	3.93	4.91	5.89	6.87
space heating	High-efficiency furnace	supermarket	68	3431	28.1	4.02	5.03	6.03	7.04
space heating	Double pane windows	off cnt	28	3459	28.3	4.07	5.09	6.11	7.13
space heating	Roof insulation	warehouse	113	3572	29.3	4.26	5.32	6.39	7.45
space heating	Roof insulation	ret cnt	52	3624	29.7	4.32	5.40	6.49	7.57
water heating	High-efficiency stand-alone un	retail	58	3682	30.2	4.47	5.58	6.70	7.82
water heating	High-efficiency stand-alone un	warehouse	9	3691	30.2	4.47	5.58	6.70	7.82
space heating	Roof insulation	off pkg	104	3795	31.1	4.84	6.05	7.26	8.47
water heating	Tank insulation	restaurant	12	3807	31.2	6.20	7.74	9.29	10.84
space heating	Double pane windows	off pkg	49	3856	31.6	6.20	7.75	9.29	10.84
space heating	Roof insulation	off cnt	27	3882	31.8	7.05	8.81	10.58	12.34
space heating	Double pane windows	restaurant	44	3926	32.2	8.03	10.04	12.05	14.05
water heating	Tank insulation	supermarket	1	3928	32.2	8.49	10.61	12.74	14.86
water heating	Tank insulation	warehouse	2	3930	32.2	9.55	11.93	14.32	16.71
water heating	Tank insulation	retail	9	3939	32.3	9.55	11.93	14.32	16.71
water heating	Tank insulation	office	1	3940	32.3	9.55	11.94	14.33	16.72
water heating	High efficiency boiler	restaurant	1	3940	32.3	11.45	14.31	17.18	20.04
space heating	Double pane windows	ret pkg	227	4168	34.1	11.48	14.35	17.22	20.09
water heating	Tank insulation	hospital	1	4168	34.1	11.51	14.38	17.26	20.14
water heating	Pipe insulation	hospital	2	4170	34.2	11.81	14.77	17.72	20.67
space heating	Double pane windows	supermarket	32	4202	34.4	12.55	15.69	18.83	21.97
space heating	HVAC maintenance	restaurant	47	4249	34.8	12.57	15.72	18.86	22.01
space heating	Double pane windows	ret cnt	60	4309	35.3	12.72	15.90	19.08	22.26
water heating	Pipe insulation	supermarket	0	4309	35.3	13.29	16.61	19.93	23.26
space heating	Double pane windows	warehouse	157	4466	36.6	13.80	17.25	20.70	24.16
space heating	HVAC maintenance	supermarket	56	4522	37.0	14.62	18.27	21.93	25.58
water heating	Pipe insulation	restaurant	1	4523	37.1	16.34	20.42	24.51	28.59
water heating	Pipe insulation	warehouse	0	4524	37.1	17.07	21.34	25.60	29.87
water heating	Pipe insulation	retail	1	4525	37.1	17.07	21.34	25.60	29.87
water heating	Pipe insulation	office	0	4525	37.1	17.12	21.40	25.68	29.96
water heating	Tune boiler	restaurant	0	4525	37.1	19.13	23.91	28.69	33.47
space heating	HVAC heat recovery	off cnt	27	4552	37.3	19.93	24.91	29.89	34.88
water heating	Auto reset	retail	5	4557	37.3	21.93	27.41	32.89	38.37
water heating	Auto reset	warehouse	1	4558	37.3	21.93	27.41	32.89	38.37
water heating	Auto reset	office	0	4559	37.3	21.93	27.41	32.90	38.38
space heating	HVAC maintenance	ret pkg	80	4639	38.0	24.08	30.10	36.12	42.14
space heating	Low-E glass	off cnt	25	4664	38.2	25.34	31.68	38.01	44.35
space heating	HVAC maintenance	hospital	32	4696	38.5	26.40	33.00	39.60	46.21
space heating	HVAC maintenance	warehouse	91	4788	39.2	28.70	35.87	43.05	50.22
water heating	Auto reset	restaurant	3	4790	39.2	32.01	40.01	48.01	56.01
space heating	HVAC maintenance	ret cnt	34	4824	39.5	33.08	41.35	49.62	57.89
space heating	HVAC maintenance	off cnt	35	4859	39.8	34.88	43.60	52.32	61.04
space heating	HVAC maintenance	off pkg	45	4904	40.2	36.16	45.20	54.24	63.28
space heating	Low-E glass	off pkg	43	4948	40.5	39.29	49.11	58.94	68.76
water heating	High efficiency boiler	retail	0	4948	40.5	43.10	53.87	64.65	75.42
water heating	High efficiency boiler	warehouse	1	4949	40.5	43.10	53.88	64.65	75.43
water heating	Auto reset	supermarket	0	4949	40.5	43.86	54.83	65.79	76.76
space heating	Low-E glass	restaurant	30	4979	40.8	70.83	88.53	106.24	123.94
space heating	Low-E glass	ret pkg	116	5095	41.7	71.72	89.65	107.58	125.51
water heating	Tune boiler	retail	0	5095	41.7	71.98	89.98	107.97	125.97
water heating	Tune boiler	warehouse	0	5096	41.7	71.99	89.98	107.98	125.98
space heating	Low-E glass	supermarket	24	5119	41.9	73.40	91.75	110.09	128.44
space heating	Low-E glass	ret cnt	30	5149	42.2	80.80	100.99	121.19	141.39
space heating	Low-E glass	warehouse	86	5235	42.9	82.13	102.66	123.20	143.73

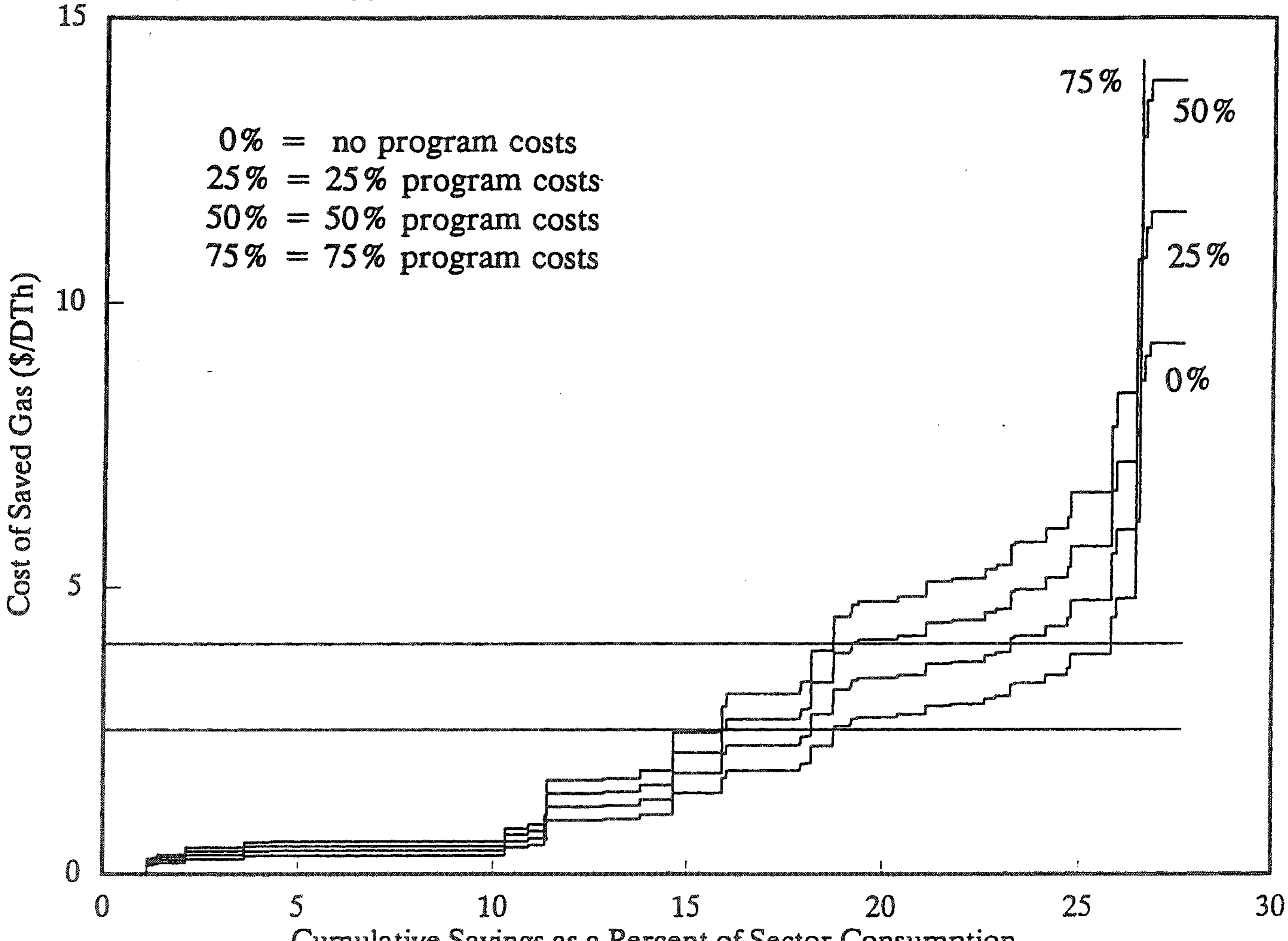
The Potential For Commercial Sector Gas Energy Efficiency For The NFG Service Territory

Table 4-25 summarizes the economic potential for commercial sector gas energy efficiency measures for each of the perspectives and sensitivities considered. Figure 4-3 presents the results graphically. Considering the case in which measure costs are increased by 50 percent, the results suggest that 16 percent or 3.2 million DTh to 19 percent or 3.9 million DTh of the gas consumed annually by the commercial sector could be saved with energy efficiency measures costing less than $2.50/Dth and $4.00/DTh, respectively. From the customer perspective ($5.00/DTh), this case indicates that 24 percent or 4.9 million DTh could be saved cost-effectively. Replacement measures (or all higher efficiency equipment) account for a small fraction of these savings, totalling 9, 14, and 16 percent of the cost-effective savings potential in each perspective, respectively. Among these replacement measures, savings due to high-efficiency gas furnaces (now covered by Federal law) contribute only 1, 3, and 8 percent to the total cost-effective savings potential in each perspective, respectively.

Table 4-25. Summary of Commercial Sector Economic Gas Savings Potential - NFG

Perspective	Measure Cost + 0%	Measure Cost +25%	Measure Cost +50%	Measure Cost +75%
Utility - $2.50/DTh	n/a	18	16	16
Utility - $4.00/DTh	n/a	23	19	19
Customer - $5.00/DTh	26	26	24	21

Figure 4–3. Supply Curve of Saved Gas, National Fuel Gas Co., Commercial Sector.



(Includes both mandated measures and measures that may be the target of utility DSM programs.)

The results appear to be robust with respect to the cost and performance sensitivities considered. Considering only the utility perspective, for example, if the cost of the energy efficiency measures is only 25 percent higher than the direct installed cost of the gas energy efficiency technologies (also corresponding to energy savings 33 percent lower), the cost-effective energy-efficiency potential increases by 2 and 4 percent at the utility cost-effectiveness thresholds of $2.50/DTh and $4.00/DTh, respectively. If the cost of the energy efficiency measures is 75 percent higher than the measure costs, the cost-effective energy-efficiency potential does not change at these gas-cost thresholds.

Table 4-26 summarizes our findings from the third case (measure costs + 50%) by end use. Savings are expressed both as percentages of annual gas consumption by the end use, as well as a percentage of total commercial sector gas consumption. The percentage of total sectoral sales accounted for by each end use is also indicated.

Table 4-26. Summary of Commercial Sector Economic Gas Savings Potential by End Use - NFG - Measure Cost +50%

Perspective	Space Heat (80%)		Water Heat (7%)		Cooking (12%)	
	% of end use	% of sector	% of end use	% of sector	% of end use	% of sector
Utility - $2.50/DTh	15	11	18	2	15	1
Utility - $4.00/DTh	18	13	19	2	15	1
Customer - $5.00/DTh	19	14	19	2	15	1

Table 4-26 highlights, as was found for both LILCO and BUG, the importance of energy efficiency measures to reduce gas used for space heating. Space heating accounts for the majority of gas consumption in the commercial sector (80 percent). Significant cost-effective savings are achievable from each perspective considered and these savings would have a major impact on commercial gas consumption. Despite the cost-effectiveness of measures directed toward reducing gas water heating and cooking energy use, the savings from these end uses account for only a modest portion of total commercial sector gas sales, although the results indicate that the majority of cost-effective savings for these end uses are highly cost-effective, costing less than the lowest cost-effectiveness threshold considered ($2.50/DTh). For example, all five cooking measures were found to be cost-effective under any scenario of gas avoided cost or cost/performance sensitivity.

Table 4-27 summarizes our primary findings separately by building type. The results are expressed both as a percentage of gas consumed by the building type and as a percentage of total commercial sector sales. The percentage of gas consumption accounted for by each building type is also indicated.

Table 4-27. Summary of Commercial Sector Economic Gas Savings Potential by Building Type - NFG - Measure Cost +50%

	Perspective					
	Utility-$2.50/DTh		Utility-$4.00/DTh		Customer-$5.00/DTh	
Building Type	% of Bldg	% of Sector	% of Bldg.	% of Sector	% of Bldg.	% of Sector
Office	26	5	26	5	26	5
Retail	14	3	14	3	14	3
Hospital	10	2	16	3	22	4
Grocery	31	3	31	3	31	3
Restaurant	6	1	6	1	6	1
Warehouse	1	0	1	0	1	0

Table 4-27 indicates that, unlike LILCo and BUG, cost-effective savings are spread among several building types, including office, retail, hospital, and grocery. Percentage-wise, office and grocery have large cost-effective savings potentials, followed by hospital and retail. Cost-effective savings are modest for the remaining building types, restaurant and warehouse.

The changes in cost-effective potential as a function of perspective provides insight into the cost-effectiveness of measures by building type. For example, the majority of savings for the office, supermarket, restaurant and all of the savings for the hospital are highly cost-effective; only modest additional savings result from considering higher cost-effectiveness thresholds. The majority of (albeit modest) savings for warehouse and, to a lesser extent, retail become cost-effective only at the higher thresholds.

Table 4-28 presents the individual results for the measures costing less than $10/Dth. The energy-efficiency measures contributing the most to the cost-effective energy efficiency potential improve the control of HVAC systems, especially the reset of supply-air temperatures for central HVAC systems and set-back of temperatures for both types of HVAC systems in offices. Significant energy savings also result from lowering hot water temperatures. Large cost-effective energy savings also result from several measures applied to hospitals including double-pane and then low-e windows, and HVAC heat recovery.

Roof insulation is the only shell measure found to be consistently cost-effective across building types.

Higher-efficiency equipment for space heating and water heating is generally cost-effective, but sometimes only marginally. Boiler tune-ups for space heating are highly cost-effective for offices and retail with central HVAC systems.

Table 4-28. Cost of Saved Gas - NFG Commercial Sector.

End Use	Measure	Bldg	Savings 1000 DTh	Cum Savings 1000 DTh	Cum as % of Sector	CSG + 0% $/DTh	CSG +25% $/Dth	CSG +50% $/Dth	CSG +75% $/Dth
water heating	Lower temperature	warehouse	14	14	0.1	0.00	0.00	0.00	0.00
water heating	Lower temperature	office	139	153	0.8	0.00	0.00	0.00	0.00
water heating	Lower temperature	retail	36	190	0.9	0.00	0.00	0.00	0.00
water heating	Lower temperature	supermarket	24	214	1.1	0.00	0.00	0.00	0.00
cooking	Ind.-dir. conv.	all buildings	15	229	1.1	0.00	0.00	0.00	0.00
water heating	High-efficiency boiler	hospital	32	261	1.3	0.15	0.18	0.22	0.26
cooking	Std.-dir. conv.	all buildings	23	283	1.4	0.16	0.20	0.24	0.28
cooking	Cat. IR fry	all buildings	148	431	2.1	0.19	0.24	0.29	0.33
space heating	Double pane windows	hospital	301	733	3.6	0.25	0.32	0.38	0.45
cooking	Power burner	all buildings	52	785	3.9	0.31	0.38	0.46	0.54
cooking	IR griddle	all buildings	98	883	4.4	0.31	0.39	0.47	0.55
space heating	Reset ss temperature	off cnt	1208	2090	10.3	0.32	0.39	0.47	0.55
space heating	Tune boiler	off cnt	121	2211	10.9	0.45	0.56	0.67	0.78
water heating	High efficiency stand-alone u	office	83	2294	11.3	0.49	0.61	0.73	0.85
space heating	Tune boiler	ret cnt	14	2308	11.4	0.57	0.72	0.86	1.01
space heating	Temperature set-back	off cnt	298	2606	12.8	0.92	1.15	1.38	1.61
space heating	Roof insulation	supermarket	194	2800	13.8	0.94	1.18	1.42	1.65
space heating	High-efficiency boiler	hospital	168	2968	14.6	1.02	1.28	1.53	1.79
space heating	Low-E glass	hospital	256	3224	15.9	1.40	1.74	2.09	2.44
space heating	High efficiency furnace	restaurant	22	3246	16.0	1.66	2.07	2.49	2.90
space heating	HVAC heat recovery	hospital	383	3629	17.9	1.78	2.23	2.67	3.12
water heating	High efficiency stand-alone u	supermarket	7	3635	17.9	1.82	2.27	2.73	3.18
space heating	Roof insulation	restaurant	37	3672	18.1	1.90	2.37	2.85	3.32
space heating	Roof insulation	hospital	17	3689	18.2	1.91	2.39	2.86	3.34
space heating	Reset ss temperature	ret cnt	111	3800	18.7	2.21	2.77	3.32	3.87
water heating	High-efficiency boiler	office	3	3803	18.8	2.35	2.94	3.53	4.11
space heating	High efficiency furnace	ret pkg	85	3889	19.2	2.56	3.20	3.84	4.47
space heating	High-efficiency boiler	ret cnt	9	3898	19.2	2.59	3.24	3.89	4.54
space heating	High efficiency furnace	supermarket	30	3928	19.4	2.68	3.35	4.02	4.69
space heating	Temperature set-back	off pkg	209	4137	20.4	2.71	3.39	4.07	4.75
space heating	High efficiency furnace	warehouse	145	4282	21.1	2.76	3.45	4.14	4.83
space heating	High efficiency furnace	off pkg	131	4413	21.8	2.91	3.64	4.37	5.09
space heating	Roof insulation	ret pkg	169	4583	22.6	2.94	3.68	4.41	5.15
space heating	High-efficiency boiler	off cnt	59	4642	22.9	3.03	3.79	4.55	5.31
space heating	Double pane windows	off cnt	75	4717	23.3	3.07	3.84	4.61	5.37
space heating	Roof insulation	ret cnt	20	4737	23.4	3.28	4.10	4.92	5.73
space heating	Roof insulation	warehouse	157	4894	24.1	3.31	4.13	4.96	5.78
space heating	Roof insulation	off cnt	113	5007	24.7	3.44	4.30	5.17	6.03
water heating	High efficiency stand-alone u	restaurant	17	5024	24.8	3.56	4.45	5.34	6.23
space heating	Roof insulation	off pkg	210	5234	25.8	3.81	4.76	5.71	6.67
water heating	Tune boiler	office	1	5235	25.8	3.93	4.91	5.89	6.87
water heating	High efficiency stand-alone u	retail	21	5256	25.9	4.47	5.58	6.70	7.82
water heating	High efficiency stand-alone u	warehouse	7	5262	25.9	4.47	5.58	6.70	7.82
space heating	Double pane windows	off pkg	100	5362	26.4	4.80	6.00	7.20	8.40
space heating	Double pane windows	restaurant	17	5379	26.5	6.14	7.67	9.21	10.74
water heating	Tank insulation	restaurant	3	5382	26.5	6.20	7.74	9.29	10.84
water heating	Tank insulation	supermarket	1	5383	26.5	8.49	10.61	12.74	14.86
space heating	HVAC maintenance	restaurant	20	5403	26.6	8.61	10.77	12.92	15.07
space heating	HVAC maintenance	supermarket	25	5429	26.8	9.04	11.30	13.56	15.82
space heating	Double pane windows	ret pkg	180	5609	27.7	9.27	11.59	13.90	16.22
space heating	Double pane windows	supermarket	12	5621	27.7	9.51	11.88	14.26	16.64
water heating	Tank insulation	warehouse	1	5622	27.7	9.55	11.93	14.32	16.71
water heating	Tank insulation	retail	3	5626	27.7	9.55	11.93	14.32	16.71
water heating	Tank insulation	office	2	5627	27.7	9.55	11.94	14.33	16.72
space heating	Double pane windows	ret cnt	21	5648	27.8	10.39	12.99	15.58	18.18
space heating	Double pane windows	warehouse	212	5860	28.9	10.96	13.70	16.45	19.19
water heating	High-efficiency boiler	restaurant	0	5861	28.9	11.45	14.31	17.18	20.04
water heating	Tank insulation	hospital	1	5861	28.9	11.51	14.38	17.26	20.14
water heating	Pipe insulation	hospital	3	5864	28.9	11.81	14.77	17.72	20.67
water heating	Pipe insulation	supermarket	0	5864	28.9	13.29	16.61	19.93	23.26
space heating	HVAC heat recovery	off cnt	75	5939	29.3	14.85	18.56	22.27	25.98
water heating	Pipe insulation	restaurant	0	5939	29.3	16.34	20.42	24.51	28.59
water heating	Pipe insulation	warehouse	0	5939	29.3	17.07	21.34	25.60	29.87
water heating	Pipe insulation	retail	0	5940	29.3	17.07	21.34	25.60	29.87
water heating	Pipe insulation	office	0	5940	29.3	17.12	21.40	25.68	29.96
space heating	HVAC maintenance	ret pkg	71	6010	29.6	17.47	21.83	26.20	30.57
space heating	Low-E glass	off cnt	73	6083	30.0	18.10	22.63	27.15	31.68
water heating	Tune boiler	restaurant	0	6083	30.0	19.13	23.91	28.69	33.47
space heating	HVAC maintenance	hospital	67	6150	30.3	19.87	24.84	29.81	34.77
space heating	HVAC maintenance	warehouse	132	6282	31.0	21.36	26.70	32.04	37.38
water heating	Auto reset	retail	2	6284	31.0	21.93	27.41	32.89	38.37
water heating	Auto reset	warehouse	1	6284	31.0	21.93	27.41	32.89	38.37
water heating	Auto reset	office	1	6285	31.0	21.93	27.41	32.90	38.38
space heating	HVAC maintenance	ret cnt	13	6298	31.0	25.69	32.11	38.53	44.95
space heating	HVAC maintenance	off pkg	95	6393	31.5	27.22	34.03	40.84	47.64
space heating	HVAC maintenance	off cnt	91	6484	32.0	27.46	34.33	41.19	48.06
space heating	Low-E glass	off pkg	93	6577	32.4	29.25	36.56	43.87	51.18
water heating	Auto reset	restaurant	1	6578	32.4	32.01	40.01	48.01	56.01
water heating	High-efficiency boiler	retail	0	6578	32.4	43.10	53.87	64.65	75.42
water heating	High-efficiency boiler	warehouse	1	6579	32.4	43.10	53.88	64.65	75.43
water heating	Auto reset	supermarket	0	6579	32.4	43.86	54.83	65.79	76.76
space heating	Low-E glass	restaurant	12	6591	32.5	51.09	63.86	76.64	89.41
space heating	Low-E glass	supermarket	9	6600	32.5	53.47	66.84	80.21	93.57
space heating	Low-E glass	ret pkg	98	6698	33.0	54.11	67.64	81.17	94.69
space heating	Low-E glass	warehouse	129	6827	33.7	59.14	73.92	88.71	103.49
space heating	Low-E glass	ret cnt	12	6838	33.7	59.78	74.73	89.68	104.62
water heating	Tune boiler	retail	0	6838	33.7	71.98	89.98	107.97	125.97
water heating	Tune boiler	warehouse	0	6839	33.7	71.99	89.98	107.98	125.98
space heating	Temperature set-back	supermarket	0	6839	33.7	374.92	468.64	562.37	656.10
space heating	HVAC heat recovery	ret cnt	0	6839	33.7	562.13	702.66	843.19	983.73

MEASURED PERFORMANCE OF COMMERCIAL SECTOR ENERGY EFFICIENCY MEASURES

The use of measured data to evaluate the in-field performance of energy efficiency measures in commercial buildings is rare. The most comprehensive source of these data is Lawrence Berkeley Laboratory's Buildings Energy Use Compilation and Analysis (BECA) project, which has collected measured performance data on almost 500 retrofit projects in nearly 1,800 commercial buildings (Greely, et al. 1990).

The BECA data provide a wealth of information regarding several aspects of the current study, including the measured performance of window modifications, HVAC controls, and improved maintenance practices. In addition, some of the data collected provide insight into the relationship between measured and predicted savings. Finally, a significant fraction of the data were collected from buildings and projects in the Northeastern region of the US, which is particularly relevant for our study.

Use of the BECA data, however, must be cautioned by the following considerations: (1) the projects included in the database were selected based on the completeness of data available -- the resulting findings, while indicative of actual performance, are not necessarily statistically representative; (2) all results are presented in common units of changes in site energy intensity, sometimes making it difficult to isolate separate gas and electricity savings; and (3) packages of measures are typically installed, making it difficult to identify the savings due to individual measures.

At the most aggregate level, the BECA data suggest that fuel savings were an important factor in the cost-effectiveness of the retrofits examined. For health and education buildings, fuel savings accounted for nearly all savings. For health (29 projects), fuel savings averaged 15% (total savings were slightly more than 15%) of pre-retrofit total site energy use, with an average payback time of just under 6 years. For education (207 projects), fuel savings averaged nearly 16% (total savings averaged slightly more than 16%) of pre-retrofit total site energy use, with an average payback time of a little more than 5 years. For offices (74 projects), fuel savings averaged 5% (total savings averaged 23%) of pre-retrofit total site energy use, with an average payback time of 2.6 years. For retail (101 projects), fuel savings also averaged 5% (total savings averaged 21%) of pre-retrofit total site energy use, with an average payback time of only 1 year.

Typically, more than one type of retrofit was considered in a project. The BECA data report savings for classes of retrofits (e.g., shell, HVAC, lights, etc.). For the 18 projects implementing shell measures alone (windows, insulation, infiltration reduction, singly or in combination), the site energy savings averaged 14%, with the majority of these savings being attributable to fuel use reductions. HVAC measures alone (115 projects) saved an average of 18%. HVAC measures in combination with shell measures (30 projects) saved an average of 24%. These savings are in line with our savings potential estimates at $4.00/DTh.

For a small number of projects, only a single retrofit was performed. While there remains the problem of separating energy savings between electricity and fuel, these measures are the only BECA data that allow for direct comparison to our study results. In general, the results are quite comparable.

Local HVAC controls (mostly, timeclocks) saved an average of 8% of total site energy use. Our simulations of timeclocks led to natural gas savings of between 8% and 13% (or about half these percentage amounts on a total site energy basis).

Improved maintenance (88 projects), often performed with in-house labor, saved an average of 12% of total site energy use. Our simulations of boiler tune-ups led to natural gas savings of between 2% and 5%. Our simulations of HVAC system maintenance measures led to natural gas savings of between 3% and 5%.

Window modifications (5 projects) saved an average of 6% of total site energy use. The simulations of double-pane windows led to natural gas savings ranging from just under 2% to nearly 10%. The simulations of low-e glass windows led to additional savings ranging from somewhat more than 1% to over 6%. For both measures, the savings are based on simulations that already include the effects of more cost-effective measures.

The BECA data also include information on the relationship between predicted and measured performance for nearly 30% of the projects. While the researchers found significant differences between the predicted and measured savings, they also note that there is "a fairly even split between underestimates and overestimates of savings."

Thus, the limited field data available tend to support the validity of the savings estimates presented in this chapter.

Chapter 5

THE ECONOMICS OF COMMERCIAL GAS FUEL-SWITCHING FOR SPACE HEATING AND COOLING

The six prototypical buildings used to assess the economic potential for commercial sector gas space-heating energy-efficiency measures in Chapter 4 were also used to examine the economics of fuel-switching from electricity to gas for space heating and cooling. The economic perspective is a comparison of the lifecycle costs of owning and operating electric compared to gas space heating or cooling equipment.[1] Because consensus over the value of gas avoided costs does not exist, the economics of fuel-switching have been analyzed using a "breakeven" gas price.

The economics of using electricity compared to gas for water heating and cooking were not studied.

THE CALCULATION OF A BREAKEVEN GAS PRICE

Lifecycle costs of electric versus gas space-heating and cooling technologies cannot be calculated without a well-defined avoided cost for gas. However, since the other costs required by such a lifecycle analysis can be specified, for example, the capital and operating cost of both technologies, the real discount rate (5 percent), and the avoided cost of electricity, a breakeven gas price can be calculated by determining the price of gas at which the lifecycle costs of

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[1] This perspective differs from that used in the analysis of residential fuel-switching presented in Chapter 3. The residential analysis considered replacement of existing electricity using equipment with gas-fired appliances. In that case, the energy cost savings from switching to gas had to off-set the *entire* capital cost of the new gas appliance in order to be cost-effective. In this Chapter, we consider the choice of equipment at the time of replacement. In this case, only the *difference* in capital costs between new gas and new electric equipment must be off-set by the energy cost savings for the gas equipment to be cost-effective. The approach for the residential and commercial sectors differ because commercial equipment is generally larger and more expensive, which means that commercial fuel-switching will usually be cost-effective only at the time existing equipment is being replaced. Residential fuel-switching will often be cost-effective on a retrofit basis.

competing electric and gas options are identical. At this price, one would be indifferent (on economic grounds) to the choice of technology. Thus, if the actual avoided cost of gas is lower than the breakeven price, then the gas technology would be more cost-effective than the electric technology and vice versa. To summarize the basic idea: a high breakeven gas price means that the gas technology will be generally cost-effective compared to the electric competitor. A detailed explanation of the calculations involved can be found in Appendix B, along with intermediate tables of results used to develop the findings presented in this Chapter.

Electric avoided costs were developed from a recent New York Public Service Commission order for long-run avoided costs for LILCo, ConEd for the BUG analysis, and NMPC for the NFG analysis. Table 1-1 gives these values for an annual average \$/kWh[2], and a winter and summer \$kW-yr. Sales of electricity to the utility for the cogeneration options were evaluated using the same avoided costs. While generalized avoided distribution costs are included in these avoided costs, site-specific avoided distribution costs, which may differ significantly from the reported service territory-wide averages and which may include distribution cost savings on the customer's side of the meter, are not included due to their highly site-specific nature.

The winter and summer capacity values of the technologies were estimated by averaging electricity demand over the peak demand-period hours (8 am to 8 pm) for weekdays in January, and over the peak demand period hours (12 pm to 6 pm) for weekdays in August, respectively. Consideration of only the change in building electricity demand during the single hour of the building's peak demand in each season, for example, would tend to overstate the capacity impacts of the technologies to the electric utility due to the lack of coincidence between the

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[2] The avoided energy cost represents an annual weighted average of peak and off-peak avoided costs for summer and winter. Later in this Chapter, a sensitivity analysis is performed on the avoided costs used in the analysis to examine the impacts of the weighting procedure on the results.

timing of a particular building's peak demand and that of the utility system.[3] Similarly, consideration of the building's peak demand only at the time of utility system peak places undue importance on a single hour's contribution. That is, peak demand periods and system peak capacity values are defined not in terms of a single hour of system peak, but on the basis of the likely times of system peak, because the time, day or even month of system peak is rarely identical from year to year. An average over the entire peak demand period, separately for the peak heating and cooling months, is a more conservative estimate of the capacity impacts of the technologies on the utility system in absence of building-specific coincidence factors.[4]

The energy performance of the gas and electric space-heating and cooling technologies was calculated using DOE-2 simulations of the same prototypes used in the analysis of gas space heating energy-efficiency measures. However, reliance on the same prototypes used to evaluate energy-efficiency potential has important consequences for the fuel-switching analysis. That is, the prototypes were calibrated to mean or average end-use EUIs to generalize results for a broad population of buildings within a service territory. This decision, essential for determining a service territory-wide energy-efficiency potential, may under- or over-state the cost-effectiveness

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[3] Class load research, for example, suggests that commercial customer class electricity coincidence factors of less 60 percent are not uncommon, especially for smaller customers (SCE 1986). A coincidence factor is defined as the ratio of a customer's demand at the time of system peak demand to the customer's actual peak demand.

[4] Not surprisingly, different approaches to estimate the coincidence between building loads and utility system peak demands can yield the same basic result. Consider, for example, the retail building with a central HVAC system with centrifugal chillers compared to the central system with a gas engine-driven chiller; the simulations of the gas engine-driven chiller for the central HVAC system were also used to estimate the performance of the packaged gas engine cooling/heating system. For a single hour: At 4 pm on the hottest day in August, which can be assumed to be the system peak hour and day, the difference in electric loads between the two simulations leads to percentage reductions in electrical peak demand of 42 percent and 30 percent for the downstate and upstate locations, respectively. Consider four hours: At 4 pm on the four hottest days in August (for a broader measure of system peak demand), the average percentage reductions in electrical peak demand are 40 percent and 31 percent for the downstate and upstate locations respectively. Consider finally, 132 hours: (i.e., application of the technique used in the current study) the differences in loads are averaged over the 6 on-peak period hours, 12 to 6 PM, of all 22 weekdays in August, leading to peak demand reductions of 37 percent and 33 percent for the downstate and upstate locations respectively. In other words, for these examples, all three methods yield approximately the same result and no one method appears uniquely biased with respect to the others.

of gas fuel-switching because the most attractive gas fuel-switching markets are likely to be found in the "tails" of the distribution of EUIs. Depending on which tail of the distribution a building happens to fall, there will be fuel-switching opportunities that are both more and less cost-effective than that indicated by the analysis. Thus, the analysis reported here is not intended to substitute for site specific analysis of promising fuel switching opportunities.

COMMERCIAL GAS AND ELECTRIC SPACE HEATING AND COOLING TECHNOLOGIES

Separate analyses were performed for gas and electric heating and cooling technologies, within both central and packaged HVAC systems. Table 5-1 lists these technologies and the building type/HVAC system configurations for which they were considered.[5]

The base technology was always assumed to be electric. For packaged HVAC systems, three base systems were considered: a packaged HVAC system with electric resistance heating and compressive cooling; a packaged HVAC system with an air source heat pump for heating and cooling; and a packaged HVAC system with gas heating and electric compressive cooling. Using these three base system configurations, up to three gas heating and cooling options were considered: packaged HVAC with standard efficiency gas heating and electric cooling ("gas heat"); a packaged HVAC with desiccant gas heating and cooling ("desiccant")[6]; and (3) a packaged HVAC with gas engine cooling and gas-fired heating ("gas eng cool").

[5] Baseboard electric resistance heat, which is found in some small commercial buildings, was not studied as part of this analysis. However, a rough indication of the cost-effectiveness of switching from electric baseboard heat to gas heat can be found by reviewing the analysis of residential fuel switching in Chapter 3.

[6] With the limited exception of the packaged dessicant heating and cooling system, no dehumidification technologies were considered.

Table 5-1. Applicability of Fuel-Switching Technologies to Commercial Building Prototypes.

Measure	Office Central	Office Pkg	Retail Central	Retail Pkg	Hospital	Super-market	Restau -rant	Warhse
Std. Gas Boiler	X		X		X			
Hi Eff Gas Boil.	X		X		X			
Elect. Boiler	X		X		X			
Pkg. Gas Heat, Elec. Cool		X		X		X	X	X
Pkg. Elec Heat/Cool		X		X		X	X	X
Pkg. Air Source Heat Pump		X		X		X	X	X
Pkg. Gas Eng Heat/Cool		X		X		X	X	X
Pkg Desiccant		X		X		X	X	X
Centrifugal Chiller	X		X		X			
Gas-fired Absor	X		X		X			
Eng. Chlr	X		X		X			
Eng. Chlr w/HR	X		X		X			
Cogeneration	X		X		X			
Cogeneration w/Absorption	X		X		X			

For central HVAC systems, separate comparisons were made for heating and cooling. For heating, the base HVAC system was an electric boiler with electric compressive cooling. The alternatives considered include: standard; and high-efficiency gas boilers, with electric compressive cooling. For cooling, the base HVAC system was a gas boiler with electric centrifugal chillers. The gas cooling alternatives considered include: gas-fired absorption chillers; gas engine-driven chillers with and without heat recovery; and packaged cogeneration with and without absorption cooling, operated in both a thermal load-following and electric load-following mode.

The energy use of all options except one was modeled using the DOE-2 building energy analysis program. The current version of the DOE-2 program (2.1D) does not offer a packaged gas engine-driven HVAC system, although both a central system engine-driven chiller and a packaged HVAC system with electric compressive cooling can be simulated. To estimate the performance of the packaged gas engine-driven HVAC system, we have used the design full-load and DOE-2 simulated part-load performance characteristics of the central system gas engine-driven chiller, adjusted for the full-load COP of packaged gas engine-driven chillers, to meet the DOE-2 cooling loads calculated for the conventional packaged gas-heated, electrically cooled HVAC system.

The cogeneration systems were sized to meet some but not all building heating or cooling loads. Due to their high capital costs, undersizing helps to ensure that the by-product of the electricity production process (heat) can be fully utilized, leading to a more cost-effective installation. The cogeneration systems were sized as follows: office, 100 kW; retail, 15 kW; and hospital, 500 kW (all sizing is made in reference to rated electric generating capacity). Also note that engine-driven cogeneration systems are rated conservatively. Most engines are capable of running at 110% of their rated capacity. Because we have undersized the cogeneration systems relative to the loads placed upon them (either thermal load or electric load following), the engines wll tend to run above design capacity during the periods over which peak capacity imapcts are calculated.

In addition to the data developed by Xenergy (Zoellick 1992) for the gas energy-efficiency analysis, there were seven additional sources of information on the capital and O&M costs, and lifetimes for the fuel-switching measures. These sources included a recent study of gas cooling for commercial buildings in Rhode Island (Xenergy 1991); additional information provided by Xenergy on packaged gas engine-drive HVAC systems (Reed 1992); the EPRI TAG manual for commercial sector technologies (DFI 1988); the Wisconsin Center for Demand-Side Research data base of commercial sector technologies (SRC 1990a); an EPRI survey of small cogeneration systems costs (SRC 1990b); a recent NYSERDA study of small cogeneration system operating experience (SAIC 1991); and an assessment of commercial building gas technologies by Northern States Power (NSP 1990). The technology cost and lifetime information from these studies is summarized in Tables 5-2 through 5-5.

The gas cooling equipment examined in this analysis is equipment that was on the market in 1992. Since this time a number of manufacturers have introduced new equipment including Altradyne which has a full product line of engine-driven chillers from 30-1000 tons, Carrier which has a 25 ton engine-driven packaged unit, and Thermoking which introduced a 15 ton engine-driven split unit (our analysis of a small engine-driven unit was based on Thermoking's 15 ton single-package unit). In addition, several new gas products are scheduled to enter the market in 1994 including York's 3 and 4 ton engine-driven heat pumps and Trane's triple-effect absorption chiller (Gobris 1993b). Similarly, new high-efficiency electrically-powered cooling equipment has entered the market. Packaged systems have been introduced by several manufacturers with COPs of 2.9 or more (Houghton and Hibberd 1993). Similarly, centrifugal chillers are now available with COPs as high as 7 (Nugent 1992). Thus, the analysis presented here is based on equipment in common use today, but not state-of-the-art equipment. If we were to compare state-of-the-art gas and electric cooling equipment, the results might be different.

Table 5-2. Summary of Fuel-Switching Technology Costs and Lifetimes - Pkg. Heating/Cooling.

System Type	Capital Cost (1991$/ton)	Lifetime	O&M Cost (1991$/ton-yr)	Source/Notes
Pkg. Rooftop - Gas Heat (eff. = 75%), Elect. Cool (COP = 2.8)	828	15	50.4	Xenergy 1991
Pkg. Rooftop - Elect. Heat (eff. = 100%), and Elect. Cool (COP = 2.8)	840	15	50.4	Derived from Xenergy 1991
Pkg. Rooftop - Air Source Heat Pump (Cooling COP = 2.8, Heating COP = 2.7)	984	15	50.4	Xenergy 1991
Pkg. Rooftop - Gas Heat (eff. = 75%) and Gas Eng Cool (COP = 0.65)	1442	15	50.4	Reed 1992a, Xenergy 1991
Pkg. Desiccant (eff. calculated by DOE-2)	1932	15	84.0	NSP 1991

Table 5-3. Summary of Fuel-Switching Technology Costs and Lifetimes - Space Heating.

System Type	Capital Cost (1991$/kBtuh)	Lifetime	O&M Cost (1991$/kBtuh-yr)	Source/Notes (kBtuh = heating capacity)
Std. Gas Boiler - sm (eff. = 80%)	6.5	15	0.97	Zoellick 1992; DFI 1988
Std. Gas Boiler - lg (eff. = 80%)	5.0	15	0.55	Zoellick 1992; DFI 1988
HiEff Gas Boiler - sm (eff. = 85%)	12.0	15	0.97	Zoellick 1992; DFI 1988
HiEff Gas Boiler - lg (eff. = 85%)	7.0	15	0.55	Zoellick 1992; DFI 1988
Electric Boiler (eff. = 100%)	6.0	15	0.72	DFI 1988

Table 5-4. Summary of Fuel-Switching Technology Costs and Lifetimes - Space Cooling.

System Type	Capital Cost (1991$/ton)[7]	Lifetime	O&M Cost (1991$/ton-yr)	Source/Notes
Centrifugal (COP = 4.6)	828	15	3.6	Xenergy 1991
Gas-fired Absorption (COP = 1.0)	1272	15	6.0	Xenergy 1991
Engine-driven Chiller (COP = 1.4)	1260	15	14.4	Xenergy 1991
Engine-driven Chiller w/Heat Recovery (COP = 1.4)	1272	15	14.4	derived from Xenergy 1991

Table 5-5. Summary of Fuel-Switching Technology Costs and Lifetimes - Cogeneration.

System Type	Capital Cost (1991$/kW)	Lifetime	O&M Cost (1991$/kW-yr)	Source/Notes (kW = elect. gen. capacity)
Cogeneration (eff. = 35%) w/o Absorption Cooling	1693	15	84	SRC 1990; SAIC 1991
Cogeneration (eff. = 35%) w/Absorption Cooling (COP = 1.0)	1857	15	84	SRC 1990; SAIC 1991

[7] Capital cost of gas cooling options includes incremental cost of additional cooling tower capacity relative to higher COP electric centrifugal chillers.

THE COST-EFFECTIVENESS OF GAS VERSUS ELECTRIC SPACE HEATING AND COOLING TECHNOLOGIES

The breakeven price of gas relative to electric commercial sector heating and cooling technologies is presented separately for each utility service territory. The breakeven gas price is expressed in $/DTh. Although there is no consensus about the exact value of gas avoided costs, a range of values from $2 to $4/DTh is a reasonable starting point.[8] The discussion of results will refer to this range in assessing the economics of fuel-switching. Results are presented separately for packaged HVAC systems and for central HVAC systems.

The analysis of fuel-switching is based on technology cost and performance estimates that represent current practices. To the extent that future technological improvements or manufacturing cost reductions through dramatically increased sales volumes reduce these costs, the results of the analysis will be conservative. In the case of packaged gas engine chillers, for example, reductions in the cost of future systems would improve their economic attractiveness relative to the analysis in this study.

On the other hand, if the technologies are delivered through utility DSM programs, additional costs will be incurred as a result of utility administrative and promotional activities. These additional costs will reduce the cost-effectiveness of gas alternatives (i.e., lower the gas breakeven price). We considered effects of these additional costs as well as technology performance uncertainties with three sensitivity analyses. Each sensitivity was implemented by increasing the capital, installation, and O&M operating costs of the gas alternatives by a fixed percentage relative to the base case.

The first three sensitivity cases increase the cost of the gas alternatives by 25, 50, and 75 percent, respectively. Although the translation is not one-for-one, these sensitivity case are

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[8] The range of gas avoided costs considered differs from that used in the residential analyses and the commercial energy efficiency analysis. On the lower end of the range, $2/DTh is close to estimates that have been made of summer avoided gas costs. We felt this lower bound would be more instructive for use in evaluating gas fuel-switching technologies competing against electric summer cooling technologies.

also equivalent to assuming that the difference in actual difference in gas consumption will be greater than that calculated by DOE-2, which might result from poorer than expected performance of the gas alternatives. Since our analysis is in the context of utility fuel-switching programs (for example, we discuss our results with reference to a range of avoided gas prices), we initiate the discussion of results around the second sensitivity case in which direct measure costs have been increased by 50 percent to account for the costs of utility promotion of a fuel-switching program (which is consistent with the discussion of gas energy efficiency measures).

Finally, to address concerns that using a weighted average avoided electric energy cost may produce biases when applied to technologies whose load shape impacts differ from those assumed in the weighting process, a fourth sensitivity analysis was performed to place an upper limit on the impact of the weighting process used to combine on and off-peak electric avoided costs from different seasons. For this sensitivity case, the weighted average avoided electric energy cost in case 3 (measure costs plus 50 percent) is replaced with on-peak avoided electric energy cost. In other words, all changes in electricity use are valued at the highest avoided cost. This sensitivity increases the gas breakeven price (relative to case 3) making the gas alternatives more attractive compared to the electric base technologies. The on-peak avoided electricity costs from Table 1-1, are \$.0460, \$.0407, and \$.0404/kWh up from \$.0393, \$.0362, and \$.0364/kWh for LILCo, BUG (ConEd), and NFG (NMPC), respectively.

We did not consider a sensitivity case that lowered the cost of the gas alternatives. Such a sensitivity might be especially important for desiccant technologies because it could in principle address the dehumidification cost savings associated with desiccant systems. That is, the dehumidification benefits of desiccants may eliminate the need for a separate mechanical dehumidification system for those applications requiring closer humidity control. For these situations, which are highly application-specific, the cost savings should be credited as offsetting the full-cost of the desiccant system.

We also did not conduct a sensitivity case that examined the economics of fuel-switching from the customer's perspective. In this case, the complexities of modern electric utility rate designs led us to conclude that a stylized example of assumed time-of-day periods, energy and demand charges (and ratchets) would not be readily generalizable. Yet, these utility-specific rate design features are critical to the economics of fuel-switching from the customer's perspective. Clearly, these features will be an essential elements in the design of utility programs to stimulate cost-effective fuel-switching.

Commercial Fuel-Switching Results for LILCo

Tables 5-6 through 5-10 present the cost-effectiveness of gas heating and cooling technologies compared to the electric base technologies.[9] Tables 5-6 through 5-9 present results for the cases assuming total measure costs are 0, 25, 50, and 75 percent higher than the direct installation and non-fuel O&M costs developed for the gas technologies. The primary discussion of results is made in reference to Table 5-8 in which gas technology costs have been increased by 50 percent. Table 5-10 presents results from the analysis considering high avoided electricity costs, in addition to total measure costs 50 percent higher than direct gas technology costs.

For the packaged HVAC system analysis, three base electricity technologies were compared to three gas alternatives. With respect to the base electric technology consisting of electric resistance heating and electric cooling, gas heating is cost-effective for all building types except offices (gas breakeven price is greater than $4.00/DTh), for which it is only marginally cost-effective (gas breakeven price is between $2.00/DTh and $4.00/DTh). Gas engine cooling is very cost-effective for the office and warehouse (gas breakeven price is greater than $6.00/DTh), cost-effective for the retail and restaurant, and marginally cost-effective for the supermarket.

With respect to the base electric technology consisting of an electric air source heat pump, gas heating is marginally cost-effective for only the office, supermarket, and restaurant. Gas engine cooling is cost-effective for both the office and warehouse, and marginally cost-effective for the retail and supermarket.

[9] Appendix B presents a sample derivation of the gas breakeven price, the intermediate project results used to develop the findings reported in this Chapter, as well as the derivation of additional information useful for fuel-switching analyses.

With respect to the base electric technology consisting of gas heating and electric cooling, the gas engine cooling system is very cost-effective for the office and cost-effective for the warehouse.

The dessicant system is not cost-effective against any of the base electric packaged HVAC systems (gas breakeven price is less than $2.00/DTh). However, as noted, dessicant system economics would be improved in those situations where the dehumidification benefits of the dessicant system could be used to off-set some of the additional costs associated with the installation and operation of a dessicant system.

Turning to the central HVAC system analyses, two different sets of analyses were performed. Electric versus gas boilers for heating, and electric versus various gas chillers and gas cogeneration systems for cooling and, in some cases, heating. Several cogeneration systems were considered, both with and without absorption chillers for cooling, and for each system two modes of operation were examined, thermal load following (or thermal tracking) and electric load following (or electric tracking).

We find that in all cases gas boilers, either standard or high-efficiency, are extremely cost-effective against the electric boiler base technology. In contrast, none of the gas cooling or cogeneration options are cost-effective against the central HVAC base technology consisting of a gas boiler and electric chiller, except in one case, the gas engine driven chiller for the office, which is marginally cost-effective.

The cases in which the cost premium for gas technologies is reduced (Tables 5-6, 5-7, and 5-10) predictably improve the cost-effectiveness of the gas technologies. Generally speaking, using the highest electric avoided costs to value electricity savings (Table 5-11) does not increase the cost-effectiveness of the technologies more than does adding only a 25% cost premium to the direct cost of the technologies (Table 5-7). The exception is gas heating for central HVAC systems, which is already extremely cost-effective compared to the base electric technology.

Of course, gas technologies are most cost-effective when no cost premium is assumed (Table 5-6). For the packaged HVAC systems, gas alternatives that were only marginally cost-effective become cost-effective (gas breakeven price is greater than $4.00/DTh). Dessicant systems become cost-effective or marginally cost-effective in some situations. For the central HVAC systems, gas engine chillers become cost-effective and several cogeneration systems become marginally cost-effective.

Under the highest cost premium scenario (Table 5-9), only gas engine cooling remains cost-effective for selected building types (office and warehouse) against electric packaged HVAC base technologies. Gas heating remains highly cost-effective against electric central HVAC systems.

Commercial Fuel-Switching Results for BUG

Tables 5-11 through 5-15 present the cost-effectiveness of gas heating and cooling technologies compared to the electric base technologies. Tables 5-11 through 5-14 present results for the cases assuming total measure costs are 0, 25, 50, and 75 percent higher than the direct installation and non-fuel O&M costs developed for the gas technologies. The primary discussion of results is made in reference to Table 5-13 in which gas technology costs have been increased by 50 percent. Table 5-15 presents results from the analysis considering high avoided electricity costs, in addition to total measure costs 50 percent higher than direct gas technology costs.

Generally speaking, the fuel-switching results for BUG tend to follow those presented for LILCo in the previous section. The energy use patterns and technology costs are, in fact, identical to the LILCo analysis since the same prototypes and simulations were used. Differences, then, only stem from the use of Con Ed electric avoided costs to value the changes in electricity use. Since the Con Ed electric avoided costs are slightly lower than those of LILCo (see Table 1-1), the effect will be to make gas technologies less cost-effective for BUG than they were for LILCo.

Table 5-6. LILCo Fuel-Switching Results - Gas Technology Cost +0%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	7.05	8.42	7.74	8.15	7.57
Dessicant	3.91	-1.29	-0.06	5.87	-10.10
Gas Engine Cooling	12.13	8.17	7.28	6.89	10.88

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	6.61	5.14	5.51	4.80	4.62
Dessicant	3.13	-8.80	-2.10	2.16	-18.13
Gas Engine Cooling	11.87	6.02	5.69	4.36	8.68

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	3.01	1.74	-4.63	-11.26	6.47
Gas Engine Cooling	19.62	7.70	6.13	3.01	20.57

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	18.32	18.26	18.32
High Efficiency Gas Boiler	19.16	19.04	19.20

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	1.62	1.11	-0.09
Gas Engine Chiller	4.31	4.26	2.63
Gas Engine Chiller w/Heat Rec	4.74	3.54	-1.19
Cogen w/o Absorp - Therm Track	-0.28	-9.72	1.21
Cogen w/Absorp - Therm Track	0.04	-7.88	1.54
Cogen w/o Absorp - Elect Track	3.57	1.88	3.76
Cogen w/Absorp - Elect Track	3.61	2.36	3.71

Table 5-7. LILCo Fuel-Switching Results - Gas Technology Cost +25%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	4.89	6.79	6.04	6.90	5.82
Dessicant	-3.96	-9.06	-3.30	2.99	-20.05
Gas Engine Cooling	10.25	6.62	5.51	5.52	8.98

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	4.45	3.51	3.81	3.55	2.87
Dessicant	-4.74	-16.57	-5.34	-0.71	-28.09
Gas Engine Cooling	9.99	4.47	3.92	2.99	6.78

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-1.06	-1.38	-16.38	-17.46	2.72
Gas Engine Cooling	14.97	3.20	-0.09	-2.60	13.09

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	18.16	18.04	18.18
High Efficiency Gas Boiler	18.93	18.73	19.00

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	0.78	-0.47	-3.57
Gas Engine Chiller	3.30	2.40	-0.07
Gas Engine Chiller w/Heat Rec	2.50	-0.57	-7.43
Cogen w/o Absorp - Therm Track	-2.58	-14.39	-0.81
Cogen w/Absorp - Therm Track	-2.35	-12.25	-0.27
Cogen w/o Absorp - Elect Track	2.74	0.53	2.84
Cogen w/Absorp - Elect Track	2.73	0.99	2.73

Table 5-8. LILCo Fuel-Switching Results - Gas Technology Cost +50%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	2.72	5.16	4.33	5.65	4.06
Dessicant	-11.84	-16.83	-6.54	0.12	-30.00
Gas Engine Cooling	8.38	5.06	3.74	4.15	7.07

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	2.28	1.88	2.10	2.30	1.11
Dessicant	-12.61	-24.34	-8.57	-3.59	-38.04
Gas Engine Cooling	8.11	2.91	2.14	1.61	4.87

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-5.14	-4.49	-28.14	-23.67	-1.03
Gas Engine Cooling	10.33	-1.30	-6.31	-8.20	5.61

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	18.00	17.81	18.04
High Efficiency Gas Boiler	18.70	18.41	18.79

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	-0.05	-2.04	-7.05
Gas Engine Chiller	2.29	0.54	-2.77
Gas Engine Chiller w/Heat Rec	0.25	-4.68	-13.66
Cogen w/o Absorp - Therm Track	-4.88	-19.05	-2.83
Cogen w/Absorp - Therm Track	-4.75	-16.61	-2.09
Cogen w/o Absorp - Elect Track	1.92	-0.82	1.91
Cogen w/Absorp - Elect Track	1.85	-0.38	1.75

Table 5-9. LILCo Fuel-Switching Results - Gas Technology Cost +75%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	0.56	3.53	2.63	4.41	2.31
Dessicant	-19.71	-24.60	-9.78	-2.75	-39.96
Gas Engine Cooling	6.50	3.51	1.96	2.78	5.17

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	0.12	0.25	0.40	1.05	-0.64
Dessicant	-20.48	-32.10	-11.81	-6.46	-47.99
Gas Engine Cooling	6.24	1.36	0.37	0.24	2.97

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-9.21	-7.61	-39.89	-29.87	-4.78
Gas Engine Cooling	5.69	-5.81	-12.54	-13.81	-1.88

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	17.83	17.59	17.89
High Efficiency Gas Boiler	18.47	18.10	18.59

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	-0.89	-3.61	-10.52
Gas Engine Chiller	1.29	-1.32	-5.47
Gas Engine Chiller w/Heat Rec	-1.99	-8.80	-19.89
Cogen w/o Absorp - Therm Track	-7.17	-23.72	-4.86
Cogen w/Absorp - Therm Track	-7.14	-20.97	-3.90
Cogen w/o Absorp - Elect Track	-1.09	-2.17	0.99
Cogen w/Absorp - Elect Track	0.98	-1.75	0.77

Table 5-10. LILCo Fuel-Switching Results - Gas Technology Cost +50% - High Avoided Electricity Cost

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	3.87	6.43	5.55	6.92	5.38
Dessicant	-8.58	-13.87	-5.41	1.80	-26.56
Gas Engine Cooling	9.32	6.13	4.79	5.29	8.22

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	3.17	2.53	2.83	2.95	1.77
Dessicant	-9.80	-22.80	-7.89	-2.59	-36.42
Gas Engine Cooling	8.90	3.57	2.85	2.29	5.53

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-5.40	-4.18	-27.33	-23.70	-0.74
Gas Engine Cooling	10.97	-0.63	-5.64	-7.45	6.25

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	21.14	20.95	21.18
High Efficiency Gas Boiler	22.03	21.74	22.12

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	0.32	-1.67	-6.36
Gas Engine Chiller	3.00	1.20	-2.07
Gas Engine Chiller w/Heat Rec	1.31	-3.67	-12.59
Cogen w/o Absorp - Therm Track	-3.56	-17.72	-1.43
Cogen w/Absorp - Therm Track	-3.42	-15.25	-0.78
Cogen w/o Absorption - Electric Track	2.76	-0.11	2.82
Cogen w/Absorption - Electric Track	2.71	0.35	2.66

For the packaged HVAC system analysis, three base electricity technologies were compared to three gas alternatives. With respect to the base electric technology consisting of electric resistance heating and electric cooling, gas heating is only cost-effective (gas breakeven price is greater than $4.00/DTh) for the restaurant and is marginally cost-effective for retail, supermarket, and warehouse (gas breakeven price is between $2.00/DTh and $4.00/DTh. Unlike the LILCo results, gas heating is not cost-effective against this base technology for the office (where it was marginally cost-effective). Gas engine cooling remains cost-effective for the office, retail, and warehouse and is marginally cost-effective for the supermarket and restaurant.

With respect to the base electric technology consisting of an electric air source heat pump, gas heating is not cost-effective for any building type. Gas engine cooling remains cost-effective for both the office and warehouse, but is marginally cost-effective for only the retail building type.

With respect to the base electric technology consisting of gas heating and electric cooling, the gas engine cooling system remains very cost-effective for the office and cost-effective for the warehouse.

As was found for LILCo, the dessicant system is not cost-effective against any of the base electric packaged HVAC systems (gas breakeven price is less than $2.00/DTh). Again, dessicant system economics would be improved in those situations where the dehumidification benefits of the dessicant system could be used to off-set some of the additional costs associated with the installation and operation of a dessicant system.

Turning to the central HVAC system analyses, two different sets of analyses were performed. Electric versus gas boilers for heating, and electric versus various gas chillers and gas cogeneration systems for cooling and, in some cases, heating. Several cogeneration systems were considered, both with and without absorption chillers for cooling, and for each system two modes of operation were examined, thermal load following (or thermal tracking) and electric load following (or electric tracking).

As was found for LILCo, gas boilers, either standard or high-efficiency, are extremely cost-effective in all cases against the electric boiler base technology. None of the gas cooling and cogeneration options are cost-effective against the central HVAC base technology consisting of a gas boiler and electric chiller.

The cases in which the cost premium for gas technologies is reduced (Tables 5-11, 5-12, and 5-15) predictably improve the cost-effectiveness of the gas technologies. Generally speaking, using the highest electric avoided costs to value electricity savings (Table 5-15) does not increase the cost-effectiveness of the technologies more than does adding only a 25% cost premium to the direct cost of the technologies (Table 5-12). The exception is gas heating for central HVAC systems, which is already extremely cost-effective compared to the base electric technology.

Gas technologies are most cost-effective when no cost premium is assumed (Table 5-11). For the packaged HVAC systems, both gas heating and gas engine cooling become cost-effective against both electric heating base technologies. The dessicant system become cost-effective against electric resistance heating in the restaurant. Against the packaged HVAC system with gas heating, the gas engine cooling system becomes highly cost-effective for the office, retail, and warehouse, is cost-effective for the supermarket, and is marginally cost-effective for the restaurant. For the central HVAC systems, gas engine chillers become cost-effective for the office, and, along with several cogeneration systems, become marginally cost-effective for all three building types.

Under the highest cost premium scenario (Table 5-14), only gas engine cooling remains cost-effective for selected building types (office and warehouse) against electric and gas packaged HVAC base technologies. Gas heating remains highly cost-effective against electric central HVAC systems.

Table 5-11. BUG Fuel-Switching Results - Gas Technology Cost +0%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	6.25	7.23	6.73	7.10	6.96
Dessicant	1.79	-4.02	-1.00	4.53	-11.61
Gas Engine Cooling	11.46	7.26	6.45	6.00	10.29

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	6.01	4.52	4.91	4.26	4.32
Dessicant	1.36	-10.22	-2.66	1.39	-18.81
Gas Engine Cooling	11.31	5.48	5.15	3.85	8.32

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	3.09	1.55	-5.11	-11.19	6.23
Gas Engine Cooling	19.13	7.31	5.73	2.61	20.03

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	16.86	16.81	16.87
High Efficiency Gas Boiler	17.62	17.50	17.66

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	1.39	0.84	-0.49
Gas Engine Chiller	3.88	3.78	2.25
Gas Engine Chiller w/Heat Rec	4.11	2.81	-1.76
Cogen w/o Absorp - Therm Track	-1.04	-10.95	0.30
Cogen w/Absorp - Therm Track	-0.72	-9.06	0.70
Cogen w/o Absorp - Elect Track	3.06	1.35	3.20
Cogen w/Absorp - Elect Track	3.10	1.83	3.15

Table 5-12. BUG Fuel-Switching Results - Gas Technology Cost +25%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	4.09	5.60	5.02	5.85	5.21
Dessicant	-6.08	-11.79	-4.24	1.66	-21.56
Gas Engine Cooling	9.58	5.70	4.67	4.63	8.38

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	3.84	2.89	3.21	3.01	2.56
Dessicant	-6.51	-17.99	-5.90	-1.49	-28.76
Gas Engine Cooling	9.43	3.93	3.37	2.48	6.41

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-0.99	-1.56	-16.86	-17.39	2.47
Gas Engine Cooling	14.49	2.81	-0.49	-2.99	12.55

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	16.70	16.58	16.73
High Efficiency Gas Boiler	17.39	17.19	17.46

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	0.56	-0.73	-3.97
Gas Engine Chiller	2.88	1.92	-0.45
Gas Engine Chiller w/Heat Rec	1.87	-1.30	-7.99
Cogen w/o Absorp - Therm Track	-3.34	-15.61	-1.73
Cogen w/Absorp - Therm Track	-3.11	-13.42	-1.11
Cogen w/o Absorp - Elect Track	2.24	0.00	2.28
Cogen w/Absorp - Elect Track	2.22	0.45	2.17

Table 5-13. BUG Fuel-Switching Results - Gas Technology Cost +50%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	1.93	3.97	3.32	4.61	3.45
Dessicant	-13.95	-19.56	-7.48	-1.22	-31.51
Gas Engine Cooling	7.71	4.15	2.90	3.26	6.48

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	1.68	1.26	1.50	1.76	0.81
Dessicant	-14.39	-25.76	-9.13	-4.36	-38.71
Gas Engine Cooling	7.56	2.38	1.60	1.11	4.51

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-5.06	-4.68	-28.62	-23.59	-1.28
Gas Engine Cooling	9.84	-1.70	-6.71	-8.60	5.07

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	16.54	16.36	16.58
High Efficiency Gas Boiler	17.16	16.87	17.26

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	-0.28	-2.30	-7.44
Gas Engine Chiller	1.87	0.06	-3.15
Gas Engine Chiller w/Heat Rec	-0.38	-5.41	-14.23
Cogen w/o Absorp - Therm Track	-5.64	-20.28	-3.75
Cogen w/Absorp - Therm Track	-5.50	-17.78	-2.92
Cogen w/o Absorp - Elect Track	1.41	-1.35	1.36
Cogen w/Absorp - Elect Track	1.34	-0.92	1.18

Table 5-14. BUG Fuel-Switching Results - Gas Technology Cost +75%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	-0.24	2.34	1.61	3.36	1.70
Dessicant	-21.83	-27.33	-10.71	-4.09	-41.47
Gas Engine Cooling	5.83	2.60	1.12	1.89	4.58

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	-0.48	-0.37	-0.20	0.51	-0.94
Dessicant	-22.26	-33.53	-12.37	-7.24	-48.66
Gas Engine Cooling	5.68	0.82	-0.18	-0.26	2.61

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-9.13	-7.79	-40.37	-29.80	-5.03
Gas Engine Cooling	5.20	-6.20	-12.94	-14.21	-2.41

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	16.38	16.14	16.44
High Efficiency Gas Boiler	16.93	16.56	17.05

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	-1.11	-3.88	-10.92
Gas Engine Chiller	0.86	-1.80	-5.85
Gas Engine Chiller w/Heat Rec	-2.62	-9.53	-20.46
Cogen w/o Absorp - Therm Track	-7.93	-24.94	-5.78
Cogen w/Absorp - Therm Track	-7.90	-22.15	-4.74
Cogen w/o Absorp - Elect Track	0.59	-2.70	0.43
Cogen w/Absorp - Elect Track	0.47	-2.29	0.20

Table 5-15. BUG Fuel-Switching Results - Gas Technology Cost +50% - High Avoided Electricity Cost

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	2.70	4.83	4.13	5.45	4.34
Dessicant	-11.76	-17.57	-6.72	-0.09	-29.20
Gas Engine Cooling	8.34	4.87	3.61	4.02	7.25

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	2.28	1.70	1.99	2.19	1.25
Dessicant	-12.50	-24.73	-8.67	-3.69	-37.62
Gas Engine Cooling	8.08	2.82	2.08	1.56	4.95

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-5.24	-4.47	-28.07	-23.61	-1.08
Gas Engine Cooling	10.27	-1.25	-6.26	-8.10	5.51

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	18.65	18.47	18.69
High Efficiency Gas Boiler	19.40	19.11	19.49

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	-0.02	-2.06	-6.98
Gas Engine Chiller	2.34	0.51	-2.67
Gas Engine Chiller w/Heat Rec	0.33	-4.73	-13.51
Cogen w/o Absorp - Therm Track	-4.75	-19.38	-2.81
Cogen w/Absorp - Therm Track	-4.61	-16.87	-2.05
Cogen w/o Absorp - Elect Track	1.98	-0.87	1.97
Cogen w/Absorp - Elect Track	1.92	-0.43	1.80

Commercial Fuel-Switching Results for NFG

Tables 5-16 through 5-20 present the cost-effectiveness of gas heating and cooling technologies compared to the electric base technologies. Tables 5-16 through 5-19 present results for the cases assuming total measure costs are 0, 25, 50, and 75 percent higher than the direct installation and non-fuel O&M cost assumptions for gas technologies. The primary discussion of results is made in reference to Table 5-18 in which gas technology costs have been increased by 50 percent. Table 5-20 presents results from the analysis considering high avoided electricity costs, in addition to total measure costs 50 percent higher than direct gas technology costs

For the packaged HVAC system analysis, three base electricity technologies were compared to three gas alternatives. Against the base electric technology consisting of electric resistance heating and electric cooling, most of the gas alternatives are cost-effective (gas breakeven price is greater than $4.00/DTh). The primary exception is the dessicant system for the warehouse, which is not cost-effective. The dessicant system is highly cost-effective for the retail building type.

With respect to the base electric technology consisting of an electric air source heat pump, gas heating and gas engine cooling are cost-effective for all building types, except for the warehouse where they are only marginally cost-effective. The dessicant system is marginally cost-effective for the restaurant.

With respect to the base electric technology consisting of gas heating and electric cooling, neither gas alternative is cost-effective for any building type.

Turning to the central HVAC system analyses, two different sets of analyses were performed. Electric versus gas boilers for heating, and electric versus various gas chillers and gas cogeneration systems for cooling and, in some cases, heating. Several cogeneration systems were considered, both with and without absorption chillers for cooling, and for each system two modes of operation were examined, thermal load following (or thermal tracking) and electric load following (or electric tracking).

We find, as was found for both LILCo and BUG, that in all cases gas boilers, either standard or high-efficiency, are extremely cost-effective against the electric boiler base technology. In contrast, none of the gas cooling or cogeneration options are cost-effective against the central HVAC base technology consisting of a gas boiler and electric chiller.

The cases in which the cost premium for gas technologies is reduced (Tables 5-16, 5-17, and 5-20) improve the cost-effectiveness of the gas technologies. Generally speaking, using the highest electric avoided costs to value electricity savings (Table 5-20) does not increase the cost-effectiveness of the technologies more than does adding only a 25% cost premium to the direct cost of the technologies (Table 5-17). The exception is gas heating for central HVAC systems, which is already extremely cost-effective compared to the base electric technology.

Gas technologies are most cost-effective when no cost premium is assumed (Table 5-16). For the packaged HVAC systems with electric heating base technologies, all gas alternatives are cost-effective, with the exception of the dessicant system for the warehouse. For the packaged HVAC system with gas heating and electric cooling as a base technology, gas engine cooling is cost-effective for the office and warehouse. For the central HVAC systems, gas engine chillers and several cogeneration systems become only marginally cost-effective in the office and hospital.

Under the highest cost premium scenario (Table 5-20), only gas heating and gas engine cooling remains cost-effective for most building types against packaged electric resistance heating HVAC systems (except warehouse). Gas heating becomes marginally cost-effective against electric air source heat pumps for office, as does gas engine cooling for all but the warehouse. Gas heating remains highly cost-effective against electric central HVAC systems.

Table 5-16. NFG Fuel-Switching Results - Gas Technology Cost +0%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	9.33	14.23	11.83	12.28	7.13
Dessicant	18.97	49.24	7.97	12.52	4.96
Gas Engine Cooling	9.20	11.60	10.06	10.32	7.00

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	8.12	9.28	8.62	8.07	4.77
Dessicant	15.98	23.80	4.83	7.43	-8.70
Gas Engine Cooling	8.30	7.59	7.27	6.56	4.95

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-6.23	-2.93	-20.68	-15.78	-1.78
Gas Engine Cooling	8.82	0.41	-1.63	-6.35	6.14

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	16.96	16.93	16.98
High Efficiency Gas Boiler	17.76	17.67	17.81

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	1.05	0.05	-7.80
Gas Engine Chiller	3.52	2.75	-2.03
Gas Engine Chiller w/Heat Rec	3.32	0.57	-12.90
Cogen w/o Absorp - Therm Track	1.02	-2.39	3.56
Cogen w/Absorp - Therm Track	0.81	-1.99	3.41
Cogen w/o Absorp - Elect Track	3.52	1.95	3.81
Cogen w/Absorp - Elect Track	3.34	2.05	3.67

Table 5-17. NFG Fuel-Switching Results - Gas Technology Cost +25%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	7.78	13.09	10.94	11.42	5.82
Dessicant	11.03	37.06	6.14	10.37	-10.79
Gas Engine Cooling	7.53	10.26	8.93	9.21	5.35

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	6.57	8.14	7.72	7.22	3.46
Dessicant	8.05	11.62	3.00	5.28	-24.45
Gas Engine Cooling	6.63	6.25	6.14	5.45	3.30

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-9.64	-5.21	-35.03	-21.84	-4.56
Gas Engine Cooling	2.40	-6.63	-10.26	-16.90	-6.26

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	16.81	16.75	16.86
High Efficiency Gas Boiler	17.55	17.41	17.64

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	0.17	-1.59	-17.32
Gas Engine Chiller	2.44	0.78	-5.67
Gas Engine Chiller w/Heat Rec	0.77	-4.27	-22.67
Cogen w/o Absorp - Therm Track	-1.06	-6.30	1.78
Cogen w/Absorp - Therm Track	-1.34	-5.77	1.77
Cogen w/o Absorp - Elect Track	2.65	0.52	2.81
Cogen w/Absorp - Elect Track	2.42	0.61	2.61

Table 5-18. NFG Fuel-Switching Results - Gas Technology Cost +50%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	6.23	11.95	10.04	10.57	4.51
Dessicant	3.09	24.88	4.31	8.22	-26.54
Gas Engine Cooling	5.86	8.92	7.79	8.10	3.69

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	5.02	7.00	6.83	6.37	2.14
Dessicant	0.11	-0.55	1.17	3.13	-40.20
Gas Engine Cooling	4.96	4.91	5.01	4.34	1.64

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-13.06	-7.49	-49.39	-27.90	-7.35
Gas Engine Cooling	-4.01	-13.68	-18.89	-27.46	-18.65

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	16.66	16.56	16.74
High Efficiency Gas Boiler	17.33	17.15	17.47

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	-0.70	-3.22	-26.84
Gas Engine Chiller	1.36	-1.19	-9.32
Gas Engine Chiller w/Heat Rec	-1.78	-9.10	-32.43
Cogen w/o Absorp - Therm Track	-3.13	-10.20	-0.01
Cogen w/Absorp - Therm Track	-3.50	-9.55	0.13
Cogen w/o Absorp - Elect Track	1.78	-0.91	1.81
Cogen w/Absorp - Elect Track	1.49	-0.82	1.55

Table 5-19. NFG Fuel-Switching Results - Gas Technology Cost +75%

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	4.68	10.82	9.14	9.72	3.20
Dessicant	-4.84	12.70	2.48	6.07	-42.29
Gas Engine Cooling	4.19	7.57	6.66	6.99	2.04

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	3.47	5.86	5.93	5.52	0.83
Dessicant	-7.82	-12.73	-0.66	0.98	-55.95
Gas Engine Cooling	3.29	3.56	3.87	3.23	-0.01

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-16.48	-9.77	-63.73	-33.96	-10.13
Gas Engine Cooling	-10.43	-20.72	-27.53	-38.01	-31.04

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	16.51	16.38	16.61
High Efficiency Gas Boiler	17.12	16.89	17.29

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	-1.58	-4.85	-36.36
Gas Engine Chiller	0.29	-3.16	-12.96
Gas Engine Chiller w/Heat Rec	-4.33	-13.94	-42.19
Cogen w/o Absorp - Therm Track	-5.20	-14.11	-1.79
Cogen w/Absorp - Therm Track	-5.65	-13.33	-1.52
Cogen w/o Absorp - Elect Track	0.90	-2.34	0.81
Cogen w/Absorp - Elect Track	0.57	-2.25	0.49

Table 5-20. NFG Fuel-Switching Results - Gas Technology Cost +50% - High Avoided Electricity Cost

Breakeven Gas Price ($/DTh)

Packaged Rooftop HVAC (reference case: electric resistance heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	6.94	12.74	10.78	11.35	5.31
Dessicant	5.79	29.06	5.06	9.29	-21.95
Gas Engine Cooling	6.49	9.63	8.50	8.85	4.44

Packaged Rooftop HVAC (reference case: electric air source heat pump)

	Office	Retail	Supermarket	Restaurant	Warehouse
Gas Heat	5.58	7.46	7.33	6.83	2.60
Dessicant	2.44	1.96	1.68	3.82	-37.56
Gas Engine Cooling	5.48	5.36	5.50	4.81	2.10

Packaged Rooftop HVAC (reference case: gas heating, electric cooling)

	Office	Retail	Supermarket	Restaurant	Warehouse
Dessicant	-13.32	-7.42	-49.04	-28.06	-7.28
Gas Engine Cooling	-3.62	-13.24	-18.46	-26.92	-18.24

Central HVAC (reference case: electric boiler, electric cooling)

Heating	Office	Retail	Hospital
Standard Efficiency Gas Boiler	18.54	18.44	18.61
High Efficiency Gas Boiler	19.32	19.14	19.45

Central HVAC (reference case: gas boiler, electric cooling)

Cooling/Heating	Office	Retail	Hospital
Gas-Fired Absorption	-0.47	-2.99	-25.81
Gas Engine Chiller	1.81	-0.78	-8.88
Gas Engine Chiller w/Heat Rec	-1.09	-8.41	-31.68
Cogen w/o Absorp - Therm Track	-2.33	-9.42	0.84
Cogen w/Absorp - Therm Track	-2.70	-8.74	0.93
Cogen w/o Absorp - Elect Track	2.31	-0.46	2.39
Cogen w/Absorp - Elect Track	2.03	-0.37	2.14

SIZE OF THE RESOURCE

Based on the economic analysis, we assessed the size of the cost-effective fuel-switching resource in the commercial sector. This analysis covers the three electric service areas most closely corresponding to the three gas utilities covered by this study -- LILCo, Consolidated Edison (whose service area partially overlaps with BUG's) and Niagara Mohawk (whose service area partially overlaps with NFG's). For this analysis we looked at total electric sales for each of the major end-uses for which fuel switching is an option (space heating and cooling); the proportion of businesses that now use electric equipment that are likely to have gas service available; and the proportion of businesses for which fuel switching is likely to be cost-effective. The product of these three variables is a rough estimate of the size of the available resource. Specific assumptions and calculations are summarized in Tables 5-21, 5-22, and 5-23, respectively. Most of the data come from New York State Energy Office sources. The proportion of businesses for which fuel switching is likely to be cost-effective was estimated by ACEEE using the same procedure as for the residential analysis that is described in Chapter 3.

The resource estimates provided by these simple models are approximate. The economics of fuel-switching, particularly for electric cooling, can be site specific. Based on our analyses of the economics of typical applications, we have made rough estimates of the proportion of buildings of each type that could benefit from cost-effective fuel switching. However, without data on the range of conditions in the real world, any estimates will be highly approximate and subject to a large error band -- on the order of plus or minus 50 percent. Furthermore, the other assumptions in the analysis are also imprecise. Thus, these estimates are intended to identify the order of magnitude of the fuel-switching resource to lay the groundwork for more detailed assessments.

Results of these analyses indicate that the economic potential for fuel-switching is approximately 3 percent of commercial electric sales for LILCo and approximately 4 percent of commercial electric sales for Con Edison and Niagara Mohawk. For the downstate utilities most of the savings are due to switching from electric to gas cooling. For the upstate utility, most of the savings are due to switching from space heating conversions; the economics of gas cooling are not nearly as favorable upstate as downstate.

Looked at another way, the economic potential for fuel-switching can result in increased commercial gas sales in the three utility service territories including a 14 percent increase for LILCo, a 30 percent increase for Con Edison, and a 7 percent increase for Niagara Mohawk. The increase is particularly large for Con Edison because of the large number of office buildings in its territory and because nearly all commercial buildings presently have gas service. The increase is relatively small for Niagara Mohawk because most of the fuel-switching potential is in space heating, and the majority of commercial buildings in the Niagara Mohawk service area already use gas for space heating. Also, due to the high saturation of gas space heat upstate, the baseline upon which sales increases are calculated is higher, making it more difficult to achieve high percentage increases in gas sales. The increase in gas sales for LILCo is in-between the increase for the other two utilities. Like Con Edison, LILCo has advantageous economics for gas cooling in many buildings and the baseline commercial gas sales are relatively low (compared to Niagara Mohawk), making it easier to achieve large percentage increases in gas sales.

Table 5-21. Estimate of Electricity Savings from Cost-Effective Fuel Switching in the Commercial Sector of Niagara Mohawk Power Corp.

	Office	Retail	Health	Supermarket	Restaurant	Warehouse	Total - Six Building Types	Notes/Sources (#'s are row #'s)
1 % of bldgs w/ gas on street	79%	79%	79%	79%	79%	79%		NYSEO 1990.
SPACE HEATING								
2 Gas share	62%	75%	51%	78%	46%	69%		Jackson 1992a.
3 Electric share	20%	9%	15%	8%	10%	5%		Jackson 1992a.
4 Elec. use - GWh (1992)	527	139	142	55	43	8	914	NYSEO 1991c.
5 Cost-eff. poten. (% elec)	65%	90%	90%	85%	85%	55%		ACEEE estimate based on Table 5-18 & allowances for outliers.
6 % elec. w/ available gas	45%	17%	57%	7%	61%	33%		(1 - 2)/(100% - 2)
7 Savings potential (GWh)	153	21	73	3	22	1	274	(4 * 5 * 6)
8 Ratio M DTh/GWh	6.27	6.27	6.27	6.27	6.27	6.27		Based on efficiencies in Tables 5-2 and 5-3; assumes 75% base-board heat, 25% heat pumps.
9 Added gas sales (M DTh)	958	133	456	20	141	9	1,717	(7 * 8)
AIR CONDITIONING								
10 Gas share	0%	0%	0%	0%	0%	0%		Jackson 1992a.
11 Electric share	78%	43%	76%	80%	61%	11%		Jackson 1992a.
12 Use - GWh (1992)	408	140	48	58	29	13	696	NYSEO 1991c.
13 Cost-eff. poten. (% elec)	10%	0%	20%	0%	0%	0%		ACEEE estimate based on Table 5-18 & allowances for outliers.
14 % elec. w/ available gas	79%	79%	79%	79%	79%	79%		(1 - 10)/(100% - 10)
15 Savings potential (GWh)	32	0	8	0	0	0	40	(12 * 13 * 14)
16 Ratio M DTh/GWh	12.36	14.31	11.21	14.70	14.70	14.70		Based on efficiencies in Tables 5-2 & 5-4 and ratios in Table 4-15.
17 Added gas sales (M DTh)	398	0	85	0	0	0	483	(15 * 16)
34 Total sav'gs potent'l (GWh)	**185**	**21**	**80**	**3**	**22**	**1**	**313**	**(7 + 15)**
35 % of comm'l elec sales	9%	2%	10%	0%	4%	1%	4%	(34/total sales from NYSEO 1991c)
36 Total sales added (M DTh)	**1,357**	**133**	**541**	**20**	**141**	**9**	**2,200**	**(9 + 17)**
37 % of comm'l gas sales	16%	1%	15%	1%	5%	2%	7%	(36/total sales from NYSEO 1991c)

Table 5-22. Rough Estimate of Electricity Savings from Cost-Effective Fuel Switching in the Commercial Sector of LILCo.

		Office	Retail	Health	Supermarket	Restaurant	Warehouse	Total - Six Building Types	Notes/Sources (#'s are row #'s)
1	% of buildings with gas on street	54%	54%	54%	54%	54%	54%		LILCo.
	SPACE HEATING								
2	Gas share	46%	49%	25%	43%	50%	40%		Jackson 1992a.
3	Electric share	20%	7%	9%	14%	6%	5%		Jackson 1992a.
4	Electric use - GWh (1992)	376	66	26	42	16	22	548	NYSEO 1991.
5	Cost-effective potential (% electric)	25%	55%	90%	50%	60%	50%		ACEEE estimate based on Table 5-8 & allowances for outliers.
6	% elec. w/ available gas	15%	10%	39%	20%	7%	23%		(1 - 2)/(100% - 2)
7	Savings potential (GWh)	14	4	9	4	1	3	34	(4 * 5 * 6)
8	Ratio M DTh/GWh	6.27	6.27	6.27	6.27	6.27	6.27		Based on efficiencies in Tables 5-2 and 5-3; assumes 75% baseboard heat, 25% heat pumps.
9	Added gas sales (M DTh)	89	24	57	26	4	16	216	(7 * 8)
	AIR CONDITIONING								
10	Gas share	3%	0%	3%	0%	0%	1%		Jackson 1992a.
11	Electric share	68%	64%	68%	61%	64%	39%		Jackson 1992a.
12	Use - GWh (1992)	292	168	104	37	38	37		NYSEO 1991.
13	Cost-effective potential (% electric)	55%	0%	20%	0%	0%	60%		ACEEE estimate based on Table 5-8 & allowances for outliers.
14	% elec. w/ available gas	53%	54%	53%	54%	54%	53%		(1 - 10)/(100% - 10)
15	Savings potential (GWh)	85	0	11	0	0	12	108	(12 * 13 * 14)
16	Ratio M DTh/GWh	13.76	13.90	11.21	14.70	14.70	14.70		Based on efficiencies in Tables 5-2 & 5-4 and ratios in Table 4-15.
17	Added gas sales (M DTh)	1,167	0	123	0	0	175	1,464	(15 * 16)
34	**Total savings potential (GWh)**	**99**	**4**	**20**	**4**	**1**	**14**	**142**	(7 + 15)
35	% of commercial electric sales	6%	6%	9%	15%	2%	6%	3%	(34/total sales from NYSEO 1991c)
36	**Total sales added (M DTh)**	**1,256**	**24**	**179**	**26**	**4**	**190**	**1,680**	(9 + 17)
37	% of commercial gas sales	28%	22%	53%	17%	6%	18%	14%	(36/total sales from NYSEO 1991c)

Table 5-23. Rough Estimate of Electricity Savings from Cost-Effective Fuel Switching in the Commercial Sector of Consolidated Edison.

		Office	Retail	Health	Supermarket	Restaurant	Warehouse	Total - Six Building Types	Notes/Sources (#'s are row #'s)
1	% of buildings with gas on street	95%	95%	95%	95%	95%	95%		NYSEO 1990.
	SPACE HEATING								
2	Gas share	30%	43%	21%	68%	50%	43%		Jackson 1992a.
3	Electric share	3%	6%	3%	20%	3%	3%		Jackson 1992a.
4	Electric use - GWh (1992)	92	75	62	72	12	18	331	NYSEO 1991c.
5	Cost-effective potential (% electric)	15%	50%	90%	40%	55%	40%		ACEEE estimate based on Table 5-13 & allowances for outliers.
6	% elec. w/ available gas	93%	91%	94%	84%	90%	91%		(1 - 2)/(100% - 2)
7	Savings potential (GWh)	13	34	52	24	6	7	136	(4 * 5 * 6)
8	Ratio M DTh/GWh	6.27	6.27	6.27	6.27	6.27	6.27		Based on efficiencies in Tables 5-2 and 5-3; assumes 75% baseboard heat, 25% heat pumps.
9	Added gas sales (M DTh)	80	215	328	153	37	41	854	(7 * 8)
	AIR CONDITIONING								
10	Gas share	1%	0%	17%	0%	0%	0%		Jackson 1992a.
11	Electric share	60%	62%	35%	96%	85%	21%		Jackson 1992a.
12	Use - GWh (1992)	1,119	250	299	121	110	36	1935	NYSEO 1991c.
13	Cost-effective potential (% electric)	50%	0%	15%	0%	0%	55%		ACEEE estimate based on Table 5-13 & allowances for outliers.
14	% elec. w/ available gas	95%	95%	94%	95%	95%	95%		(1 - 10)/(100% - 10)
15	Savings potential (GWh)	531	0	42	0	0	19	592	(12 * 13 * 14)
16	Ratio M DTh/GWh	13.76	13.90	11.21	14.70	14.70	14.70		Based on efficiencies in Tables 5-2 & 5-4 and ratios in Table 4-15.
17	Added gas sales (M DTh)	7,309	0	472	0	0	276	8,057	(15 * 16)
34	**Total savings potential (GWh)**	**544**	**34**	**94**	**24**	**6**	**25**	**728**	**(7 + 15)**
35	% of commercial electric sales	7%	9%	8%	4%	5%	4%	4%	(34/total sales from NYSEO 1991c)
36	**Total sales added (M DTh)**	**7,389**	**215**	**800**	**153**	**37**	**318**	**8,912**	**(9 + 17)**
37	% of commercial gas sales	79%	30%	28%	31%	12%	14%	30%	(36/total sales from NYSEO 1991c)

Chapter 6

GAS DSM PROGRAMS: LESSONS LEARNED

INTRODUCTION

Contrary to the relatively dynamic and rapidly evolving relationship electric utilities have with DSM, few gas utilities are aggressively pursuing DSM primarily because the gas regulatory framework and technical analysis has not yet developed in most jurisdictions. However, interest in gas DSM and integrated resource planning (IRP) is increasing. A recent survey of state public utility commissions (PUCs) identified 15 PUCs that are actively developing or considering IRP for gas utilities (Goldman and Hopkins 1991). Gas utilities in these and other states are aware that if they have not already begun offering DSM programs, they soon may be required to do so. This chapter examines utility experience with gas conservation programs to summarize lessons learned and what they teach us about operating successful programs.

Although many gas utilities offer customers information and audit programs, such as those offered under the federally-mandated Residential Conservation Service (RCS) program, few utilities go beyond this initial step. These programs generally provide on-site computerized energy audits and supply a detailed audit report. Audits are typically provided to customers at a nominal charge, although some programs offer free audits. According to an evaluation of the RCS program six years after it started, approximately seven percent of eligible customers had participated in the program (DOE 1987). Evaluations of the program have found that audited households have average net savings (relative to a control group of non-audit recipients) of three to five percent (Hirst 1984). Several studies found the program cost-effective from the utility and societal perspectives when savings from all fuels were considered, although net benefits from the program were small (see, for example, Hirst and Hu 1983). Due to the large number of audit programs and their limited net benefits for this project, we focused on gas DSM programs that go beyond just providing information and instead offer financial incentives for customers to adopt gas-saving measures.

Since few aggressive gas conservation programs have been pursued to date, and since gas utilities rarely track their conservation program results closely, this is a rough, preliminary examination. As more programs are offered and experience gained, analysis with a greater degree of depth and accuracy will be possible.

OVERVIEW OF DATABASE

This analysis of gas DSM programs was primarily based on a survey of approximately forty utilities which yielded data from more than seventy programs. To compare programs, we used three indices: participation rates, gas savings as a percent of retail gas sales, and levelized utility costs per therm saved. Participation rates (participating customers divided by eligible customers) indicate the effectiveness of a program in reaching the eligible customer base. Gas savings as a percent of gas retail sales to the relevant customer class indicate the effectiveness of a conservation program in significantly affecting a utility's overall gas demand. The levelized utility costs per therm saved indicate the program costs to a utility over the lifetime of the typical program measure. Since each index used in this analysis provides only a partial picture of gas conservation programs, it is important to consider the indices collectively rather than separately. A particular focus of this analysis is on programs that result in high participation rates and/or high gas savings at or below marginal gas costs. If demand-side resources are going to play a major role in meeting future gas needs, then programs will need to reach a substantial number of customers and will need to have a significant impact on the gas consumption of the customers who are reached.

In preparing the database, utilities offering gas conservation programs were identified through literature and word-of-mouth and contacted by phone, fax, and/or mail. Program results were available from 16 utilities offering 69 conservation programs. Data collected from utilities included a program's annual and cumulative number of participants, eligible customers, gas savings, and expenditures.[1] The data analysis for this chapter focused on annual data (generally

[1] Cumulative gas savings refer to the annualized savings for each measure performed since the start of the program.

for 1991), since little cumulative information was available. However, cumulative data were analyzed where available. Participation rates, gas savings as a percent of gas retail sales to the relevant customer class,[2] and levelized utility costs per unit of gas saved were calculated for those programs for which data were available. Annual gas savings per participant were also calculated. However, this index should be used with caution, since high values can reflect either substantial energy savings per customer or merely that the program primarily served large customers. Another index we attempted to calculate is gas savings as a percent of the pre-program gas use of participating customers. However, data to compute this index were not available.

In calculating levelized program costs, a discount rate of five percent and a measure lifetime of ten years were assumed (except for large equipment replacement and new construction programs, for which measure lifetimes of 20 and 30 years were assumed respectively). These measure lifetimes are based on measure life estimates developed in Chapters 2 and 4. The measure lives used are generally less than the engineering lives of equipment and instead are based on typical lives in the field after considering such factors as building renovation, pre-mature equipment failure or replacement, and improper maintenance of equipment.

Tables 6-1 and 6-2 give an overview of the commercial/industrial and residential programs in the database. Appendix C includes program descriptions and a complete compilation of data for all programs in the database.

Caveats

The data summarized here are subject to several important caveats that should be kept in mind when using this report.

There are great variations in the way gas utilities track and report program results and

[2] For example, residential gas savings as a percent of residential gas sales for a program.

Table 6-2. Summary of Statistics on Gas Conservation Programs for Residential Customers.

Program code *	Utility	Program	Program Start Date	Data Dates: Start	Data Dates: End	Annual participation rate	Cumul. participation rate	Annual savings as % of therm sales	Cumul. savings as % of therm sales	Levelized utility cost ($/DTh)	Annual savings/participant (therms)
A&I	Berkshire Gas	Residential Conservation (Low Income)	1991	1/91	1/92	0.9%	0.9%	0.02%	0.02%	3.40	320
A&I	Berkshire Gas	Residential Conservation (Multi-family)	1991	1/91	1/92	3.0%	3.0%	0.16%	0.16%	3.15	211
A&I	Berkshire Gas	Residential Conservation (Non-Low Income)	1991	1/91	1/92	0.1%	0.1%	0.01%	0.01%	9.69	288
A&I	Boston Gas	Attic Insulation Program	1991	1/91	12/91	0.7%	0.7%	0.07%	0.07%	7.67	142
EQR&R	Boston Gas	Domestic Hot Water Heater	1990	2/91	3/92	7.1%	7.1%	0.41%	0.41%	0.75	47
EQR&R	Boston Gas	Home Heating Control Program	1991	2/91	3/92	1.2%	1.2%	0.16%	0.16%	1.41	173
A&I	Boston Gas	Multifamily Plan	1991	1/91	12/91	n/a	n/a	0.07%	0.07%	n/a	40
EQR&R	Connecticut Natural Gas	Set-Back Thermostat Program	1989	1/90	12/91	n/a	n/a	0.02%	0.07%	1.10	100
A&I	Connecticut Natural Gas	Weatherization & Attic Insulation Program	1989	11/89	1/92	5.6%	8.3%	0.10%	n/a	3.56	71
A&I	Elizabethtown Gas	Assistance Sealup Program	1984	4/86	3/87	12.2%	n/a	0.06%	n/a	6.76	53
EQR&R	Elizabethtown Gas	Furnace/ Boiler Rebate Program	1985	4/86	3/87	0.8%	n/a	0.04%	n/a	1.87	72
A&I	Elizabethtown Gas	Regular Sealup Program	1984	4/86	3/87	0.6%	n/a	0.02%	n/a	2.00	34
EQR&R	Elizabethtown Gas	Set-back Thermostat Rebate Program	1986	4/86	3/87	0.4%	n/a	0.09%	n/a	0.21	333
EQR&R	Elizabethtown Gas	Water Heater Rebate Program	1985	4/86	3/87	3.6%	n/a	0.02%	n/a	4.03	14
A&I	Elizabethtown Gas	Weatherization Low-Interest Loan	1984	4/86	3/87	0.1%	n/a	0.10%	n/a	0.54	1,876
EQR&R	Madison Gas & Electric	High-Efficiency Water Heater Rebates	n/a	6/90	5/91	0.9%	n/a	0.05%	n/a	0.35	59
EQR&R	Madison Gas & Electric	Low-Flow Showerhead Installation	n/a	6/90	5/91	2.2%	n/a	0.14%	n/a	0.41	66
A&I	Madison Gas & Electric	Residential Weatherization	n/a	6/90	5/91	0.4%	n/a	0.004%	n/a	2.86	11
EQR&R	Northern States Power - WI	Appliance Efficiency Rebate	1984	1/91	12/91	0.2%	n/a	0.18%	n/a	0.81	497
A&I	Northern States Power - WI	Low-Income Weatherization	1981	1/91	12/91	0.5%	n/a	0.06%	n/a	7.23	330
A&I	Pacific Gas & Electric	Appliance Efficiency Incentives	n/a	3/90	2/91	1.0%	n/a	0.10%	n/a	2.32	58
EQR&R	Pacific Gas & Electric	Direct Assistance: Customer Appliance	n/a	3/90	2/91	0.3%	n/a	0.004%	n/a	n/a	42
A&I	Pacific Gas & Electric	Direct Assistance: Weatherization	n/a	3/90	2/91	8.0%	n/a	0.17%	n/a	5.67	62
EQR&R	Peoples Gas, Light, & Coke	Efficient Gas Heating Equipment Incentive	1984	1/91	1/92	0.8%	n/a	0.04%	n/a	0.42	158
A&I	Peoples Gas, Light, & Coke	Multifamily Low-Interest Loan Program	1984	1/91	1/92	0.1%	n/a	0.01%	n/a	5.80	6,636
A&I	Public Service E&G	Weatherization Low-interest Loan Program	1984	4/86	3/87	n/a	n/a	0.02%	n/a	12.74	99
EQR&R	San Diego Gas & Electric	Low-Flow Showerhead Program	1990	3/90	2/91	4.5%	6.2%	0.20%	0.29%	0.26	30
A&I	South Jersey Gas	Assistance Sealup Program	n/a	4/86	3/87	n/a	n/a	0.01%	n/a	4.68	65
A&I	South Jersey Gas	Regular Sealup Program	n/a	4/86	3/87	n/a	n/a	0.02%	n/a	0.49	452
EQR&R	South Jersey Gas	Space & Water Heating Financing	n/a	1/91	12/91	0.2%	n/a	0.14%	n/a	n/a	920
A&I	South Jersey Gas	Weatherization Low-interest Loan Program	n/a	4/86	3/87	n/a	n/a	0.05%	n/a	1.10	672
EQR&R	Southern California Gas	Appliance Efficiency Program	1990	7/90	2/91	n/a	n/a	0.03%	0.04%	7.44	n/a
A&I	Southern California Gas	Direct Assistance Program	1983	3/90	2/92	2.5%	5.1%	0.15%	n/a	5.37	124
NC	Southern California Gas	High Efficiency New Home Program	1990	7/90	2/91	n/a	n/a	0.01%	0.01%	5.92	n/a
NC	Southern California Gas	New and Innovative Multi-family Program	1990	3/90	2/92	1.3%	3.1%	0.002%	0.004%	8.67	42
A&I	Southern California Gas	Residential Weatherization	n/a	7/90	2/92	n/a	n/a	0.07%	0.07%	2.76	n/a
EQR&R	Washington Gas Light	Multi-family Rehabilitation	1989	1/89	12/91	1.2%	2.4%	n/a	n/a	n/a	n/a
EQR&R	Washington Gas Light	Residential Boiler/Furnace Replacement	1989	1/89	12/91	0.2%	0.7%	0.02%	0.13%	9.20	125
A&I	Washington Gas Light	Residential Weatherization	1989	1/89	12/91	0.9%	2.7%	0.05%	0.29%	4.39	70
EQR&R	Wisconsin Fuel & Light	Furnace Rebate Program	1987	1/90	12/91	0.1%	0.1%	0.02%	0.03%	n/a	225
A&I	Wisconsin Gas	Large Multi-family Conservation	1990	10/90	10/91	13.0%	13.0%	0.16%	n/a	3.18	2,958
NC	Wisconsin Gas	Large Multi-family New Construction	1990	10/90	10/91	80.0%	80.0%	0.02%	n/a	2.17	174
A&I	Wisconsin Gas	Residential Conservation	1989	9/90	10/91	4.3%	n/a	0.46%	n/a	3.74	151
NC	Wisconsin Gas	Residential New Construction	1989	6/89	10/91	0.2%	n/a	0.02%	n/a	1.91	155
A&I	Wisconsin Gas	Small Multi-family Rental Conservation	1989	6/89	10/91	18.9%	n/a	0.10%	0.10%	2.61	62
A&I	Wisconsin Natural Gas	Low-Income Weatherization (Homeowner)	n/a	1/91	12/91	0.4%	n/a	0.07%	n/a	5.81	2,073
A&I	Wisconsin Natural Gas	Low-Income Weatherization (Rental)	n/a	1/91	12/91	1.1%	n/a	0.04%	n/a	5.57	383
A&I	Wisconsin Natural Gas	Savings Plus: Homeowner	n/a	1/91	12/91	3.9%	n/a	0.40%	n/a	0.90	167
A&I	Wisconsin Natural Gas	Savings Plus: Rental	n/a	1/91	12/91	1.5%	n/a	0.15%	n/a	0.75	354

* A&I=Audit & Installation Program; EQR&R=Equipment Retrofit/Replacement Program; NC=New Construction Program

Table 6-1. Summary of Statistics on Gas Conservation Programs for Commercial & Industrial Customers.

Program code *	Utility	Program	Program Start Date	Data Dates: Start	End	Annual participation rate	Cumul. participation rate	Annual savings as % of therm sales	Cumul. savings as % of therm sales	Levelized utility cost ($/DTh)	Annual savings/participant (therms)
A&I	Madison Gas & Electric	Large C&I Conservation Services	n/a	6/90	5/91	n/a	n/a	0.15%	n/a	0.90	n/a
NC	Madison Gas & Electric	Large C&I New Construction	n/a	6/90	5/91	n/a	n/a	0.24%	n/a	0.58	n/a
A&I	Madison Gas & Electric	Major Accounts Program	n/a	6/90	5/91	n/a	n/a	0.04%	n/a	1.35	n/a
A&I	Madison Gas & Electric	Small C&I Conservation Services	n/a	1/91	1/92	n/a	n/a	0.14%	n/a	3.56	n/a
NC	Madison Gas & Electric	Small C&I New Construction	n/a	6/90	5/91	n/a	n/a	0.08%	0.21%	3.13	n/a
A&I	Northern States Power - WI	Boiler/Steam Trap Efficiency Improvement	1990	1/91	12/91	0.1%	0.1%	1.34%	1.34%	4.78	15,497
EQR&R	Pacific Gas & Electric	Customized Rebates: Commercial	1983	3/90	2/91	0.05%	n/a	0.06%	n/a	n/a	5,547
EQR&R	Pacific Gas & Electric	Customized Rebates: Industrial	1983	3/90	2/91	1.8%	n/a	0.19%	n/a	0.00	66,109
EQR&R	Pacific Gas & Electric	Direct Rebates: Commercial	1983	3/90	2/91	2.9%	n/a	0.11%	n/a	n/a	172
EQR&R	Pacific Gas & Electric	Direct Rebates: Industrial	1983	3/90	2/91	15.9%	n/a	0.50%	n/a	n/a	11,282
A&I	Southern California Gas	Commercial Equipment Replacement Upgrade	1989	3/90	2/91	0.7%	n/a	0.18%	0.32%	0.49	4,776
NC	Southern California Gas	High Efficiency New Commercial Buildings	n/a	3/90	2/91	n/a	n/a	0.08%	0.09%	0.31	12,566
A&I	Southern California Gas	Industrial Equipment Replacement/Heat Recovery	1990	3/90	2/92	1.5%	1.5%	0.18%	0.31%	0.39	26,204
EQR&R	Washington Gas Light	Commercial/Multifamily Water Heater Replacement	1989	1/89	12/91	n/a	0.9%	0.16%	0.96%	3.34	n/a
A&I	Wisconsin Gas	Existing Commercial Customer Conservation	1990	10/90	10/91	8.7%	8.7%	0.40%	0.40%	3.59	464
A&I	Wisconsin Gas	Large C&I Conservation: New Equipment	1990	10/90	10/91	0.7%	0.7%	0.98%	0.98%	1.53	83,247
A&I	Wisconsin Gas	Large C&I Conservation: Retrofit Equipment	1990	10/90	10/91	0.5%	0.5%	0.43%	0.43%	1.76	54,154
A&I	Wisconsin Gas	Large C&I Steam Trap Operation & Maintenance	1990	10/90	10/91	0.6%	0.6%	0.22%	0.22%	0.26	24,672
NC	Wisconsin Gas	New Commercial Construction Conservation	1990	10/90	10/91	n/a	n/a	0.02%	0.02%	1.95	342
EQR&R	Wisconsin Natural Gas	Blueprint for Savings: C&I Heating Upgrade	1986	1/91	1/91	3.0%	n/a	1.06%	n/a	0.53	2,381

* A&I=Audit & Installation Program; EQR&R=Equipment Retrofit/Replacement Program; NC=New Construction Program

in the quality of the data collected for this analysis. Utility data for gas conservation programs are generally crude and incomplete. When collecting data from utilities, for example, it became apparent that program participation is often tracked by the number of measures installed rather than the number of customers who participated. In some cases, utilities were willing to make rough guesses on the average number of measures installed per participant. Even when the utility tracked the number of participating customers, for programs targeting a subset of a market sector, such as low-income residential customers, the utility generally did not have estimates of the number of customers eligible to participate in the program.

Most utilities represented in this analysis did not subtract free riders (customers participating in a program who would have taken the same conservation actions even if the program was not offered) from their savings estimates. Thus, the savings values reported in the database may overestimate the incremental savings achieved by the programs. In addition, most utilities based their gas savings estimates on engineering analyses; more sophisticated evaluations of actual savings were rarely available.

While utility data on direct (i.e. rebate) program expenditures were usually available, data on indirect (i.e. administrative) costs were not consistently available. To incorporate indirect costs into the analysis, for those programs lacking data on indirect costs, indirect costs were assumed to be 30 percent of direct program expenditures based on recent research on the indirect costs of electric DSM programs (Berry 1989, Nadel 1990). This estimate was used because little reliable data on gas DSM programs were available to perform such a calculation. Furthermore, many of the programs in the database are pilot programs with high "start-up" administrative costs; pilot programs generally have higher administrative costs than typical DSM programs.

Another word of caution regarding a program's levelized cost is that only utility costs were available and thus levelized costs in this study are from the utility's perspective. A more useful measure would be levelized costs from the Total Resource Cost perspective, since this is the predominant test for DSM program cost-effectiveness in most states. Whereas the utility cost test only considers the costs of a DSM program to the sponsoring utility, the Total Resource

Cost test takes both the utility and customer costs into account. Since utilities rarely collect customer cost data, we were unable to analyze program cost-effectiveness from the total resource perspective.

Another limitation of this review is that the sample size is small -- 69 programs divided into six somewhat arbitrary categories. Certain categories only contain four or five programs whereas other categories contain five times this amount. Therefore, generalizations about one of the more popular categories will be more accurate than generalizations about categories with only a few programs.

Due to the many caveats, this report should be regarded as advancing the study of gas utility DSM and encouraging continued experimentation with program design, not as a final word on these issues.

Program Types

Two-thirds of the programs in the database are offered by gas-only utilities, and one-third are offered by combination electric/gas utilities. Wisconsin utilities dominate the database; more than one-third of the programs originate from this state. California utilities have one-fourth of the programs; New Jersey and Massachusetts utilities combined have another quarter of the programs. Programs from utilities in Connecticut, Illinois, and Washington D.C represent the remainder of the database. The 49 residential programs comprise the bulk of the programs in the database. There are 20 commercial and industrial (C&I) programs for which data were available, and all except one are offered by Wisconsin and California utilities. There are commercial and industrial gas conservation programs offered in other states, but data could not be obtained for these programs. Four of the residential programs in the database, and one of the C&I programs, are pilot programs.

For convenience, the gas conservation programs in the database are grouped into six different categories: three residential categories and three C&I categories. The residential categories are audit and installation, heating equipment retrofit/replacement, and new construction. The C&I categories are audit and installation; equipment retrofit/replacement; and new construction. Table 6-3 summarizes the number of programs in the database for each category.

Residential Audit and Installation Programs

Residential audit and installation programs account for more than one-third of the programs in the database. These programs offer eligible customers an energy survey (either mandatory or optional) leading to recommendations and financial incentives to install gas-saving measures. The surveys vary in their comprehensiveness, from a brief energy survey addressing one particular measure such as insulation, to a more thorough energy audit leading to recommendations on a wide range of cost-effective gas-saving measures. Measures rebated include basic weatherization measures, replacement of space and/or water-heating equipment with more efficient equipment, installation of low-flow showerhead and setback thermostats, equipment tune-ups and retrofits, and custom measures. Incentives include 30 to 100 percent subsidies for the cost of materials and installation; cash rebates of up to $250 for weatherization measures and space and water heater upgrades; and low-to-no-interest loans for installing measures. More than one-third of the programs target low-income customers. Incentives for low-income programs are significantly more generous than those for non-low-income customers and usually cover 100 percent of the materials and installation costs of gas-saving measures. Roughly one-fifth of the programs in this category are targeted for multifamily customers; incentives are generally offered to the building owner.

Residential Heating Equipment Retrofit/Replacement Programs

The residential heating equipment retrofit/replacement category represents one-fourth of the database. Programs in this category primarily offer incentives for upgrading water and space heating equipment with more energy-efficient units. A few programs target one specific heating retrofit measure such as low-flow showerhead or setback thermostat installation. Customer incentives for equipment upgrades are either cash rebates ranging from $25 to $540, low-interest

Table 6-3. Utility Programs in Database by Category.

Program Category	Residential	Commercial/Industrial
Audit and Installation	28	10
Equipment Retrofit/ Replacement	17	6
New Construction	4	4
Total	49	20

loans, arrearage forgiveness[3], or free equipment and installation. Low-flow showerhead programs offer free equipment to participants. Setback thermostats are offered at a 50 to 100 percent subsidy.

Residential New Construction Programs

Residential new construction programs generally offer cash incentives to builders or developers of single-family and multifamily residences for installing energy-efficient gas equipment. Most programs require that the building exceed certain state-defined or utility-defined building standards. Cash incentives are offered, generally from $100 to $150 per dwelling unit. A few programs offer additional bonuses when certain building standards or equipment efficiency thresholds are exceeded.

Commercial and Industrial Audit and Installation Programs

Commercial and industrial audit and installation programs make up half of the C&I programs in the database. Programs in this category initially offer, although do not always require, various energy surveys leading to recommendations and incentives for installing gas-saving measures. Most of these programs offer incentives for a wide range of measures, such

[3] The utility "forgives", or cancels, any debts accrued by the customer through unpaid gas bills.

as installing vent dampers, efficient gas space and water heaters, setback thermostats, pipe insulation, infrared heating units, boiler heat-recovery equipment, water heater blankets, ceiling insulation, and custom-designed measures. A few programs, however, focus on only one area of potential improved gas efficiency, such as inspection of steam traps and installation of a computerized steam trap maintenance program. Incentives range from a fixed dollar per estimated unit of gas saved to a percentage of the incremental project costs to a fixed rebate such as $60 per setback thermostat.

Commercial and Industrial Equipment Retrofit/Replacement Programs

The commercial and industrial equipment retrofit/replacement category includes programs that are similar to the C&I audit and installation programs, with the exception that energy surveys are not offered. More than half these programs are customized rebate programs in which the customer submits project proposals and the utility performs cost-benefit analyses to determine which measures are eligible for an incentive. These custom programs offer incentives in the form of fixed dollar per first year therm savings, with a limit set at a certain percentage of project costs. A few programs offer rebates for installing particular pieces of equipment, such as setback thermostats, water heater blankets, water heater heat recovery equipment, and other measures. There is only one commercial/industrial program in the database that focuses entirely on space and water heating equipment upgrades. This program offers participants 15 percent of the cost of purchasing and installing high-efficiency furnaces and boilers. For most of the programs in this category, the customer has a choice between the incentives outlined above or a low-interest loan.

Commercial and Industrial New Construction Programs

There are only four commercial and industrial new construction programs for which data were available. These programs offer financial incentives to builders constructing new commercial or industrial facilities who install certain gas-conserving measures. Incentives are oriented toward installing particular types of equipment.

Some of the measures rebated in the new construction programs include installing vent dampers, boiler water resets, setback thermostats, infrared heating units, efficient gas cooking equipment, efficient space and water heating equipment, and energy-management systems. One program has an additional element that provides incentives for exceeding certain minimum thermal building envelope efficiency standards. Customer incentives are in the form of either fixed cash rebates from $5 to $150, depending on the type of equipment, or rebates based on a percentage of the project costs.

RESULTS

For this study, an ideal program is defined as one that has a high participation rate in combination with high gas savings as a percent of sales to the relevant customer class at low levelized utility cost. If programs were within or below the range of marginal costs discussed in Chapter 1, from $2.50 to $4.00/DTh, they were considered likely to be cost-effective from the utility perspective.[4]

Trends were sought among the six program categories. Average values for the different measures of success were calculated for the entire database and separately for each category. Additionally, programs in each category with the lowest and highest values for the different parameters were examined. After isolating particularly "successful" or "unsuccessful" programs as defined by this analysis, we explored the reasons for success or failure. This information was obtained through telephone interviews with program managers and written materials on the different programs.

The Typical Program

Based on the information in the database, the average gas conservation program was approved in 1988, has an annual participation rate of two percent, an average savings as a

[4] This range agrees with marginal cost estimates made by regulatory staff in other states represented in the database, notably California and Wisconsin (Bloch 1992, Wood 1992).

percent of retail gas sales to the relevant customer class of 0.11 percent, and a levelized utility cost of $3.39/DTh saved. These values exclude major outliers.[5] The average residential program has a two percent annual participation rate, savings as a percent of residential sales of 0.08 percent, a levelized utility cost of $4.30/DTh saved, and has saved approximately 160 therms per year per participant. The average C&I program has an annual participation rate of two percent, savings as a percent of C&I sales of 0.21 percent, a levelized utility cost of $1.68/DTh saved, and has saved approximately 19,000 therms per year per participant.

The Successful Program

A "successful" gas conservation program in the database is defined as program that annually or cumulatively saves 0.30 percent or more of a utility's retail gas sales and/or has an annual or cumulative participation rate greater than five percent. The levelized utility cost for the "successful" program must fall at or below the $4.00/DTh cost-effectiveness threshold. There are 16 programs in the database which meet these requirements, almost half of which are offered by Wisconsin Gas Company. The average annual participation rate for these 16 programs is eight percent, savings as a percent of the relevant customer class' sales are 0.38 percent, and the average levelized utility cost is $2.04/DTh saved.

The average successful residential program saves approximately 100 therms per participant per year, whereas the average successful C&I program in the database saves approximately 20,000 therms per year per participant. Compared to the typical program in the database, the successful programs have achieved, on average, more than three times the participation rate and savings at lower cost. The average savings per participant for the "successful" residential programs are slightly lower than the averages for the entire residential database.

Table 6-4 highlights the overall results of the database, and Tables 6-5 and 6-6

[5] For this analysis, "major outliers" has been defined as those values which are more than five times or less than one-fifth of the median value for the index in question.

Table 6-4. Overall Database Results for Typical and Successful Programs.

	Participation Rate	Savings as a % of Gas Sales	Levelized Utility Cost ($/DTh)	Number of Programs
"Typical" Program	2%	0.11%	3.39	69
"Successful" Program	8%	0.38%	2.04	16

summarize the results for residential programs and C&I programs separately. All values are average annual values and exclude major outliers.

Although the database contains more than twice as many residential programs as C&I programs, there are an equal number of C&I and residential programs in the "successful" program category. The C&I heating equipment retrofit/replacement programs account for one-fifth of the successful programs yet only account for one-tenth of the programs in the database. Likewise, the C&I audit and installation programs are over-represented; approximately one-third of the successful programs are C&I audit and installation programs, whereas only one-seventh of the database falls within this category. Residential heating equipment retrofit/replacement programs are under-represented in the successful program category; although this category accounts for one-fourth of the database, only one such program met the criteria for success as defined in this study.

It is difficult to pinpoint the reasons for the over-representation of C&I programs in the successful category, but two important contributors are worth noting. First, C&I programs in the database generally target a larger proportion of the customer base than residential programs. Whereas many residential programs target a subset of the entire residential sector (for example, multifamily customers), most C&I programs in the database target all commercial and industrial customers. Due to the fact that a larger number of customers are targeted, and to the fact that savings per participant are generally high, it is easier for the C&I programs to achieve the "successful program" savings threshold of 0.30% of sector gas sales. Six of the eight

Table 6-5. Database Results for Residential Programs.

	Residential Average	Audit & Installation	Heating Equipment Retrofit/Replacement	New Construction	"Successful" Programs
Participation Rate	1.6%	1.5%	1.0%	1.3%	8.7%
Highest 1/4		9.8%	7.1%	n/a	
Lowest 1/4		0.2%	0.2%	n/a	
Highest Value		18.9%	15.6%	80.0%	
Lowest Value		0.1%	0.1%	0.2%	
Savings as % Gas Retail Sales	0.08%	0.08%	0.08%	0.01%	0.26%
Highest 1/4		0.24%	0.25%	n/a	
Lowest 1/4		0.01%	0.02%	n/a	
Highest Value		0.46%	0.41%	0.06%	
Lowest Value		0.004%	0.004%	0.002%	
Levelized Utility Costs ($/DTh)	4.30	4.71	0.93	2.91	2.15
Highest 1/4		8.40	6.50	n/a	
Lowest 1/4		1.20	0.51	n/a	
Highest Value		10.27	9.60	17.10	
Lowest Value		0.50	0.21	0.03	
Savings/Participant (therms per year)	171	191	148	124	100
Highest 1/4		1,818	494	n/a	
Lowest 1/4		46	40	n/a	
Highest Value		6,636	920	174	
Lowest Value		11	14	42	
Number of Programs	49	28	17	4	8

Note: "Highest 1/4" and "Lowest 1/4" refer to portions of the programs within either the highest or lowest one-fourth of the values in each category and index.

Table 6-6. Database Results for Commercial & Industrial Programs.

	C&I Overall	Audit & Installation	General Equipment Retrofit/Replacement	New Construction	"Successful" Programs
Participation Rate	1.5%	0.8%	2.6%	n/a	2.5%
Highest 1/4		5.1%	n/a	n/a	
Lowest 1/4		0.3%	n/a	n/a	
Highest Value		8.7%	15.9%	n/a	
Lowest Value		0.1%	0.048%	n/a	
Savings as % Gas Retail Sales	0.21%	0.26%	0.20%	0.10%	0.48%
Highest 1/4		0.92%	1.57%	n/a	
Lowest 1/4		0.11%	0.03%	n/a	
Highest Value		1.34%	2.79%	0.24%	
Lowest Value		0.04%	0.02%	0.02%	
Levelized Utility Costs ($/DTh)	1.68	2.14	0.42	1.91	1.66
Highest 1/4		4.20	n/a	n/a	
Lowest 1/4		0.40	n/a	n/a	
Highest Value		4.80	0.50	3.90	
Lowest Value		0.30	0.30	0.20	
Savings/Participant (therms per year)	19,337	40,755	6,403	6,454	19,759
Highest 1/4		68,701	38,696	n/a	
Lowest 1/4		2,620	2,228	n/a	
Highest Value		83,247	66,109	12,566	
Lowest Value		464	172	342	
Number of Programs	20	10	6	4	8

Note: "Highest 1/4" and "Lowest 1/4" refer to portions of the programs within either the highest or lowest one-fourth of the values in each category and index.

"successful" C&I programs qualified for the category as a result of their high annual savings as a percent of gas sales.

A second contributor to the large number of C&I programs in the successful category relates to the fact that residential programs in the database have, on average, higher utility costs per therm saved than C&I programs. Three residential programs met the savings and participation thresholds for "successful" status but were removed because they did not fall below the levelized utility cost threshold of $4.00/DTh, whereas only one C&I program meeting all other successful program requirements was removed due to its high costs.

Data Analysis by Program Type

Residential Audit and Installation Programs

The residential audit and installation programs have been offered, on average, since 1986. The average participation rate of these programs is the highest of all six categories in the database. However, the audit and installation programs are the most expensive programs in the database. This is partially due to the time and labor required to perform residential audits and installations. In addition, many of these programs target low-income customers who generally receive large financial incentives. Due primarily to the auditing process, which helps identify optimal packages of measures, the programs save a significant amount of gas per participant.

Residential Heating Equipment Retrofit/Replacement Programs

Programs in this category generally started in 1988. This category has the second lowest average utility cost of the six categories in the database. The equipment retrofit/replacement programs generally demand less time and labor on the part of the utility than most other programs, since customers often receive a rebate simply with proof of purchase. Since heating equipment lifetimes can be more than 20 years, roughly five to ten percent of residential customers replace heating equipment each year and the relatively low participation rates in this category reflect this.

Residential New Construction Programs

These programs are the newest residential programs in the database and have been offered, on average, since 1990. There are only four residential new construction programs in the residential database. Therefore, results should be regarded with extra caution, particularly participation rates because a utility's estimate of the number of eligible customers is usually based on guesswork, not objective data. This category, as well as the commercial new construction category, has had limited success in achieving large savings as a percent of sales, due to low participation rates and low savings per participant. In addition, the newness of the programs and the amount of utility outreach required has contributed to the results. The relatively high levelized utility costs for these programs is partly due to high start-up costs.

C&I Audit and Installation Programs

Programs of this type generally started in 1990. The average gas savings per participant is the highest of all six database categories at approximately 22,000 therms per year per participant; however, the participation rates for programs in this category are among the lowest of the six categories. These programs may have lower participation rates due to the paperwork and customer time required. The eligible customer base is usually large and generally includes all C&I customers. In addition, most of the programs in this category are relatively new and customers are just becoming familiar with them. As with residential programs, C&I audit and installation programs are more costly than the C&I equipment retrofit/replacement programs in the database.

C&I Equipment Retrofit/Replacement Programs

The C&I equipment retrofit/replacement programs are among the lowest cost programs in the database. Among the commercial and industrial programs, these programs have the highest participation rates and savings as a percent of sales. Although this category and the C&I audit and installation category do not appear to differ considerably in terms of the types of programs they contain (with the exception that the latter offers audits), results from the analysis favor the equipment retrofit/replacement category. This may reflect that the equipment retrofit/replacement programs on average date to 1985, whereas the audit and installation programs have generally only been offered for two years. The lack of an audit for the equipment retrofit/replacement programs decreases the time and paperwork required and may be more appealing to the customer and cheaper for the utility. However, the average savings per participant value is not as high as the average value for the audit and installation category. Four of six equipment retrofit/replacement programs are offered by Pacific Gas & Electric as part of its direct and customized rebate programs.

Commercial and Industrial New Construction Programs

Like the residential new construction programs, the C&I new construction programs in the database have, on average, been offered since 1990. There are only four C&I new construction programs in the database; therefore, results should be regarded with caution. None of the four commercial programs in this category had information on participation rates. The programs with the highest savings as a percent of sales in this category are less than the average levels of the other two commercial categories.

Notable Programs

Having summarized the overall results of this survey, we now review a few of the more successful programs in the database, using the definitions of success as outlined above. The same caveats discussed above, such as lack of post-installation savings evaluation and the lack of estimates of free rider share, apply to the "successful" programs as discussed below. Residential programs are listed first, followed by commercial and industrial programs.

Residential Programs

1. Boston Gas' Domestic Hot Water Heater Program

A heating equipment retrofit/replacement program with noteworthy results is Boston Gas'

Domestic Hot Water Heater program. The program provides, at no cost to the customer, low-flow showerheads, hot water heater wraps, six feet of pipe insulation, and a variety of other water heating retrofit measures. This program began in 1991. In its first year, the hot water heater program reached approximately seven percent of eligible customers, more than twice the participation rate of the average program in the database. Gas savings as a percent of residential gas sales for this program were 0.41 percent. These results were achieved at a levelized utility cost of only $0.75/DTh. This program served 34,000 customers in 1991. This high participation, coupled with the utility's rough estimate that 20 percent of a participant's domestic water heating consumption is saved through this program, led to high savings as a percent of sales.

Part of the apparent success of this program may be due to the regulatory financial incentive that Boston Gas receives for achieving DSM savings. Another reason for the program's apparent success is the attempt by the utility to make the program user-friendly by minimizing the time, paperwork, and financial requirements for the customer. Savings estimates are based on engineering analyses that may differ significantly from actual results. An impact evaluation is now underway and is expected to be completed by early- to mid-1993 (Greenblatt 1992).

2. Wisconsin Gas' Large Multifamily Conservation Program

Through its newest conservation program, the Large Multifamily Conservation program, Wisconsin Gas offers audits, recommendations, and financial incentives to owners of multifamily buildings of five or more units to encourage gas conservation. The program began in early 1990. After an initial energy survey by a utility field representative, if a building owner decides to go forward with measure implementation, the utility will inspect the installation and train the maintenance personnel about equipment operation. Energy savings from heating and distribution system improvements are the focus of the program.

The program offers incentives for installation of outdoor resets and cutouts, vent dampers, low flow showerheads, remote sensing thermostats, main line air vents, and weatherization measures. Incentives are also available for replacing boilers with high-efficiency models and for boiler tune-ups. The program manager noted that the most commonly installed measures are boiler control measures (Derepkowski 1992). Customers hire contractors to install the measures. A percentage of the equipment and installation costs, between 20-50 percent depending on the measure, are refunded to the participant upon project completion.

The program was initially marketed through direct contact with building owners and building management agencies. However, in the past year the program has been marketed through word-of-mouth by building owners and contractors and through brochures distributed to customers by contractors and field representatives. Equipment manufacturers offer seminars for potential participants in the program when requested.

In 1991, the program achieved a participation rate of five percent. Since the start of the program, 13 percent of the eligible customer base has participated. Savings as a percent of residential sales were 0.16 percent in 1991, annual savings per participant were approximately 2,960 therms, and the levelized program cost to the utility was $3.18/DTh saved.

The program manager noted that initially, when the program was first offered, there was a general lack of awareness on the part of building owners who did not believe there were any cost-effective gas conservation measures for their buildings. However, over the past two years, word has spread among building owners about the potential energy savings available through participation in the program. The response of the customers is now much less skeptical than it was initially (Derepkowski 1992).

The utility plans to modify the program to offer incentives for customers who install packages of measures. These incentives will be higher than the individual incentives for each measure, and will hopefully capture a greater fraction of the available electricity savings within a building (Derepkowski 1992).

3. Wisconsin Gas' Residential Core Conservation Program

Wisconsin Gas has offered the Residential Core Conservation program to owners and renters of one-to-four unit family dwellings since 1989. The core residential program offers rebates and energy services that include free energy audits, an 800 number telephone information line, and a dealer/contractor trade ally support program. A wide range of incentives is offered, including fixed rebates or a percentage of materials and installation costs for prescriptive measures (efficient gas space and water heaters and insulation) and a percentage of first year savings for custom measures. This program has had few custom measure installations. Marketing strategies include mass media advertising, bill stuffers, trade ally cooperation, and marketing at trade shows.

In 1991, the Core Residential Conservation program had a participation rate of four percent, savings as a percent of residential sales of 0.46 percent, savings per participant of roughly 151 therms per year, and a levelized utility cost of $3.74/DTh saved. The savings for this program are the highest in the audit and installation category and roughly four times greater than the average for the entire database. According to the program administrator, the relative high costs are related to the extensive marketing techniques used in the program and the large number of insulation measures performed. The program administrator also noted that insulation measures have tended to be more labor intensive, and thus more expensive, and have brought less savings per installation than the heating measures. Program staff attribute the moderately high participation and savings to the multi-faceted marketing approach that is used. In addition, it was noted that the free ridership in the space heating part of the Residential Conservation program is relatively high (Piessens 1992)

The Wisconsin Public Service Commission (PSC) is facilitating a shift within Wisconsin utilities from the "menu" approach to incentives for individual conservation measures toward a "bundling" of conservation measures in order to achieve greater savings at lower cost and with less hassle (Kaul 1992). In order to accomplish this shift, as well as address the fact that high-efficiency furnaces (90%+ AFUE) are now the norm in the Wisconsin marketplace, the PSC has ordered all utilities to discontinue, by 1993, "stand-alone" rebates for furnaces in the residential sector. The PSC, as well as a number of utilities, believes that high-efficiency furnaces are well enough established in the market that dealers can successfully promote energy-efficient models in the future without incentives (Kaul 1992).

Commercial Programs

1. Washington Gas' Commercial/ Multifamily Water Heater Replacement Pilot Program

In 1988, Washington Gas was directed by the Washington, D.C. Public Utility Commission to test opportunities for achieving significant gas savings over the next ten years through gas DSM programs (Chapman 1992). Conservation goals were set for different customer classes and end-uses. In the multifamily and commercial sectors, these goals call for reducing water heating energy use by 35 percent and 25 percent respectively relative to the utility's base forecast for the year 2000. One of the DSM programs developed to assist the utility in meeting these goals is the Commercial/ Multifamily Water Heater Replacement Pilot Program.

Initiated in early 1990, this pilot offers owners of multifamily and commercial buildings financial incentives for installing efficient water heaters. Free energy audits are available to customers. The program focuses on equipment replacement at the time of equipment "burn-out". An incentive of $85 per 10,000 Btu input rating is offered for installing a gas water heater with a thermal efficiency of at least 80 percent. Washington Gas performs impact evaluations every year for new participants. Annual impact evaluations are also performed for existing participants in order to track the persistence of savings.

Since the start of the program, approximately one percent of the eligible buildings have participated in the program. In 1991, the savings as a percent of commercial gas sales[6] were 0.16 percent. The program has cumulatively saved 0.96 percent of commercial sales. The

[6] Commercial sales include multifamily sales.

levelized cost to the utility was $3.34/DTh, making this program one of the more costly of the "successful" programs. However, it should be noted that, among the 16 successful programs, this is the only pilot program. Washington Gas has recently proposed to the Commission that the program be expanded to a full-scale program.

The program manager attributes the moderate success of the program largely to the incentive, which generally covers the incremental costs of purchasing energy-efficiency water heaters. In addition, the aggressive conservation goals of the utility and Commission have enhanced the commitment of the utility towards achieving program savings (Chapman 1992).

In the future, Washington Gas plans to offer a DSM program which provides incentives for the installation of joint water heater/space heater systems in commercial and multifamily buildings (i.e. water heaters linked to heat exchangers off the main heating system). Utility staff noted that greater savings at lower cost may be possible beyond what is being achieved through offering separate DSM programs for the two end uses (Chapman 1992).

2. Wisconsin Natural Gas' Blueprint for Savings Program for C&I Heating

A commercial equipment retrofit/replacement program with relatively high values for participation rate and gas saved as a percent of sales is Wisconsin Natural Gas' Blueprint for Savings program for C&I heating. This is the only commercial/industrial program in the database that offers incentives solely for space and water heating equipment upgrades. The program offers participants an incentive equal to 15 percent of the materials and installation costs of the replacement equipment. Participants have the option of choosing an interest rate buy-down financing package in place of the rebate.

In 1991, this program had a participation rate of approximately three percent and gas savings as a percent of sales of 1.1 percent, the highest percent savings of the "successful" programs. The levelized utility cost was low, at $0.53/DTh saved. Based on data collected from the utility, the average annual savings per participant are estimated at 2,381 therms. Cumulative data were not available.

The success of this program may be due to the fact that it has been around since 1986; initially it started as a pilot program that was expanded to full-scale operation in 1989. This program is part of a large Blueprint for Savings conservation package which has been widely marketed to all customers for more than six years. The program requires relatively little paperwork and time by utility staff, since the customer installs the equipment and receives a rebate afterwards; this aids in keeping utility costs down.

Industrial Programs

1. Pacific Gas & Electric's Industrial Direct Rebate Program

A notable program with a relatively high participation rate and gas savings as a percent of sales is PG&E's industrial direct rebate program which has been offered since 1984. The direct rebate program offers industrial customers fixed incentives (e.g. a fixed dollar amount per piece of equipment installed) for a wide variety of gas-conserving measures, including heat recovery measures, setback thermostats, air compressor system retrofits, and insulation. In 1991, this program served 16 percent of the eligible customer base. Savings were approximately 0.50 percent of PG&E's industrial retail gas sales and more than 11,000 therms per participant. Although accurate data on PG&E's direct and indirect costs for this program were unavailable, a rough calculation indicates that these results are achieved at a very low cost to the utility.

The age of the program, and the utility's overall long-term experience with DSM, contribute to the program's success; years of experience have allowed the utility to refine the program so that it operates smoothly and is marketed successfully. The program targets industrial customers which consume a relatively large portion of the utility's gas sales. The number of PG&E's industrial customers is relatively small; therefore marketing can be more intensive and focused than programs that target a large number of customers. In a recent study of electric utility experience with DSM, industrial programs tend to be the most cost-effective electric DSM programs (Nadel 1990). The low apparent cost of this industrial program may indicate that the same is true for gas utility DSM programs.

DISCUSSION

Realistically, the present quality of the data from gas conservation programs prohibit a definitive statement of which programs have been successful and which have not; however, some trends are worth noting.

One clear trend from the database analysis is that commercial and industrial programs appear to achieve greater savings as a percent of sector gas sales than residential programs, and at less than half the cost.

More than half of the programs analyzed, and nearly all of the programs with high participation rates and savings, have estimated levelized costs to the utility of less than $2.50/DTh. Approximately three-fourths of the programs analyzed have levelized utility costs of less than $4.00/DTh. This indicates that programs can be designed that will be cost-effective to gas utilities (assuming long-run marginal gas costs are between $2.50 and $4.00/DTh). However, it should be reiterated that due to the unavailability of customer cost data, our estimates of levelized costs and cost-effectiveness are based on the utility perspective and not the total resource perspective.

Although audit and installation programs in the database generally require more time and money on the part of the utility than the equipment retrofit/replacement programs, the diversity of measures performed and the individual attention paid to each customer result in greater savings as a percent of sales and per participant. The equipment retrofit/replacement programs in the database, on the other hand, generally have high participation rates and low utility program costs. The sharp contrast in levelized costs to the utility between the two program categories is partly due to the fact that the equipment retrofit/replacement programs require little work on the part of the utility; often customers mail in their proof of purchase for efficient heating equipment and receive a rebate. In addition, a few of the equipment retrofit/replacement programs are collaborative efforts with either another utility or community-based organizations, and therefore costs are shared among more than one party.

In order to achieve high participation and large savings in the long-term, a gas or combination utility should be offering the best of both types of programs. Equipment replacement programs are critical because, as discussed in Chapters 2 and 4, some conservation opportunities are only cost-effective when existing equipment must be replaced (for example, it is often not cost-effective to install a new furnace on a retrofit basis). In addition, equipment retrofit/replacement programs, with their high participation rates and low cost, can be used to interest customers in DSM. Audit and installation programs can be used as a follow-up to obtain more in-depth savings.

The two new construction categories presently appear to be least "successful" in attracting participants and low-cost savings. This may be because new construction programs are generally new and "immature" programs. To date, marketing has required a significant amount of outreach from the utility. Despite unimpressive program results to date, there is a large untapped cost-effective gas savings potential in the new construction market and more experience is needed to learn how to tap it. In addition, the savings in the new construction market are "lost opportunity" resources; if conservation measures are not installed during construction, it may be prohibitively expensive to retrofit them later.

There are a number of program design features that appear to be linked with the successful programs in the database. For example, many of the successful programs are user-friendly and require little time and paperwork, such as Boston Gas' Domestic Hot Water Heater program and Wisconsin Natural Gas' Blueprint for Savings program. Moreover, the successful programs tend to have innovative marketing strategies, such as use of trade associations and allies in the case of Wisconsin Gas' Large Multifamily Conservation Program. Also, some of the more successful programs offer customers a diversity in types of incentives, such as with Wisconsin Natural Gas' Blueprint for Savings program and Wisconsin Gas' Residential Core Conservation program. A choice of incentives can widen the range of customers who find a program appealing.

In conclusion, preliminary data indicate that utility gas DSM programs can be cost effective to the utility compared to marginal gas supply costs, and thus a viable resource for gas utilities. Furthermore, data indicate that the average gas DSM program has lower participation rates and savings than the average electric DSM program, and the results of the best gas DSM programs are less than the best electric programs (Nadel 1990). This indicates that there may be ways that even the more successful gas DSM programs can be improved, which is not surprising given the much more extensive level of activity with electric DSM. These conclusions, however, should be confirmed -- or modified -- when better data on actual program impacts become available. Obtaining such data should be given high priority by gas utilities and regulators.

Chapter 7

ELECTRIC-TO-GAS FUEL SUBSTITUTION POLICIES AND PROGRAMS: EXPERIENCE TO DATE

INTRODUCTION

In the ongoing process of developing electric utility IRP and DSM methodologies, fuel switching from electricity to other fuels as an electric demand-side resource has become a topic of hot debate. While there are clear societal and ratepayer benefits associated with certain gas substitution activities as discussed in Chapters 3 and 5, few regulators have officially mandated fuel switching as a necessary component in IRP processes, due primarily to concerns about the role of regulators in influencing customer choice and inter-fuel competition (see, for example, Kaul 1992 and McDonald 1992). Still, some states have openly addressed the fuel-switching issue, and a number of electric-to-gas conversion programs are offered by utilities.

Although fuel-switching issues have received considerable attention, limited information is available about actual experience with fuel-switching policies and programs. This chapter brings together information on the current status of fuel switching in the most active states and provinces and the results of a survey of electric-to-gas fuel conversion programs offered by utilities. Fuel switching from electricity to other fuels, such as propane or oil, is not addressed in this study. Moreover, while this discussion focuses on electricity-to-gas conversions, there are cost-effective opportunities to switch from fossil fuels to electricity, primarily in the industrial sector (Resource Dynamics 1986). However, an analysis of such opportunities is beyond the scope of this study.

INTERFUEL SUBSTITUTION POLICY

There are numerous end-uses that can be powered by either gas or electricity, including space heating and cooling, water heating, cooking and clothes drying. As shown in Chapters 3 and 5, extensive opportunities exist for cost-effective fuel switching. Considerable debate remains as to whether regulators should require utilities to consider fuel switching as a potential resource when developing integrated resource plans. Depending on one's perspective, incentives to customers to fuel-switch can be seen as a promotional practice on the part of a gas utility designed to increase sales or a genuine technique for providing least-cost energy services. Many unresolved issues were brought up during interviews conducted for this report with regulators and gas and electric utilities from across the country. These include:

* Do regulators have the authority to influence customer fuel choice and inter-fuel competition?;

* Should electric to gas fuel switching be considered an electric demand-side resource?;

* Which energy source is most cost-effective and efficient for specific end uses (the answer will vary depending on the region of the country and the specific application under consideration)?; and

* Who should pay for fuel switching, the electric or gas utility, or both?

Regulatory staff noted during interviews that dual-fuel and gas-only utilities are more supportive of fuel switching than electric-only utilities. It also became clear through interviews that the most aggressive fuel-switching programs are generally in states with the most progressive regulatory framework for electric and gas integrated least-cost planning.

Review of Interfuel-Substitution Policies in the Most Active States and Provinces

British Columbia

British Columbia Hydro (BC Hydro), a provincial electric utility in Canada, offers a number of electric-to-gas water heater conversion programs. According to the manager of these programs, the gas conversion programs are the lowest cost DSM programs at BC Hydro, which was up until a few years ago a dual-fuel utility (Bachard 1992). Since the local gas companies were recently part of BC Hydro, there is still generally a good rapport among the gas and electric utilities. BC Hydro has collaborated with two local gas utilities on the programs. The gas utilities pay for administering and delivering the gas substitution programs while BC Hydro pays customer incentives (see Table 1 and Appendix D for more information on these programs). This collaboration is a central reason for the success of the fuel-switching programs (Bachard 1992, Jung 1992). Despite the program success, utility staff noted that there is no official corporate policy stance at BC Hydro regarding fuel switching (Bachard 1992).

California

In order to address questions regarding cost-benefit methodologies for fuel switching, the California Public Utility Commission (PUC) has recently reached decisions on fuel-substitution policy guidance and fuel switching in the new construction market. In November 1992, the PUC adopted a "three-pronged" test for determining the cost-effectiveness of a fuel-substitution program. The three elements of the test include the "Source Btu" test (the program must not increase source Btu consumption), the Total Resource Cost test, and an environmental test which is independent of economic considerations (the program must not adversely impact air quality, based on PUC-defined air emissions values). Prior to this ruling, the PUC had assessed the cost-effectiveness of fuel-substitution programs on a case-by-case basis, and the new guidance is intended to streamline and standardize the process. Whereas the PUC has ruled that retrofit fuel-substitution programs must be kept separate from DSM programs and must be subject to the three-pronged cost-effectiveness test, the PUC has recently agreed to allow utilities to include new construction fuel-substitution programs in their package of energy-efficiency programs. This decision was made mainly to keep utility fuel-switching programs aligned with the treatment of fuel switching in California building standards (Schultz 1992).

At the present time, there are few gas substitution programs offered by utilities in California. These programs are offered by either dual-fuel utilities as conservation activities or by gas utilities as conservation or marketing when high-efficiency gas equipment is eligible for rebates.

Florida

The Florida Public Service Commission (PSC) has no official stance on whether fuel switching is an electric demand-side resource; however, there is a strong push to encourage cost-effective electricity-to-gas fuel switching (McCormick 1992). In 1987, the PSC proposed a rule that would require electric utilities to address electric-to-gas substitution in their conservation plans. The electric utilities responded by stating that they would sue the PSC if required to consider fuel switching. As a result, the issue has been put aside and is only addressed in relation to gas substitution programs offered by the state's gas utilities. People's Gas, for example, has a series of gas substitution programs which the PSC has encouraged them to offer since the early 1980s. Regulatory staff thought that the strong negative response of electric utilities was surprising, considering that electric utilities have over six million customers and the customer growth rate is almost four percent per year whereas the customer base for gas utilities in Florida totals roughly 300,000 and is growing between one and two percent per year (McCormick 1992).

Hearings are presently being held on revised conservation goals for electric utilities. Decisions based on the hearings will be made in early 1993. The conservation goals are not expected to focus specifically on fuel switching due to the contentious nature of the subject; however, staff noted that the language will attempt to encourage fuel switching (McCormick 1992).

Maine

Due to a recent change in rate design for electric utilities in Maine, which led to increased residential rates, there has been a significant increase in naturally-occurring electric-to-gas fuel switching in Maine. In 1991, a fuel-switching decision resulted in an initial resolution by the Maine PUC that utilities should help low-income customers switch from electricity to other fuels. Outstanding issues include who should pay for fuel switching (electric or gas utilities) and whether or not fuel switching is an electric DSM resource. In the hope of moving the debate forward, the Maine legislature passed a bill in mid-1992 recommending that the PUC speed up the process.

In response to the legislature's bill, a number of parties -- including the Commission's advocacy staff, third-party affiliates, gas utilities, but excluding electric utilities -- responded by designing and proposing to the Commissioners a pilot low-income fuel substitution program. The state housing authority and community action programs would administer and implement the proposed program, since these parties have already worked closely with low-income residents. Funding for the program is proposed to come from the electric utilities. The Commission's advisory staff and examiners endorsed the program. However, in October 1992, the Commissioners rejected the program. Staff attributed the Commissioner's rejection largely to concerns about the costs of the program; the budget for the proposed one-year pilot program is approximately $3.5 million. Recent rate increases have led the Commission to act conservatively when considering any action that may lead to additional increases (Bergeron 1992).

In December 1992, Central Maine Power (CMP), the largest investor-owned utility in Maine, was ordered by the Commission to study the cost-effectiveness of fuel switching based on existing data on naturally-occurring fuel substitution. CMP is to submit their research report by mid-1993, at which point the Commission will begin fuel-switching litigation (B. Hamilton 1993).

Massachusetts

In 1991, Boston Gas intervened in Massachusetts Electric's (MECo's) pre-approval hearings for the electric company's conservation programs. According to Boston Gas, fuel switching is a cost-effective demand-side resource that electric utilities ignore when designing conservation programs. Boston Gas performed studies which concluded that fuel switching is cost-effective for the following end-uses: air conditioning, water heating, and space heating. MECo maintains that fuel switching at these end-uses is often not cost-effective and that electric utility customers should not have to subsidize gas utility marketing programs (Hicks 1993). The electric utility noted that they are waiting for the case to be addressed by the Massachusetts Department of Public Utilities (DPU).

Regulators still have not set a date for hearings on the MECo case. According to the DPU, the case will probably be split into two separate stages. The first stage may address the costs and benefits of fuel switching at various end-uses, and the second stage may address the allocation of the costs associated with fuel switching. Commission staff noted that the gas substitution debate will probably not be resolved in the near future, as other issues are receiving higher priority (Latham 1992).

Most gas, electric, and oil companies in Massachusetts have become involved in the fuel-switching debate, and the situation, according to the DPU, is sticky (Latham 1992). The Oil Heating Council has intervened with the argument that gas companies will have an unfair advantage if allowed to use conservation funds for marketing purposes; the gas utilities would essentially receive cost recovery for marketing. Staff at the DPU noted that even joint electric and gas utilities in Massachusetts are not supportive of fuel switching. For example, the gas and electric portions of Commonwealth Energy sometimes act as competing entities. As a result, there is little agreement within the company on how to approach fuel switching (Latham 1992).

Nevada

In 1991, Southwest Gas, Nevada's largest local distribution company, was instructed by the Nevada PSC to re-file the DSM portion of its 1990 Resource Plan due to the inadequacy of the Plan's conservation programs. According to Southwest Gas and other sources, during the preparation of the 1991 re-filing, the gas utility received encouragement from the Commission to include fuel-switching programs (Kolberg 1992, Zanoni 1993). The majority of the programs contained in Southwest Gas' 1991 re-filing of its 1990 Plan were electric-to-gas fuel-substitution programs. According to the PSC and utility staff, there was some disagreement among Commission members as to how to address fuel switching; some members felt it was inappropriate to discuss fuel switching within a gas utility's least-cost plan (P. Hamilton 1992; Kolberg 1992; Zanoni 1993). The PSC decided, after Southwest Gas' re-filing was submitted, that fuel switching should not be addressed as part of the gas utility's demand-side resource acquisition plan. Southwest Gas was ordered by the Commission to remove the fuel-switching programs from its re-filing.

In addition, the Commission ordered the largest electric and gas utilities, Nevada Power and Southwest Gas, to work together toward energy efficiency. According to the Commission, this order stemmed from concerns for the rapid growth of new housing which was growing at five to eight percent per year (P. Hamilton 1992). The Commission held a workshop to encourage free dialogue among the parties with the hope of working out problems which might arise as a result of cooperative efforts. Among the issues that the utilities were instructed to address was fuel switching. Both utilities gave similar responses to the issue of fuel-switching in comments they prepared on the Commission's order: (1) the utilities noted that there is little precedent to go by in the fuel-switching arena, particularly with joint electric and gas utility cooperation; (2) many sticky issues still remain, such as who pays and the cost-effectiveness of fuel switching at various end-uses; and (3) the utilities would prefer to wait until more experience has been gained in other regions of the country.

In November 1992, the two utilities filed amendments to their Resource Plans based on the cooperative effort. Five joint Southwest Gas/Nevada Power "fuel-neutral" programs (programs designed not to influence a ratepayer's choice of fuel) were proposed. Staff at the Commission noted they were disappointed that the two utilities had not addressed fuel choice in the proposed new construction programs (McRae 1992). The Regulatory Operations Staff at the Commission is now analyzing the filings. The Commission expects to set these two dockets for hearing in the spring of 1993.

New Jersey

In mid-1992, new electric and gas LCPs were submitted to the New Jersey Board of Regulatory Commissioners which reflect the Board's recent approval of regulatory incentives for utilities to pursue conservation. Plans submitted by one electric utility and one dual-fuel utility have been approved; approval of other plans will be considered by the Board in early

1993. As part of the final settlement on the two approved plans, the utilities have agreed to participate over the next two years in an evaluation of the lifecycle costs of different gas and electric HVAC systems, including gas air conditioning.

The Commission presently takes the stance that DSM rebates should not promote the use of one fuel over another. However, Commission staff noted that the results of the study described above may help the Commission redefine their position toward fuel switching for certain end-uses (Mosser 1992).

New York

In 1988, the New York PSC recommended that utilities, in preparing a package of electric DSM programs, consider many different types of programs, including electric-to-gas fuel-substitution programs. At that time, one DSM program which the PSC required all utilities to offer was an HVAC program. The Commission gave suggestions on possible types of HVAC programs, and among these suggestions was gas air conditioning. Six of the seven combination utilities in New York (there are no electric-only utilities in New York) submitted plans which included gas substitution programs, and the majority of these proposals were for gas air conditioning.

According to Commission staff, the gas substitution programs have been implemented with varying degrees of success over the past four years (Gallagher 1992). Some of the combination utilities have "pulled away" from fuel switching, generally due to equity concerns; the electric side of the utility does not believe it should have to pay for the total costs of the gas substitution programs. In the case of gas and combination utilities with overlapping service territories, there have been problems with gas and electric utilities offering rebates for the same measure, sometimes allowing customers to receive rebates totaling more than the material and installation costs of the measure. Until the recent past, little coordination has occurred between the gas and electric utilities, according to Commission staff (Gallagher 1992). In December 1992, the Commission endorsed a recommendation that electric and gas utilities, whether within one company or between two companies with overlapping service territories, need to coordinate fuel-switching programs. The Commission recommended that the utilities should jointly negotiate cost-sharing agreements (Gallagher 1992). One example of improved coordination is the recent attempt by Consolidated Edison and Brooklyn Union Gas, two utilities with overlapping service territories, to link their separate gas air conditioning programs.

Ontario

The provincial legislature in Ontario recently amended the regional Power Corporation Act to allow local electric utilities to promote fuel switching. Before amending this key legislation, fuel switching by electric utilities was not allowed. According to the Ontario Ministry of Energy, it was expected that when this permission was granted, Ontario Hydro, the provincial electric generating utility, would be eager to promote fuel switching. However, due to Ontario Hydro's current financial problems and capacity surplus, and because market conditions apparently promote gas substitution, Ontario Hydro is not yet encouraging fuel switching (O'Dell 1992). Whereas a few years ago Ontario Hydro was projecting that utility-induced electric-to-gas fuel substitution would reduce the utility's load requirements by 1,275 MW by the year 2000, this past year the utility projects that utility-induced fuel switching will reduce load requirements by only 237 MW by the year 2000. The large decrease in the projected fuel-switching potential is due to the large increase in naturally-occurring fuel switching which has occurred in the last few years (and which is expected to continue to occur) resulting from the expanding gap between electricity and gas costs to customers. Ontario Hydro's Darlington Nuclear Power Plant recently began operation, and costs associated with building and operating the plant are now being reflected in customer rates (Katsuras 1992). One utility staffmember roughly estimated that rates will increase 20% due to the costs of the nuclear power plant (Zakaib 1993).

Although Ontario Hydro isn't eager to offer financial incentives to customers to fuel switch, according to utility staff several small efforts are addressing the issue. The utility is preparing studies on the cost-effectiveness of switching various end-uses to gas. Results will be released in early- to mid-1993 and incorporated into the informational component of their Home Power Savers program (Katsuras 1992). The component allows utilities who purchase Ontario

Hydro's power to include fuel-switching options in their home energy audit recommendations. In addition, Ontario Hydro will offer financial incentives for switching from electricity to gas in the commercial and industrial new construction market under very limited conditions.

Oregon

There is no mandate or state policy which favors gas substitution in Oregon. However, according to staff at the Oregon Department of Energy (ODOE), a question continuously asked in the Northwest is why electric utilities are investing in gas-fired power plants when they could invest in replacing residential electric space and water heating with more economical and resource-efficient gas water and space heating (Stephens 1992). A collaborative process initiated in 1990, including the Oregon Public Utility Commission (PUC), ODOE, the electric utilities, and the gas local distribution companies (LDCs), studied using gas for residential water and space heating. A preliminary analysis completed in 1991 indicated that there is a large cost-effective potential for fuel switching at these end-uses. The technical potential for residential water and space heating gas-substitution in Oregon, in areas where gas service will be available in the next 20 years, has been estimated at approximately 400 MW. The cost-effective residential water and space heating fuel-switching potential has been estimated at 275 MW (Stephens 1992).

Based on the findings of this analysis, the Oregon PUC formally reaffirmed its willingness to consider proposals from gas and electric utilities for fuel-switching programs, provided that the programs are cost-effective. The Commission recommended that the parties involved in the collaborative process jointly agree on methods for estimating the costs and savings associated with different fuel-switching program options. Staff at the Commission noted that electric utility fuel-substitution and electric utility DSM programs are addressed separately in Oregon, since the Commission-approved approach for evaluating fuel switching programs is significantly different than the approach for DSM programs (Jasso 1992).

Commission staff also noted that there is presently a high level of naturally-occurring fuel switching in the region, and some gas utilities are concerned that a large number of free-riders will participate if they offer financial incentives to customers to switch from electricity to gas (Jasso 1992).

Utility response to fuel switching has varied. In their draft least-cost plan, Pacific Power & Light dismissed fuel switching as an insignificant resource. The fuel-switching issue has evolved further for Portland General Electric (PGE), which recently decided to close their 400 MW+ Trojan Nuclear Power Plant by 1996. PGE must replace the lost load with other resources and has begun to seriously consider fuel switching as a resource. A possible collaboration between Northwest Natural Gas and PGE to offer a joint electric-to-gas water heating conversion program has failed to get off the ground, reportedly due to conflicting goals of the two utilities; PGE is only interested in giving up their space heating load, whereas Northwest Natural Gas is only interested in obtaining more water heating load (Stephens 1992).

In 1991, the capacity-constrained Bonneville Power Administration (BPA) began preparation of a technical analysis on the potential for fuel switching as well as a fuel-switching policy on how to work with the public utilities to whom they sell power. The preliminary results indicated that there is at least 200 MW of cost-effective fuel-switching potential in BPA's entire service area and roughly 70 MW of cost-effective potential in BPA's Oregon service area (Stephens 1992). Due to strong concerns of their public utility customers about BPA's involvement in fuel-switching issues, the technical analysis and policy study were stopped before completion.

BPA's decision to discontinue work on fuel switching was criticized by the U.S. Office of Management and Budget (OMB), U.S. Representative Ron Wyden of Oregon, and DOE. In response, BPA recently proposed a fuel-switching strategy that, among other things, allocates $3 million for pilot programs which promote active fuel switching (Stephens 1992). In addition, the Northwest Power Planning Council (NWPPC) recently formed a task force to re-examine gas-related issues, such as gas pricing, gas-fired generation, and fuel switching. The first meeting of the task force was held in December 1992 and included representatives from utilities, OPUC, ODOE, and other parties. Based on the outcome of the task force, the NWPPC will release an issue paper summarizing the results of a re-evaluation of BPA's basic power planning assumptions.

Vermont

The Vermont Public Service Board (PSB) is one of the few commissions that openly refers to electric-to-gas fuel substitution as an electric utility demand-side resource. According to both the Board and the Vermont Department of Public Service (the ratepayer's advocate), there is a large cost-effective fuel-switching potential in Vermont (Parker 1992, Weston 1992). An estimate of the size of this potential is not available.

In April 1990, the PSB ordered electric utilities to pursue all cost-effective demand-side resources, including fuel switching, when developing least cost plans. At this time, some of the utilities, the Department of Public Service (DPS), and intervenors either had already entered into or began an extensive collaborative process to design comprehensive DSM programs.

Negotiations with some of the electric utilities resulted in comprehensive energy-efficiency packages. However, negotiations with the investor-owned utilities (IOUs) reached a stalemate over the fuel-switching issue. The IOUs in Vermont stated that the PSB did not have the authority to mandate fuel switching. The Board took nine months to respond, and in March 1991, the PSB rejected the argument and stated it did have the authority to direct a provider of essential services to employ state-of-the-art technology and practices necessary to deliver adequate service to its customers at the lowest possible cost. All Vermont utilities were ordered to submit analyses of the cost-effectiveness of fuel switching and to incorporate cost-effective fuel substitution into their DSM programs.

Central Vermont Public Service (CVPS) performed their fuel-switching analysis outside of the collaborative. Their analysis concluded that the cost-effectiveness of fuel switching needs to be analyzed on a case-by-case basis, and that there is no end-use for which fuel switching is unilaterally cost-effective (Gamble and Weedall 1992). In July 1991, CVPS, the DPS, and other intervenors reached a compromise agreement on a fuel-switching program for CVPS which did not include financial incentives. As of January 1992, CVPS has offered the following fuel-switching services to residential customers: (1) free energy audits to customers for whom fuel switching may be cost-effective; (2) information on fuel-switching options and the costs and savings associated with these options; and (3) assistance in obtaining non-utility financing for fuel-switching measures (Gamble and Weedall 1992, Weston 1992). By early 1993, CVPS will report to the PSB on the progress of their fuel-switching effort.

Vermont Gas Systems, Vermont's local distribution company, was ordered by the PSB in 1991 to coordinate fuel switching with the electric utilities and participate in cost-sharing. A collaborative has been formed as a result.

The regulatory context in Vermont has allowed utilities to choose from a relatively wide variety of fuel-substitution programs. As a result, a number of different program designs have emerged. The majority of the programs offer customers detailed on-site technical and financial analyses of their fuel-switching options and assistance in obtaining market-rate financing from third parties. In addition, a number of municipal utilities in Vermont offer financial incentives to customers to encourage fuel substitution. By early 1992, programs offered by municipal utilities had seen participation rates of up to 44% of electric space heating customers and load reductions of up to 11% of winter peak load for the entire utility (Hamilton, et al. 1992).

Only one utility service territory in Vermont (Burlington Electric Department) has significant access to natural gas. Although there are a number of interesting fuel-substitution programs, they generally switch customers from electric to oil or propane heat. As a result, only Burlington Electric Department's (BED) programs are highlighted in this chapter. Under a grant from the U.S. Department of Energy, BED offered a fuel-switching pilot in 1990. Due to the success of the pilot, BED began offering a full-scale space and water heating conversion program in mid-1991. These programs are discussed later in this chapter.

Washington

The Washington Utilities and Transportation Commission has not formally stated that electric-to-gas fuel switching should be seen as an electric DSM resource. However, in 1991, the Commission approved a residential fuel-switching pilot program as part of Washington Water Power's (WWP) 1991 electric least-cost plan. WWP, a combination utility, paid financial incentives to eligible customers who converted from electric to gas space and water heating. Due to the success of the pilot in recruiting participants and acquiring savings, WWP has begun a full-scale version of the fuel-switching program (the pilot is described in greater detail later in this chapter).

The Snohomish County Public Utility District (PUD) joined Washington Natural Gas in offering a water heating fuel-switching pilot program in early 1991 which was highly successful in acquiring cost-effective savings and participation, according to the utilities. The program attracted three times as many customers as a similar program previously offered by Washington Natural Gas (this program will be discussed in greater detail later in this chapter). There is no full-scale version of this program proposed to date.

The Washington State Energy Office (WSEO) has estimated that the technical and cost-effective fuel-switching potentials in the state of Washington are approximately 900-1000 MW and 400-600 MW, respectively. The cost-effective potential is net of naturally-occurring fuel substitution (Byers 1992). WSEO recently obtained a grant from DOE through Oak Ridge National Laboratory to manage a cooperative least-cost plan between the largest electric and gas utilities in Washington State, Puget Power and Washington Natural Gas. The plan will focus on all cost-effective actions, including cost-effective fuel substitution, that can reduce the costs of energy services in the utilities' overlapping service territory. The joint plan will be prepared over the next 18 months (Byers 1992).

Seattle City Light, a large electric utility, is presently considering offering a joint program with Washington Natural Gas to switch electric water heating customers to gas; this program could be eligible for a portion of the $3 million which BPA is offering for fuel-switching activities (Byers 1992).

Wisconsin

The Wisconsin Public Service Commission (PSC) sees interfuel substitution "to be a cost-effective demand-side option" (Wisconsin PSC 1992). Due to concerns regarding customer choice and market impacts of mandating fuel-switching programs, however, the PSC does not require utilities to offer fuel substitution programs. Nevertheless, in the latest Advanced Plan Order released by the Commission, five points address fuel-switching issues. First, utilities are required to consider fuel switching as a demand-side option in preparing their Advanced Plans. Second, utilities must provide complete information to customers on their fuel-switching options. Third, the state's largest electric and gas utilities -- Wisconsin Gas and Wisconsin Electric Power Company -- are required to make an effort to embark on a joint gas substitution pilot program. Fourth, electric DSM incentives cannot exceed gas DSM incentives for the same end-use, if gas is available to the customer. Finally, the order requires that utilities study the cost-effectiveness and feasibility of using new heat pump technologies, the majority of which are gas technologies (Kaul 1992).

Northern States Power Company - Wisconsin (NSPW), a dual-fuel utility, completed a gas fuel-switching technical assessment in 1989. The motivation to perform the analysis was primarily two-fold: (1) the electric side of the utility is summer peaking and the gas portion of the utility is winter peaking; (2) in areas where gas lines have been laid out, only 50 to 60 percent of the customers use gas. The assessment identified, among other things, the customer segments for whom natural gas is the best fuel. An integrated electric/natural gas computer model and database were developed and various demand-side technologies were evaluated. In 1992, as a result of the assessment NSPW offered financial incentives on a case-by-case basis to commercial and industrial customers who switched certain end-uses to gas. The end-uses most commonly switched are air conditioning and water heating. Although fuel switching is promoted in the residential sector, incentives have not been offered since fuel switching is already occurring due to forces in the marketplace, according to the utility (Reck 1993).

INTERFUEL SUBSTITUTION PROGRAMS

A survey was conducted and a database compiled on the achievements-to-date of electric-to-gas substitution programs. This database on fuel-switching programs was developed primarily to understand what is happening across the country with respect to utility electricity-to-gas substitution programs, the savings and participation achieved by existing programs, and the traits that may characterize successful programs.

Methodology

Telephone interviews were conducted with program managers at more than 40 utilities that had been noted through literature or word-of-mouth as offering fuel-substitution programs. As a result of interviews, it became clear that many fuel-switching programs offer incentives for customers to switch from electricity, propane, or oil to natural gas; data from these programs rarely distinguished which fuel a customer had replaced with gas. Ultimately, data were obtained from 28 programs offered by 19 utilities.

Data requested from the sponsoring utilities included the number of program participants, eligible customers, electricity savings, added gas load due to the program, direct and indirect program expenditures, and 1990 gas sales by customer class for combination and gas utilities. Data on 1989 electricity sales by customer class for combination and electric utilities were obtained from annual documents published by the U.S. Department of Energy (DOE/EIA 1991b; DOE/EIA 1991c). Utilities were asked to adjust the number of eligible customers to equal the portion of the targeted customer base currently using electricity at the end-use to be switched, and to exclude customers who are currently using oil or propane at the end-use in question. Both cumulative (since the start of the program) and annual (for the most recent year) data were requested from utilities. A program's performance over the long-term is best reflected through information collected since the start of the program. However, since cumulative data were rarely available, the analysis focused on annual data.

In order to analyze the data collected from utilities, several indices were calculated.

Annual participation rates (number of participants divided by the number of eligible customers) and annual electricity savings as a percent of the utility's electricity sales to the relevant customer class were used as the primary indices of program success (for example, residential electricity savings as a percent of residential electricity sales for a program). Linked with these two indices is the levelized utility cost ($ per kWh saved), based on an assumed five percent discount rate and a measure lifetime of twenty years. Although it would have been desirable to look at all costs on the electric side and the gas side, including customer payments and monies spent by both gas and electric utilities, generally the only program costs available were those directly spent by the sponsoring utility on direct incentive payments and administrative costs.

Using these indices as a basis for analysis, we have defined a program with a high participation rate and large savings as a percent of sales at a low levelized utility cost as successful. In addition to the preceding indices, we also calculated annual electricity savings per participant and annual utility gas load added as a percent of the utility's gas sales to the relevant customer class for combination and gas utilities. Table 7-1 presents an overview of the database. Appendix D includes a program description and complete compilation of data for each program in the database; a few additional programs are included in the appendix but not in the database due to lack of sufficient data.

Database Highlights

There are eight gas utilities, eight combination electric/gas utilities, and three electric utilities represented in the database. New York, Massachusetts, and Wisconsin utilities are each responsible for roughly one-fifth of the programs in the fuel-switching database. The programs are equally split between residential programs and commercial/industrial programs. Of the 28 programs, roughly half are offered by gas utilities, one-third by combination electric/gas utilities, and only a few are offered by electric utilities. Five of the programs are pilots; the remainder are full-scale. One pilot program is a joint effort between an electric utility and a gas utility.

Table 7-1. Database of Utility Electric-to-Gas Fuel Substitution Programs.

Gas, elec., or combo util-ity	Program code *	Utility	Program	Program Start Date	Program End Date	Data Dates: Start	Data Dates: End	Annual parti-cipa-tion rate	Annual elec. savings as % of GWh sales	Cumul. elec. savings as % of GWh sales	Annual elec. saved per parti-cipant (MWh)	Annual therms added as % of therm sales	Cumul. therms added as % of therm sales	Annual level-ized utility costs ($/kWh)	Pilot or full-scale
A. Commercial and Industrial Programs															
gas	HVAC	Baystate Gas Co.	High-Efficiency Heating Conversion	1990	-	12/90	11/91	0.3%	n/a	n/a	n/a	0.02%	0.02%	n/a	Full
gas	GNRL	Boston Gas Co.	Cogeneration Rebate Program	1985	-	6/91	5/92	0.01%	n/a	n/a	180	0.02%	0.60%	0.003	Full
gas	HVAC	Boston Gas Co.	Gas Air-Conditioning Program	1988	-	1/91	12/91	0.003%	n/a	n/a	77	0.06%	0.10%	0.012	Full
elec	HVAC	British Columbia Hydro	Power Smart: Water Heater Conversion	1990	3/91	4/91	3/92	n/a	0.04%	0.04%	44	n/a	n/a	0.001	Pilot
combo	HVAC	Consolidated Edison	Gas Air Conditioning Program	1988	-	1/91	12/91	0.004%	0.02%	0.04%	260	0.20%	0.53%	0.059	Full
combo	HVAC	Long Island Lighting Co.	Dollars & Sense: Gas Air Conditioning	1986	-	10/90	9/91	0.02%	0.04%	n/a	206	n/a	n/a	n/a	Full
combo	GNRL	Madison Gas & Electric	Electric-to-Gas Fuel Switch	1988	-	1/91	12/91	n/a	0.04%	n/a	n/a	0.68%	n/a	0.022	Full
gas	GNRL	National Fuel	Commercial Building Energy Management	1991	-	1/91	12/91	0.1%	n/a	n/a	67	0.003%	0.003%	0.001	Full
combo	HVAC	Orange & Rockland	Non-Electric Cooling Program	1989	-	1/90	12/90	0.02%	n/a	n/a	n/a	0.49%	n/a	0.001	Full
gas	HVAC	Peoples Gas Systems	Gas Space Conditioning Allowance	1990	-	10/90	9/91	n/a	n/a	n/a	2333	0.16%	0.26%	0.0003	Full
combo	HVAC	Public Service E&G	C&I Gas Air Conditioning Program	1989	12/92	1/91	12/91	0.1%	0.01%	0.02%	850	0.06%	0.12%	0.013	Full
combo	HVAC	San Diego G&E	Gas Air Conditioning	n/a	-	3/90	2/91	1.3%	0.23%	n/a	2067	1.40%	n/a	0.003	Full
gas	HVAC	Wisconsin Natural Gas	Gas Air Conditioning Program	1989	-	1/90	1/91	0.005%	n/a	n/a	n/a	0.02%	0.04%	n/a	Full
gas	HVAC	Wisconsin Natural Gas	Gas Space & Water Heating	1989	-	1/90	12/90	0.04%	n/a	n/a	n/a	0.02%	0.05%	n/a	Full
B. Residential Programs															
gas	HVAC	Baystate Gas Co.	High-Efficiency Heating Conversion	1990	-	12/90	11/91	3.2%	n/a	n/a	27	0.04%	0.04%	n/a	Full
elec	HVAC	British Columbia Hydro	Power Smart: Water Heater Conversion	1989	-	4/91	3/92	9.7%	0.19%	n/a	5	n/a	n/a	0.002	Full
elec	HVAC	Burlington Electric Dept	Heat Exchange	1991	-	4/91	3/92	10.3%	2.12%	2.12%	8	n/a	n/a	0.009	Full
elec	HVAC	Burlington Electric Dept	Pilot Fuel Substitution Program	1990	2/91	8/90	2/91	2.4%	0.12%	0.12%	8	n/a	n/a	0.063	Pilot
combo	HVAC	Madison Gas & Electric	Water Heating Fuel Switch	1988	-	1/91	12/91	4.5%	0.24%	n/a	n/a	0.27%	n/a	0.006	Full
gas	GNRL	National Fuel	Appliance Conversion Program	1988	-	1/91	12/91	0.02%	n/a	n/a	11	0.01%	n/a	0.014	Full
gas	GNRL	National Fuel	ECB - Zero-Interest Loan	1988	3/92	1/91	12/91	0.4%	n/a	n/a	1	0.001%	0.001%	0.084	Full
combo	HVAC	Northern States Power-MN	Furnace & Water Heating Conversion	1989	11/90	11/89	10/90	7.0%	n/a	n/a	n/a	0.49%	n/a	n/a	Full
combo	GNRL	Pacific Gas & Electric	Natural Gas Homes	n/a	1989	3/90	2/91	n/a	0.15%	n/a	n/a	0.19%	n/a	0.012	Full
gas	GNRL	Peoples Gas Systems	Residential Home Builder	1981	-	10/90	9/91	n/a	n/a	n/a	7	0.26%	2.50%	0.008	Full
elec & gas	HVAC	Snohomish County PUD & Washington Natural Gas	Water Heater Fuel-Switching Program	1991	6/91	2/91	5/91	14.9%	0.03%	0.03%	4	n/a	n/a	0.005	Pilot
combo	HVAC	Washington Water Power	Switch Saver (loan only)	1991	7/91	3/91	7/91	1.4%	0.04%	0.04%	10	0.03%	0.03%	0.020	Pilot
combo	HVAC	Washington Water Power	Switch Saver (shared savings)	1991	7/91	3/91	7/91	17.4%	0.26%	0.26%	10	0.18%	0.18%	0.014	Pilot
gas	HVAC	Wisconsin Fuel & Light	Electric-to-Gas Water Heater Program	n/a	8/91	1/90	1/91	0.3%	n/a	n/a	n/a	0.11%	n/a	n/a	Full

* Program codes are as follows: GNRL=General Equipment Fuel Conversion Program; HVAC=Heating, Ventilation, & Air Conditioning Fuel Conversion Program.

Program Descriptions by Customer Class

Residential Fuel Substitution Programs

The residential programs in the database can be divided into two broad categories: heating equipment conversion programs and general equipment conversion programs. The heating conversion programs represent one-third of the database. Generally, these programs provide customers with cash rebates for replacing electric space and/or water heating equipment with efficient gas equipment, provided the customer is already connected to a gas main. Incentives are in the form of either cash rebates ranging from $50 to $300 per piece of equipment; ten to forty percent of materials and installation cost; low- or zero-interest loans; or, in the case of one pilot program, free materials and installation. Some programs require other measures to be performed in conjunction with the switch, such as weatherization measures. One program is jointly offered by electric and gas utilities with overlapping service territory. Three offer incentives for replacing water heating equipment only. The rest of the programs offer incentives for switching water and/or space heating equipment.

The four residential general equipment conversion programs in the database promote the installation of efficient gas space heaters, water heaters, ranges, and clothes dryers. Two of the four programs are new construction programs and two are for existing homes. The new construction programs offer financial incentives to builders of single-family homes to install gas equipment. The programs for existing homes offer homeowners and landlords either zero-interest loans or cash rebates for fuel substitution in existing single or multifamily dwellings.

C&I Fuel Substitution Programs

Commercial and industrial programs in the fuel-substitution database can be divided into two categories: HVAC equipment conversion programs and general equipment conversion programs. Programs in the C&I HVAC equipment conversion category, the largest category in the database, offer incentives for customers to switch to gas-fired space cooling and heating equipment and gas-fired water heating equipment. Two-thirds of the programs in this category offer incentives for commercial and industrial customers to fuel switch to efficient gas air conditioning equipment. These incentives are either on a per ton or per kW deferred basis and range from $100 to $400 per ton and from $200 to $500 per kW deferred. The other programs in this category offer commercial and industrial customers incentives to install efficient gas-fired water and/or space heaters. Incentives are in the form of either $200 to $800 cash rebates per piece of equipment; low-interest loans; or 15 percent of the cost of materials and installation. In addition, one program offers commercial customers an incentive of $400 to $500 to replace an electric dishwasher booster heater with a gas-fired booster heater.

The C&I general equipment conversion category contains programs offering incentives for C&I conversions of a wide variety of equipment types; HVAC conversions are just one component. One program offers a $150 incentive to customers who switch from electric to efficient gas water and space heaters in addition to special case-by-case incentives for customer-designed electric-to-gas switching projects. Another program offers $1 per 1000 BtuH of installed input for replacing electric equipment with efficient gas space and water heating, cogeneration, and air conditioning equipment.

Table 7-2 indicates the number of programs in each of the four categories described above.

<u>Caveats</u>

Before discussing the results of the fuel-switching survey, it is important to note that the data summarized here are subject to several caveats.

There are great variations in the quality of the data. The type of utility, whether gas, combination electric/gas, or electric, affects the type, and often the quality, of data collected. As noted by one California regulator, fuel-switching data from combination utilities are usually less biased than similar data from electric or gas utilities (Schultz 1992). Gas utilities account for roughly half the programs in the database. Data collected by these utilities, and to a lesser extent the combination utilities, are generally rough and incomplete. Often, data from the gas

Table 7-2. Number of Utility Fuel-Switching Programs in Database by Category.

Program Category	Residential	Commercial/Industrial
HVAC Equipment Fuel Conversion	10	11
General Fuel Conversion	4	3
Total	14	14

utilities were collected from marketing staff who acknowledged that data collection was often limited to the number of rebates offered and the added gas load.

The savings data should be regarded with extra caution for a number of reasons. For all of the fuel-switching programs offered by gas utilities, and most of those offered by combination utilities, available data on added gas use and electricity savings are rough estimates based on engineering analyses rather than direct measurements and/or billing analyses. This lack of after-the-fact verification of program results restricts the accuracy of the analysis. The small number of programs in the database (28 programs), as well as the even smaller number of programs having electricity savings data (14 programs), also limits the accuracy of the analysis. Half the programs in the database are marketing programs run by gas utilities; for all of these programs, electricity savings as a percent of electricity sales could not be calculated.[1] In addition, most utilities represented in the database did not subtract free riders from their savings and participation estimates. The data may overestimate the incremental savings and participation achieved by the programs as a result.

Another word of caution is that whereas data on direct (i.e. rebate) program expenditures were usually available, data on indirect (i.e. administrative) costs were not consistently available. To adjust for programs lacking data on indirect costs, indirect costs were assumed to be 30

[1] Only a few of the electric-to-gas conversion programs offered by gas utilities tracked the electricity savings achieved through conversion. However, for these few programs, there was generally more than one neighboring electric utility "acquiring" the savings.

percent of direct program expenditures based on experience with electric DSM programs (Berry 1989, Nadel 1990). Also, there are potential hazards in comparing the costs of fuel-switching programs in this database to costs associated with electric DSM programs, since calculations in this study only include utility costs and not the additional gas costs to the participants (total societal costs were rarely calculated by the utilities).

RESULTS

The Typical Fuel-Switching Program

The average program in the database, excluding major outliers, has seen annual participation from roughly two percent of the eligible customer base, electricity savings as a percent of electricity sales to the relevant customer class of 0.13 percent, and a levelized utility cost of $0.011 per kWh saved. The average annual therms added to a utility's load are 0.14 percent of the utility's gas sales to the appropriate customer class.

Data Analysis by Customer Class

Table 7-3 highlights the results of the database for residential and C&I programs separately. Values in the table are average annual values.

The typical residential electric-to-gas fuel-conversion program has seen an annual participation rate of roughly five percent and an annual electricity savings as a percent of sales of 0.17 percent at a levelized utility cost of $0.016 per kWh saved. This is roughly two times the participation at a cost 50 percent higher than the typical program for the entire database. The average annual therms added as a percent of gas sales for residential programs is 0.14 percent.

The typical C&I electric-to-gas fuel-switching program in the database has had annual participation from only 0.1 percent of the eligible customer base and annual savings as a percent

Table 7-3. Summary of Results for Programs in Fuel-Switching Database.

	Average for Residential Programs		Average for Commercial & Industrial Programs	
Annual Participation Rate	4.9%		0.1%	
Highest Value		17.4%		1.3%
Lowest Value		0.2%		0.003%
Annual Electric Savings as % of Electricity Sales*	0.17%		0.04%	
Highest Value		2.12%		0.23%
Lowest Value		0.04%		0.01%
Annual Therms Added as % of Gas Sales*	0.14%		0.16%	
Highest Value		0.27%		1.40%
Lowest Value		0.001%		0.003%
Annual Cost per kWh Saved	$0.016		$0.005	
Highest Value		$0.084		$0.022
Lowest Value		$0.002		$0.001
Number of Programs	14		14	

* Electricity savings and therms added are taken as a percent of the utility's sales to the relevant customer class.

of sales of 0.04 percent; both of these are much lower than the average values for the entire database. At $0.005 per kWh saved, the average levelized utility cost of these C&I programs is less than one-third that of the residential programs in the database. The average annual therms added as a percent of gas sales for C&I programs is 0.16 percent. The measures most commonly performed in the C&I category are air conditioning and heating equipment conversions.

C&I programs have been highly cost-effective from the perspective of the utility purchasing the electricity savings. Two of the cheapest C&I fuel-conversion programs in the database either receive partial funding from the local government or share the cost of the program between electric and gas utilities. However, this does not completely account for the difference between the average cost of residential compared to C&I fuel-switching program. Despite similar marketing and administrative costs per customer for commercial and residential programs, there are generally more savings per dollar spent in a commercial program compared to a residential program when looking at similar end-uses, such as water or space heating, because commercial customers are larger.

The average C&I program in the database has achieved only a fraction of the average savings and participation of residential programs. This may be partially due to the large potential for residential space and water heater conversions (see chapter 3). Also, three of the four municipal electric utility fuel-switching programs in the database are residential programs, and three of the four pilot programs in the database are residential programs. As discussed below, pilot and municipal electric utility programs tend to have high participation rates. In addition, a few utilities offering both residential and C&I fuel-switching programs noted that, in general, the level and rate of response from residential customers is often greater and quicker than that of commercial customers (Chrisione 1992, Bachard 1992).

Successful Fuel-Switching Programs

A "successful" fuel-switching program in the database is defined as a cost-effective program that annually saves at least 0.2 percent of electricity sales and/or has an annual participation rate of at least five percent. "Cost-effective" has been defined as any fuel-switching program costing the utility less than $0.04 per kWh saved. Seven programs in the database meet the criteria of a successful program. On average, compared to the typical program in the database, these programs have achieved three times the participation, two times the savings, and five times the added gas load as a percent of gas sales at no additional cost to the utility sponsoring the program. The average successful program has achieved an annual participation rate of seven percent, annual savings as a percent of electricity sales of 0.24

percent, annual gas added as a percent of gas sales of 0.61 percent, and a levelized utility cost of $0.011 per kWh saved. All of the seven programs are HVAC equipment conversion programs. Three of the programs are offered by electric utilities, three by combination utilities, and one program is jointly offered by a gas utility and an electric utility. Six of the seven programs are residential programs. Four of the seven programs are offered by municipal utilities. Three of the programs are pilot programs, and the rest are full-scale. Results of data analysis on the "typical" and "successful" programs in the database are highlighted in Table 7-4. Table 7-5 summarizes the annual results for the seven successful programs in the database. Levelized utility costs are based on cumulative program results when available; otherwise, the costs are based on annual data. The seven successful programs are discussed in greater detail in the sections below.

BC Hydro's Power Smart Residential Water Heating Conversion Program

BC Hydro initiated their residential water heater conversion program in 1989. Residential customers are eligible to receive a $100 to $200 rebate for converting electric water heaters to efficient gas heaters, provided the customer is already connected to a gas main. The program is a joint effort between BC Hydro and three gas utilities in their service territory. The gas utilities pay for the marketing and administrative costs of the program and BC Hydro pays the customer incentives. As a result, the program has been highly cost-effective to BC Hydro. In 1991, the program achieved an annual participation rate of ten percent (of 50,000 eligible customers) and savings as a percent of residential sales of 0.2 percent. The levelized cost to BC Hydro was $0.002 per kWh saved. This only includes costs to BC Hydro, and does not include costs to the gas utilities.

The success of the program has been partially attributed to the fact that the gas utilities strongly market the program with a clear incentive to make it work. In addition, since BC Hydro was, until recently, a dual-fuel utility, there is a particularly good rapport between the electric utility and neighboring gas utilities. Utility staff noted that, for the most part, the typical animosity between competing gas and electric utilities does not exist in BC Hydro's service territory (Bachard 1992). Another reason for the success may relate to the fact that, generally

Table 7-4. Average Results for Typical and Successful Fuel-Substitution Programs.

	Participation Rate	Electricity Savings as % of Electricity Sales	Added Therms as % of Gas Sales	Levelized Utility Cost ($/kWh)	Number of Programs
Typical Program*	2.3%	0.13%	0.14%	$0.011	28
Successful Program*	7.3%	0.24%	0.61%	$0.011	7

* Excluding major outliers.

speaking, public electric utilities generally do not have the same aversion to fuel switching as private utilities. Public utilities may be more willing to aggressively pursue fuel switching as a DSM resource. Moreover, the program has been in existence for three years, and customers have become familiar with the program, which is marketed as part of the large Power Smart package of DSM programs.

Burlington Electric Department

In late 1989, the Burlington Electric Department (BED), a small municipal electric utility in Vermont, received a grant of $125,000 from the U.S. Department of Energy (DOE) to offer a DSM demonstration program designed to quickly save a significant amount of power with little disruption to operations or to the utility's customers. Under the grant, BED offered a residential space heater "supplemental" fuel-switching pilot program that ran from mid-1990 through mid-1991. The pilot program installed 48 gas-fired space heaters as supplemental heating units in 20 single-family and 24 multifamily residences heated with electric resistance heat. Customers had a fixed choice of ten heaters to choose from. Radio control switches were attached to the electric heating units to allow the utility to shut off most of the electric heat during peak hours. About one-half of the participants never used their electric heat after the gas heat was installed. The utility paid for 100 percent of the cost of materials and installation. The average cost per home was $2,223.

Table 7-5. Database Results for the Seven "Successful" Programs.

Utility	Program	Participation Rate	Electricity Savings as a % of Sales	Gas Added as a % of Gas Sales	Levelized Utility Cost ($/kWh saved)
BC Hydro	Residential Water Heating Conversions	10%	0.19%	n/a	$0.002
Burlington Electric Dept.	Pilot Fuel Substitution Program	3%	0.23%	n/a	$0.031
Burlington Electric Dept.	Residential Heat Exchange	10%	2.12%	n/a	$0.009
Madison G&E	Residential Water Heating Conversions	5%	0.24%	0.27%	$0.006
San Diego G&E	C&I Gas Air Conditioning Program	1%	0.23%	1.40%	$0.003
Snohomish County PUD and Washington Natural Gas	Cooperative Water Heating Fuel Switching Pilot	15%	0.03%	n/a	$0.005
Washington Water Power	Switch Saver Pilot: Shared-Savings	17%	0.26%	0.18%	$0.014

Roughly three percent of BED's residential electric heat customers participated in the program. The savings achieved, as a percent of residential electricity sales, were 0.23 percent. The levelized utility cost was $0.031 per kWh saved, although this cost was absorbed by the DOE grant. The fact that participants received free gas-heating equipment and installation made the program very attractive to customers. In addition, program staff attribute the success of the program to its simplicity, including the limited number of options offered customers and a simple contract. Marketing was based on telemarketing.

As a result of the success of the pilot, BED launched a full-scale electric heat-conversion program, Heat Exchange, in mid-1991 to convert 1,500 dwellings and save 12 GWh annually by 1998. Under the full-scale program, an energy audit is initially performed by a BED contractor who custom-designs gas space-heating systems for participants and also determines if weatherization improvements are needed. Weatherization measures are generally performed in one out of every five dwellings. The utility also encourages water heating conversions. Worth noting is the fact that more than one-half of BED's electric space heat customers are renters, rather than homeowners.

Under the Heat Exchange program, participants have two forms of financing available to them, a "positive cash flow" loan or a cash rebate. If the loan option is chosen, BED will finance, through a local bank, the first costs for the weatherization and water and space heating system improvements. The customer retains 40 percent of the calculated monthly energy savings, and BED recovers the remaining 60 percent over a five-year period, up to the loan amount (without interest). Any remaining balance after five years is paid by BED. If the rebate option is chosen, the participant receives approximately ten to forty percent of the installation costs after the equipment switch and weatherization measures are performed, depending on the type and cost of heating equipment chosen by the customer. Participants choose the rebate option over the loan option by a four to one margin. The program manager noted that the utility costs for the loan portion of the program are initially higher than the rebate portion; however, ultimately, after customer loan payments are credited, the costs to the utility are the same for both options (Buckley 1992).

In the first year of the Heat Exchange program, savings of 2.1 percent of BED's residential sales were achieved along with a ten percent participation rate. The levelized utility cost of the program was only $0.009 per kWh saved. The percent savings is by far the largest savings figure in the database.

Before the program even began, the utility had a waiting list greater than the six-year target of 1,500 dwelling units. BED reports that there has been no need to market the program; instead, the utility has focused on "traffic control". The program's success is partially due to the customers' understanding of the financial benefits of using gas heat in the cold Burlington climate. The targeted marketing of the pilot program, and word-of-mouth marketing of the full-scale program, helped generate the large response (Buckley 1992).

Madison Gas & Electric's Residential Water Heating Fuel-Switching Program

Madison Gas & Electric (MG&E), in the late 1980s, was given a mandate by the Wisconsin Utility Commission to put at least 50 percent of residential water heaters under direct load control before any further construction of new generating facilities could continue. MG&E decided that it was cheaper to fuel switch customers to efficient natural gas equipment than to invest in the load-control equipment. As a result, the utility began offering a residential electric-to-gas water heating conversion program in 1988. Roughly 80 percent of the combination utility's residential customers already use gas water heat, and MG&E is aiming to switch the remaining 20 percent to gas. The water heater program offers a $100 rebate to customers who replace an electric water heater with high-efficiency gas equipment.

In 1991, the program achieved savings of 0.24 percent of Madison G&E's residential electricity sales and a participation rate of five percent. The annual gas added to the utility's system as a percent of residential gas sales was 0.24 percent. The results were achieved at a levelized utility cost of $0.006 per kWh saved. The program has exceeded the participation goals set by the utility.

One reason for the success of the program, according to the utility, is that MG&E has been committed to switching electric water heating customers to gas and has advocated gas water heating for the past two decades through bill inserts, thus exposing customers to a consistent, long-term message. In addition, the size of the incentive is a determining factor in the program's success (Chrisione 1992). The $100 incentive pays for approximately 20 percent of the materials and installation cost of switching. The utility has worked with plumbers and trade allies to ensure product and service availability. MG&E has even considered lowering the customer rebate to $75 and offering the plumbers, who have a financial interest in selling the product, a rebate of $25 per piece of equipment converted. There has been some indication, however, that the plumbers do not need an incentive and would rather have the money continue to go to the customer (Chrisione 1992).

San Diego Gas & Electric's Commercial & Industrial Gas Air Conditioning Program

Since 1986, San Diego Gas & Electric has offered a gas air conditioning/thermal energy storage program for commercial and industrial customers. The program provides cash incentives to customers who replace conventional electric air conditioners with more efficient gas systems or with thermal energy storage systems. The utility provides engineering analyses for both types of systems and lets the customer choose between the two. An estimated two-thirds of the program savings are due to thermal storage and one-third to gas air conditioning (Nadel 1990). The data reported here is limited to the gas air conditioning portion of the program.

The customer incentive for installing gas air conditioners ranges from $50 to $200 per kW shifted depending on the size of the equipment. Marketing is done primarily through the utility's account executives who are in regular contact with the largest commercial customers. In addition, the program is marketed at trade show exhibits and through information seminars.

In 1990, the program achieved savings of approximately 0.20 percent of commercial and industrial electricity sales and a participation rate of one percent. The levelized utility cost was low at $0.003 per kWh saved. The program has increased the utility's commercial and industrial gas sales by 1.4 percent. According to the program manager, program participation has been slow for the past two years due to the economic downturn. In the late 1980s, much of the gas air conditioning was being installed in C&I new construction. Due to the recession, the activity in this market sector has dropped significantly in the past three years. However, the utility sees a significant DSM savings opportunity with gas air conditioning and plans to continue offering the program (Linderman 1992).

Snohomish County PUD/ Washington Natural Gas' Cooperative Fuel-Switching Pilot Program

From February 1991 through April 1991, the Snohomish County Public Utility District #1, a municipal utility in Washington State, coordinated with Washington Natural Gas to offer the Cooperative Water Heating Fuel-Switching Pilot program. Two of the central purposes of the program were to acquire electricity savings and to analyze the customer response to a joint electric utility/ gas utility fuel-switching program. This is the only cooperative effort in the database between a neighboring electric and gas utility.

The program targeted a specific region of the two utilities' overlapping service territories and was offered to owners of single-family homes. To initiate the marketing effort, approximately 1,400 letters were mailed explaining the benefits of water heating electric-to-gas substitution. The letters had the logos and signatures from both utilities. A follow-up telemarketing campaign was performed. Ultimately, 209 customers converted from electric to gas water heaters, or 15 percent of the eligible customer base. This is three times the participation rate relative to a similar program offered earlier by Washington Natural Gas. As a result of the fuel-switching pilot, Snohomish PUD saved 0.03 percent of its residential electricity sales. Washington Natural Gas did not track the added gas load due to this program. The levelized cost to the utilities is $0.005 per kWh saved. The Snohomish PUD is monitoring the savings over a one-year period ending in mid-1993.

According to surveys conducted after the pilot program ended, 90 percent of the participants felt that the cooperation of the utilities in offering a joint program enhanced the attractiveness of the program. Both the electric utility and the gas utility were positive about the results of the program, noting that the joint approach led to greater customer trust in the program. However, to date, no full-scale program has been proposed. Although the gas utility supports a full-scale version of the program, upcoming rate increases have caused the electric utility to curb spending in areas that may lead to additional increases in rates (Lintz 1992, Stackpole 1992). Snohomish PUD expects to re-evaluate the economics of fuel switching as a demand-side resource in late 1993 (Lintz 1992). In the meantime, Seattle City Light, a nearby electric utility, and Washington Natural Gas are considering a joint fuel-switching effort (Byers

1992, Stephens 1992).

Washington Water Power's Switch Saver Pilot Program

Washington Water Power (WWP), a dual-fuel utility, conducted a test DSM program for four months during 1991 to evaluate the impact and cost-effectiveness of two different types of customer incentives for residential fuel-switching from electric space and water heating to efficient gas heating. Two geographically separate locations in the utility's Idaho service territory were chosen to conduct the pilot Switch Saver program. In one location, a low-interest loan (12% financing, no down-payment) was offered for the fuel switch. In the other location, 100 percent funding of the change-out was provided by the utility, and participants were assessed monthly shared savings charges based on the expected net bill savings over a five-year period. Installation costs of up to $4,400 per joint space/water change-out and $850 per water heater change-out were paid for by the utility. The shared-savings charges ranged from $12.95 to $48.00 per month for joint space/water change-outs and $4.95 to $9.95 per water heater change-out depending on the installation cost.

Marketing was based on a direct mail promotion campaign explaining the benefits of switching to gas space and water heating. In evaluating the program, WWP considered free-ridership in calculating net program results. The utility estimated free riders at 45 percent for the loan portion of the program and 11 percent for the shared-savings portion of the program (Washington Water Power 1991). The high level of free riders for the loan portion of the program was attributed by the utility to the relatively small size of the incentive and the small number of participating customers (Johnson 1992).

For residences converting both water and space heating, the shared savings-based test program resulted in a 20 percent net participation rate and the loan-based test program resulted in a two percent net participation rate. For residences converting only water heating, the net participation rates were 14 percent for the shared savings program and one percent for the loan-based program. Overall, the shared savings-based program resulted in a net participation rate of 17 percent, net savings as a percent of residential electricity sales of 0.26 percent, added gas load as a percent of the utility's gas sales of 0.18 percent, and a levelized cost to the utility of $0.014/kWh saved. The total cost of this program, to both the customer and the utility, was approximately $0.031/kWh saved. The loan-based program resulted in an overall net participation rate of one percent, net savings of 0.04 percent, and a levelized utility cost of $0.020/kWh. The shared-savings portion of the program resulted in net savings six times larger than the those of the loan-based program and a participation rate 17 times as large; however, the shared-savings approach was more expensive to the utility.

Even though the program only ran for four months, as opposed to one year for most of the other programs in the database, the participation rate for the shared-savings portion of the program is among the highest in the database, primarily because this was a pilot program targeting only one geographic region with approximately 4,000 eligible customers.

The utility concluded that to significantly increase the level of fuel switching compared to what is already occurring in the market, direct utility intervention with significant financial incentives, such as shared-savings agreements or cash grants rather than loans at market-level interest rates, is necessary (Washington Water Power 1992). Due to the success of the pilot program, Washington Water Power has since begun offering a full-scale space and water heating fuel-substitution program. The new program, the Energy Exchanger, began in mid-1992 and is offered to all eligible Washington and Idaho customers. The utility offers cash incentives up to $640 and up to $2,750 for each water and space heater electric-to-gas conversion, respectively. Additional incentives are offered to customers who exceed fixed efficiency thresholds for the new space and water heating equipment. Similar incentives for exceeding efficiency thresholds are available for new residential construction. According to the utility, the program has experienced a tremendous response from customers. In the first six months of the program, over 15,000 customers have expressed interest in participating in the program; over 1,800 joint water and space heating conversions have been completed, and over 1,200 water heater conversions have been completed (Padayao 1992). The marketing of the new program has been primarily through newspaper ads and through the 120 contractors who sell the equipment. The utility has roughly estimated that the free ridership during the first two years of this program is approximately 20 percent; the utility expects to evaluate the free ridership more closely in the next year (Johnson 1992).

DISCUSSION

Based on the average levelized utility cost of $0.010 per kWh saved for programs in the database, fuel-switching programs are apparently highly cost-effective as an electric demand-side resource from the sponsoring utility's perspective. The overall cost effectiveness of fuel-switching programs from a TRC or societal perspective cannot be determined based on the data available, however.

Results of the database indicate that residential programs apparently have greater participation and greater savings than C&I programs. HVAC equipment conversion rebate programs apparently are more successful than general equipment conversion rebate programs.

Gas utilities and, to a lesser degree, dual-fuel utilities have more of an incentive to switch customers from electricity to gas than electric utilities. Database results for the three different types of utilities therefore appear to be counter intuitive (see Table 7-6). The programs offered by electric utilities have considerably higher participation rates and savings and lower costs than programs offered by gas and dual-fuel utilities. Furthermore, combination utilities in the database have achieved almost seven times the added gas load as a percent of gas sales compared to the gas utilities in the database.

In considering these results, it should first be noted that the analysis of electric utility programs is based on only five programs. In addition, there are no data on electricity savings as a percent of electricity sales for the gas utility programs, and therefore we are basing most of the comparison on participation data. It appears that most of the gas utility programs target a larger customer base than the electric utilities. Three of the five electric utility programs were pilot programs targeting certain areas of the sponsoring utility's service territory.

Moreover, the programs offered by electric utilities are also the only programs in the

Table 7-6. Comparison of Database Results for Electric, Gas & Combination Utilities.

	Participation Rate	Electricity Savings as % of Electricity Sales	Added Gas Load as % of Gas Sales	Levelized Utility Cost ($/kWh)	Number of Programs
Gas Utilities	0.1%	n/a	0.05%	$0.007	13
Combination Utilities	2.6%	0.13%	0.34%	$0.015	11
Electric Utilities	8.2%	0.21%	n/a	$0.005	5

database offered by municipal utilities. There has been some indication through interviews that municipal utilities have been more willing to pursue fuel switching than private electric or dual-fuel utilities (Bachard 1992, Parker 1992, Weston 1992). Results from municipal utility programs compared to investor-owned utility programs in the database, highlighted in Table 7-7, support such a conclusion. Furthermore, one of the electric utilities was formerly a dual-fuel utility and has a relatively close relationship with neighboring gas utilities. In an unusual example of cooperation, this utility has been able to work with the gas utility in offering gas substitution programs. The program manager for this utility's gas substitution program indicated that the joint effort, and the fact that the gas utilities market the program, is the reason for the program's success (Bachard 1992).

Clearly electric utilities have greater experience in operating DSM programs, and this experience probably is reflected in the fuel-conversion program results. As gas utilities gain more experience, they should be able to increase participation rates and savings achieved per dollar spent.

The limited experience with electric-to-gas fuel-switching programs indicates that fuel switching can be successful. Programs which met the criteria for success defined in this analysis generally have one or more of the following features: (1) the program design has been kept

Table 7-7. Comparison of Database Results for Municipal and Investor-Owned Utilities.

	Participation Rate	Electricity Savings as % of Electricity Sales	Added Gas Load as % of Gas Sales	Levelized Utility Cost ($/kWh)	Number of Programs*
Municipal Utilities	8.2%	0.64%	n/a	$0.005	5
Investor-Owned Utilities	2.0%	0.10%	0.11%	$0.010	24

* The one joint municipal utility/private utility program is counted within both categories.

simple, and customers do not need to invest much time and effort to participate; (2) the program has been a cooperative effort involving both gas and electric (or dual-fuel) utilities; (3) the program offers significant direct financial incentives, such as a rebate or shared-savings incentive; and (4) the program started as a pilot program and was then expanded to full-scale implementation.

Experimentation by a larger number of utilities is needed before more definitive conclusions can be drawn. In addition, more data should be collected by utilities in order to improve the analysis of fuel-switching programs. For example, electricity savings achieved through gas utility programs promoting electric-to-gas conversions should be tracked. Moreover, the total costs and energy impacts of fuel-switching programs, on both the gas and the electric side of the equation, should be more thoroughly evaluated so that the quality of the analysis can be improved and the cost-effectiveness of these programs from a Total Resource Cost perspective assessed.

Chapter 8
CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The analysis in the previous sections leads to the following conclusions:

1. There is a substantial economic savings potential from gas efficiency measures. For the residential sector, assuming program administrative costs of 50 percent of measure costs, the total economic savings potential is 23 to 30 percent of gas sales at a marginal gas cost of $2.50/DTh and 38 to 42 percent at a marginal gas cost of $4.00/DTh, varying slightly from utility to utility. Of this total potential, approximately 10 percentage points are from measures mandated under Federal law and the remainder are potential targets for utility programs. For the commercial sector, with 50 percent program costs, the economic savings potential is 17 to 21 percent of gas sales for gas marginal costs of $2.50 to 4.00/DTh, varying slightly by utility. Mandated measures account for less than one percentage point of this potential. If program costs are only 25 percent, the economic savings potential increases by approximately six percentage points in the residential sector and approximately one percentage point in the commercial sector. Based on average retail gas costs, the economic savings potential from all measures (mandated and non-mandated) is more than 50 percent in the residential sector and approximately 30 percent in the commercial sector.

   The economic savings potential is significantly higher in the residential sector than the commercial sector for several reasons. First, there are probably more efficiency measures appropriate for the residential sector than for the commercial sector. For example, the majority of residential buildings have accessible attics and woodframe construction to which attic and wall insulation can be retrofit. In the commercial sector, built-up roofs and masonry or curtain-wall construction are much more difficult to retrofit. Second, residential sector gas use is dominated by space heating; commercial sector gas use is more diffuse. Since savings are generally highest with space heating, residential potentials will be higher. Third, due to time and budget constraints, our commercial sector analysis did not include as many efficiency measures as the residential analysis. Some additional measures could be added to increase the savings potentials, particularly for HVAC controls. Thus, our analysis probably underestimates commercial sector savings potentials to some degree, but even correcting for these problems, savings potentials as a percent of sector gas sales are likely to be lower in the commercial sector.

2. <u>There is also a substantial economic potential for fuel-switching</u>. In the residential sector, assuming 50 percent program costs, it will be generally cost-effective from the total resource perspective to switch electric water heat to gas and will often be cost-effective to switch electric dryers to gas at the time of equipment replacement. For homes with electric baseboard heat, conversion to a gas hydronic system will generally be cost-effective from the total resources perspective upstate for detached homes but not for attached homes. Downstate, conversion of electric baseboard systems will occasionally be cost-effective. For homes with electric heat pumps, conversion to a primary or backup gas furnace will generally be cost-effective upstate, and is of marginal cost-effectiveness downstate in all but the apartments.

   In the commercial sector, all analyses assumed that fuel-switching is done when existing equipment is replaced. At 50 percent program costs it is usually cost-effective to replace an all-electric packaged heating and cooling system with either a gas heating/electric cooling system or an all-gas engine-driven packaged system. Downstate it is sometimes cost-effective to change a gas heating/electric cooling packaged system to an all-gas engine-driven packaged system. Similarly it is usually cost-effective to convert an electric boiler to a gas boiler but rarely cost-effective to convert an electric chiller to a gas chiller. Without program costs, gas engine-driven chillers often are cost-effective downstate (and may be marginally cost-effective in some applications upstate), and several cogeneration/gas abosorption chiller systems become marginally cost-effective downstate.

Overall, the economic savings potential for fuel-switching in the residential sector is estimated to be on the order of 3 to 4 percent of downstate electricity sales and 10 percent of upstate electricity sales. Put another way, residential fuel-switching can increase gas utility sales to the residential sector by approximately 1 to 2 percent downstate and 4 percent upstate. In the commercial sector, the economic potential for fuel-switching is approximately 3 to 4 percent of LILCo's, Con Edison's, and Niagara Mohawk's commercial electric sales. Cost-effective commercial fuel-switching can increase commercial gas sales in the LILCo, Con Edison, and Niagara Mohawk service territories by approximately 14 percent, 30 percent, and 7 percent respectively.

3. A number of successful gas DSM and fuel-switching programs have been offered by utilities, but in general, program experience in these areas is limited. Our research found more than 100 gas DSM and fuel-switching programs throughout the U.S. and Canada; however most have recently begun and have achieved limited results to date. A few programs have achieved annual participation rates of 5 percent or more and/or have reduced utility gas or electricity sales by at least 1 percent, indicating that substantial savings are possible.

However, the results of the most successful gas DSM and fuel-switching programs are paltry compared to the most successful electric DSM programs where the best programs have participation rates of 30 percent or more (Nadel 1990 and 1991a) and successful utility-wide DSM efforts have reduced sales by 1 percent for each year of program operation (e.g. 5 percent savings after five years) (Nadel 1991b). The difference between the most successful gas and electric DSM programs is probably due to the fact that gas programs are just developing while electric programs are well established.

Out of 62 gas efficiency programs for which the cost of saved gas could be calculated, 71 percent had estimated CSGs to the utility of less than $4.00/Dth saved including 48 percent with estimated CSGs less than $2.50/Dth saved. If initial indications prove correct that long-run marginal gas costs are between $2.50-4.00/Dth, the presence of many gas DSM and fuel-switching programs with CSGs below these levels indicates that programs can be designed that will probably be cost-effective for New York State gas utilities using the utility-cost test (a test which includes utility costs for DSM measures but not customer costs). However, programs must be carefully designed so program costs are kept within cost-effectiveness limits. Similarly, approximately half the fuel-switching programs analyzed have estimated levelized costs to the utility of less than $0.01/kWh saved, and most of the remainder have estimated levelized costs less than $0.03/kWh, indicating that fuel-switching programs can be designed that are cost-effective to electric utilities.

RECOMMENDATIONS

Two types of recommendations are discussed: recommended changes to programs and policies in New York State and recommendations for future research projects.

Programs and Policies

There is a substantial resource available from cost-effective gas efficiency and fuel-switching measures. Even our worst-case sensitivity analyses indicate a cost-effective gas efficiency savings potential of at least 12 percent in the residential sector and at least 16 percent in the commecial sector from non-mandated measures. Furthermore, experience with gas DSM and fuel-switching programs shows that programs which are cost-effective from the utility perspective can be offered. New York State gas utilities should expand current efforts to pursue this resource by:

1. Expanding the range of current pilot DSM and fuel-switching programs to gain more program design and operation experience and lay the groundwork for possible full-scale programs that may be offered in the future. Both existing programs and these new programs should be thoroughly evaluated.

2. Begin preparing integrated least-cost plans (LCPs) that develop long-range strategies for meeting future energy needs at the lowest cost to consumers and society. Such plans, should include extensive reliance on DSM and fuel-switching programs to the extent these programs have a lower cost to society than traditional gas and electric supply options.

In selecting targets for initial programs, two priorities appear to be justified: equipment replacement programs (which promote high-efficiency equipment and fuel-switching when existing equipment is replaced), and comprehensive residential weatherization programs (that identify optimal weatherization packages for each home and assist homeowners with measure financing and arranging for measure installation). These programs target several of the largest opportunities for achieving energy savings. The first program also targets a "lost opportunity" resource; if high efficiency equipment is not installed when existing equipment is replaced, it will be many years before the equipment is again replaced and thus the opportunity to achieve energy savings will be lost for a long time. The second program can build upon the existing HEICA program operated by all New York utilities. To be truly comprehensive, the number of measures covered by HEICA needs to be expanded as should the range of financing and installation services that are offered.

In addition to these two priorities, gas utilities should explore opportunities to offer joint programs with electric utilities because cost sharing can reduce program costs for each utility. Joint programs are also less confusing to customers than separate electric and gas programs for the same population and joint programs allow gas utilities to benefit from electric utility DSM experience.

To encourage gas utility actions, we recommend that the NYPSC:

1. Continue to work with gas utilities to develop long-run avoided gas costs so that a methodology to compute marginal gas costs is agreed on and estimates of marginal gas costs are available for each utility. These values are essential for determining the cost-effectiveness of gas DSM and fuel-switching programs;

2. Encourage gas utilities to prepare pilot program plans and begin preparing LCPs.

3. Set up cost-recovery procedures so that gas utilities are assured that prudent investments in gas DSM will be charged to rate payers.

4. Review the impact of gas efficiency and fuel-switching programs on gas and electric utility profitability and take steps to ensure that the LCP to society is the most-profitable plan for utilities. The NYPSC has been a national leader promoting electric DSM. Similar steps should be taken to promote gas DSM and fuel-switching programs.

5. Open a docket or collaborative program design process for both gas and electric utilities to discuss optimal ways to promote cost-effective fuel-switching. This should address who should implement fuel-switching programs (gas or electric utilities or some combination) and how costs should be allocated.

To complement the previous activities, gas utilities and the New York State Energy Office (NYSEO) should work on developing contractor skills in areas that will be critical for the success of gas DSM programs. Several major opportunities for gas savings are not widely understood by New York contractors. Contractors should be trained so that savings are maximized and costs are reasonable. Contractor training efforts should be paced to keep just ahead of the anticipated demand for DSM services. Contractor training will probably be needed in:

* Infiltration reduction;

* Duct sealing;

* Comprehensive furnace and boiler tuneups including boiler temperature modulation (similar to successful programs in Colorado (Proctor and Mills 1987, Proctor 1987); and

* Comprehensive heating and hot water equipment system conservation packages for multifamily buildings similar to programs operated by the Center for Energy and the Urban Environment in Minneapolis and the Center for Neighborhood Technology in Chicago.

Research

While the analyses discussed in this report justify specific program and policy actions, many questions still remain that should be addressed by additional research. Areas meriting research attention include:

1. Field studies on the gas savings that can actually be achieved from comprehensive gas efficiency packages. As discussed in Chapter 2, studies have been done for small single-family ranch houses and large steam-heated multifamily apartment buildings. Similar studies for other building types would be useful to verify the accuracy of our technical savings potential estimates. Initial efforts should address brownstone townhouses and several of the most common types of commercial buildings. Brownstones are a priority because savings opportunities appear to be particularly large in brownstones. Commercial buildings are a priority due to the dearth of *comprehensive* retrofit studies in this sector.

2. Preparation of thorough evaluations on existing gas DSM and fuel-switching programs. As noted in Chapters 6 and 7, few existing programs have been thoroughly evaluated, including compilation of accurate savings, cost, and

participation estimates. Proper evaluation of existing programs should be a high priority.

3. A set of pilot programs to examine customer response to different levels of gas DSM and fuel-switching incentives. Several pilot programs should be offered which are similar in all respects except for the amount of incentive provided. Such studies, which have been conducted by electric utilities for electric DSM measures, isolate the impact of incentive level on customer response. Similar studies should be performed for gas DSM and fuel-switching measures which differ substantially from the measures already studied. For example, electric utilities have already studied attic insulation, infiltration control, and basic weatherization improvements. Research is needed on high efficiency heating and hot water systems, wall insulation, duct sealing, and fuel-switching.

4. Field studies on the gas savings that can be achieved by specific efficiency measures whose performance in the field is not well understood. As discussed in Chapter 2, field studies have been conducted on the savings achieved from many individual efficiency measures. However, for some measures, such as duct sealing in cold climates, field studies are still needed.

5. An examination of how gas DSM and IRP could affect gas rates, and how competition with oil might affect gas DSM and IRP. Gas utilities are concerned that gas DSM will raise gas rates and thereby affect gas utilities' ability to compete with oil for important loads. On the other hand, gas DSM and IRP have the potential for reducing capital expenditures for new gas lines and/or for allowing gas utilities to promote fuel switching from oil where it is cost-effective from a societal perspective to do so. These issues may to be controversial; a study that explores these effects and their interactions could help bring some objectivity into debates on these issues. Also, to the extent rate impacts or effects on inter-fuel competition prove to be significant, such a study should

investigate ways to reduce these impacts. Research recommendations 7 and 15 also relate to this topic.

6. An investigation of the gas savings and fuel-switching potential in the industrial sector. Investigating fuel-switching opportunities is a particular priority because many will favor using electricity, providing a useful balance to the gas-oriented programs that tend to predominate in the residential and commercial sectors.

7. Research on the marginal costs of extending and reinforcing local gas distribution networks. To the extent gas capacity costs are affected by gas DSM and fuel-switching programs, many of these costs will occur at the local distribution level. A better understanding of these costs will be essential for accurately determining the avoided costs of gas DSM and fuel-switching programs.

8. An investigation of gas use patterns in upstate New York to explore why upstate homes use substantially less gas per square foot per heating degree day than downstate homes. This project can lead to developing improved models of upstate energy use and improved estimates of the savings potential upstate.

9. A review of the administrative costs of DSM programs in New York State, including electric DSM programs, gas DSM programs, and fuel switching programs. As discussed in Chapter 1, preliminary estimates of administrative costs in New York State differ substantially from the results of national studies. More precise data on administrative costs in New York State should compiled and analyzed including analysis on how these costs differ from program type to program type and whether and why administrative costs in New York differ from those elsewhere in the country.

10. Preparation of improved commercial sector forecasting data including energy use intensities, equipment saturations, and floor areas. As discussed in Chapter 4, the data included in the NYPP and NYSEO forecasts are problematic because

limited effort has been made to correlate them with actual gas sales. Improved data will need to be collected for each gas utility. Current estimates are crude and grouped according to electric utility service area and not gas utility service area.

11. Further analysis of gas DSM and fuel-switching programs. As noted in Chapters 6 and 7, gas DSM and fuel-switching programs are not widely offered nor are complete program data available. Thus, few conclusions can be drawn about how to structure programs to maximize the amount of cost-effective savings. However, gas DSM and fuel-switching programs are growing rapidly, and an analysis of program experience in about two years should be useful. After such a study is completed, it may also be appropriate to analyze the achievable gas conservation potential. Achievable potential studies are discussed in Chapter 1.

12. A field study to examine the relationship between gas savings from different efficiency and fuel-switching measures and gas demands at different times of the year, including the period of peak demand. There is a widespread belief in the gas industry, based on experience in the early 1980's with voluntary thermostat setbacks and other weatherization measures, that gas efficiency measures save energy during shoulder periods but not during periods of peak demand. While such a pattern may be true for thermostat setbacks and other measures such as boiler temperature modulation and heat pumps whose control algorithms vary with the weather (for example, consumers are reluctant to set back thermostats on the coldest days of the year), we do not think this pattern should apply to weatherization "hardware" such as insulation, infiltration and duct leakage reduction, and new furnaces, boilers, and water heaters. Several New England utilities are now studying this issue (RCG/Hagler, Bailly 1992). It is unclear whether this study will provide enough data to satisfy outstanding concerns about the peak demand impacts of gas efficiency measures. After the New England study is completed, New York utilities should assess whether additional research is needed.

13. A study on the costs and savings of actual fuel-switching installations. Many hundreds of New York homes and dozens of New York businesses have switched from electric heating or cooling to other fuels; an analysis of the actual costs of these conversions and the savings achieved would serve as a check on our analyses and would help to indicate the range of conversion costs and savings that can be expected in the field.

14. A field survey of a random sample of electrically heated and cooled buildings to assess the costs and savings from fuel-switching. This study can indicate the number of buildings for which fuel-switching is economical, the key variable in estimating the size of the fuel-switching resource. The estimates made in the present study are rough approximations subject to substantial uncertainty. A field survey will provide more accurate estimates. As part of this study, simple screening tools can be developed to assess the economics of fuel-switching on a building-specific basis, taking account of site-specific energy use and fuel and conversion costs. Such screening tools will be useful if fuel-switching programs are offered.

15. A study on the economics of fuel-switching to other fuels besides natural gas. Many regions of the state do not have natural gas service. For these regions, fuel oil and propane are the primary competitors to electricity. A study to assess the economics of switching to these fuels would complete the assessment of fuel-switching for the residential and commercial sectors.

CONCLUDING THOUGHTS

By implementing these recommendations, New York State has an opportunity to achieve substantial long-term energy and cost savings for its citizens. However, achieving these savings will require extensive long-term effort because it will take time to develop and test program designs and because many savings opportunities are only available when equipment is replaced, and these opportunities will occur over several decades. Still, in order to achieve significant savings this decade, initial steps must be made now. Just as New York State is a now a national leader in electric DSM efforts, with diligent work, New York can also become a leader in the gas DSM arena.

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Appendix A

MODELING HEAT LOSSES FROM UNINSULATED ATTICS, WALLS, AND BASEMENTS

To accurately model the uninsulated case, the insulating value of components without insulation must be estimated. This is an area where small changes in materials or conditions can have a large impact. This appendix describes how assumptions for no-insulation conditions were developed.

Attic Insulation

Calculating attic heat loss is modeled in most software and hand calculations as a one-dimensional conduction phenomenon. In reality, it is not only a multidimensional heat transfer, but there are very complicated mechanisms that make a one-dimensional calculation an extreme oversimplification. The primary driving forces in an attic are the exterior roof and gable temperatures which are affected by outdoor temperature, wind, ventilation rate below the roof, solar gain, and sky temperature. Heat exchange from below the ceiling to the outdoors occurs through conduction through the insulated area, and by radiation and convection from the upper surface of the insulation through the attic and roof. Complicating factors, such as wind blowing through the insulation, rafters, and ductwork make each attic a nearly insoluble mathematical or engineering problem. Indeed, ASHRAE is in the process of selecting a contractor to produce a new improved attic heat transfer algorithm to use in mainframe computer programs such as DOE-2 and BLAST.

Obviously, we need to simplify the assumptions and the calculation procedure so that calculations can be easily done on a personal computer. The goal is to choose a one-dimensional R-value that characterizes a wide variety of attic situations with reasonable parity with real attic heat loss. If there is insulation in the floor, the R-value of the insulation dominates the calculation, and the one-dimensional model is accurate. If, on the other hand, there is no insulation, the effective R-value has a very wide range in real situations (from R-1.5 to R-7 or more).

To find the best average R- value for the uninsulated case, we used a method recommended by the California Energy Commission (California Energy Commission 1989) which accounts for ventilation and buffering effects, and the effective R-value was calculated to be 4.4. In addition, we reviewed measured data for savings at various insulation thicknesses and compared the percent saved in the field studies to the REM Design calculations for the colonial prototype. These were found to be within a reasonable range. Field data is scarce, but for one program where houses were insulated to R-30 from R-0 the savings were 21 percent as compared to 20 percent calculated with REM Design. In another program where houses were insulated from R-11 to R-30, the savings were 13 percent as compared to 5 percent in the REM calculations. The lowest savings from any attic insulation program were around 12 percent for increasing various R-values to R-19 or more. (Cohen, Goldman, and Harris 1991).

Several computer models and a simplified hand calculation were also run to compare predictions for savings in million BTU/year to the REM Design estimates. These are summarized below:

	WAPA	CALPAS	EEDO	REM	REM%
R-0>30	16.22	25.8	46.1	31.2	20%
R-0>40	16.91	25.8	46.8	32.3	20%
R-5>30	6.78	10.6	32.5	16.7	11%
R-11>30	3.35	5.2	9.1	7.5	5%
R-19>30	1.29	2.0	3.2	2.5	2%
R-5>40	7.47	11.7	14.3	17.8	11%
R-11>40	4.03	6.3	9.8	8.6	5%
R-19>40	1.97	3.1	3.9	3.6	2%

Using the approach described above, an effective R-value of 4.4 was used, and an input value of R-2.1 was calculated and used for the uninsulated attic cases to which internal REM Design algorithms add the remaining R-2.3. For flat roofs, a similar approach led to an effective R-5, and an input value of R-2.85 used with the cathedral ceiling component model in REM Design.

Wall Insulation

Effective wall R-values for the uninsulated base case with wood frame walls and 16-inch on-center studs were estimated to be R-6.49. Since REM Design calculates an effective R-value of 2.75 in this case, an additional R-3.74 was input to achieve realistic wall performance in the uninsulated case. Similarly, the brownstone building has an effective R-value of only 2.9 for 12-inch stone with metal lath and plaster; brick and 6-inch concrete block is the same. The input R-value for the base case was therefore R-0.15.

Floor Insulation

In floors, heat transfer is complicated by multiple paths and surface temperatures. In this case, the basement walls and floor temperature affect the heat loss through the floor. These, in turn, depend on ground temperature and conductivity as well as the amount of masonry exposed directly to the outdoors. In this case, we do not have the advantage of any reliable measured data, but there has been considerable work done by Oak Ridge National Laboratory (ORNL) and by the Underground Space Center in Minneapolis which published The Foundation Handbook (Labs et al. 1988). This handbook is based on a specially modified version of DOE-2 designed to more accurately model ground losses. Also, there have been several field studies of savings due to basement wall insulation (Robinson, et al. 1990) that allowed us to compare our predictions of savings to a relatively small sample of 15 houses with these measures.

Here again, we developed an effective R-value for the floor based on the predicted savings from The Foundation Handbook and compared these to other software predictions. REM calculates the effective R-value of an uninsulated floor to be roughly R-3.3 including the effects of below-grade and above-grade heat loss through basement walls. EEDO, another software product based on LBL algorithms, calculates an R-value of 3.0 for an uninsulated floor, but then adds the below-grade wall and floor resistances to get an overall uninsulated equivalent

R-value of 11.23. Using the ORNL handbook, the loss would be larger than EEDO, but smaller than the REM R-0 case, of the order of 17 million BTU per year for this basecase. REM predicts 31.3 MMBTU for the floor loss, ORNL predicts 17 MMBTU, and EEDO predicts 12 MMBTU. All three procedures predict similar floor losses at R-19 - approximately 6 MMBTU. We therefore chose an overall effective R-value of 7.3 to duplicate the ORNL estimated floor losses. REM Design is executed with R-4 in the floor which produces an effective overall R-7.3 and a total floor (floor only, not including interactive effects), loss for no insulation of 16.8 MMBTU. The resulting savings of approximately 7 percent are in line with the ORNL predictions. Verified and comparable field studies for this measure are unavailable.

For the basement wall, modifying the automatically calculated REM Design R-values was unnecessary. However, comparing the insulated floor situation and the insulated basement wall situation creates difficulties due to different temperatures in the basement. This becomes a particular concern for the minimum savings analysis, where the base case has insulated walls, the null case has no floor or wall insulation, and an alternate case has an insulated floor. In the base case with R-11 basement walls, the basement temperature is elevated, and the ductwork is included within the insulated envelope. In actual houses the basement temperature may be as high as the room temperature above the basement -- losses from the basement are very low, and heat leakage from ducts, pipes, and equipment is sufficient to heat the basement. Of course, the savings from insulation in a basement with a 60^0 F temperature are far higher than in a 40^0 F basement. Most data suggest that savings from insulating the floor are comparable to insulating the basement wall. The R-0 floor in the REM model has an effective R-value of 3.3. Running the floor R-0 case with this effective R-value led to overestimates of savings from insulation in floors when compared to field studies, program data, and the LBL CIRA algorithms (implemented in EEDO 2.0), but less than the Oak Ridge Foundation Insulation model. To achieve parity and match results to field studies, the R-0 floor case was modeled with an additional R-4 for an effective R-7.3 and the below-grade masonry with an additional R-4 to simulate ground resistance.

To assess the effective savings from basement wall insulation, it was necessary to develop a new base case for a semi-heated basement such as would result from increasing the thermal resistance of a basement with ducts and equipment. To achieve this, we created a heated basement base case with no wall insulation, no duct losses (ducts are now losing heat to the heated space), and used a thermostat set point of 60^0 F. We then ran the same model with added R-11 basement wall insulation above and below grade. The difference between the two cases is the savings from the wall insulation, and the number input to the spreadsheet is the result of subtracting, or adding in the minimum savings case, the savings from the original unheated basement basecase. The predicted savings of 7.3 percent for the colonial prototype compare well with the Robinson field study where savings averaged 7.9 percent.

Appendix B

METHODOLOGY FOR CALCULATING BREAKEVEN GAS PRICE AND INTERMEDIATE RESULTS FOR THE GAS FUEL-SWITCHING ANALYSES

To better understand the concept of a breakeven gas price, it is instructive to review a simplified algebraic derivation followed by an example. The breakeven gas price is always calculated in reference to the lifecycle cost of an assumed base electric technology compared to a candidate gas alternative. For the total lifecycle costs (TLCC) of the two competing technologies to be equal:

TLCC of option 1 = TLCC of option 2 equation 1

The total lifecycle cost of each option is the sum of the capital and installation costs of each option (CIC), its non-fuel operating and maintenance cost (OMC), its electricity cost (ELC), and its gas cost (GSC). That is:

TLCC = CIC + OMC + ELC + GSC equation 2

Since initially a societal perspective on the economics of fuel-switching is desired, the costs of electricity and gas are evaluated using long-run avoided costs (LRACs) for both energy sources and future operating costs are present-valued using an assumed 5 percent real discount rate based on the utility cost of capital as discussed in Chapter 2.

Of course, the GSC is unknown, since it is the product of the quantity of gas consumed (GQ) times the long-run avoided cost for gas (GLRAC) which is unknown.
Formally:

GSC = GQ * GLRAC equation 3

The breakeven gas price is based on the concept that, if the two lifecycle costs are equal, simple algebraic manipulation of the terms will allow one to solve for the unknown GLRAC.

That is, substituting equation 3 into equation 2, and equation 2 into equation 1, start with the equality:

$$CIC_1 + OMC_1 + ELC_1 + (GQ_1 * GLRAC) = CIC_2 + OMC_2 + ELC_2 + (GQ_2 * GLRAC)$$

Then, solve for GLRAC:

$$GLRAC = [(CIC_2+OMC_2+ELC_2) - (CIC_1+OMC_1+ELC_1)] / (GQ_1 - GQ_2)$$
equation 4

In other words, given that two options have different non-gas lifecycle costs, the price of gas that will make the total lifecycle costs of the two options equivalent is just this difference in non-gas lifecycle costs divided by the difference in gas consumption.

Tables B-1 to B-3 present intermediate values used to develop the gas breakeven prices presented in Chapter 5. For each technology considered (base and gas alternative), costs are reported on a normalized basis (using floor area) for each component in the calculation of the gas breakeven price. The capital and installation costs of the technologies are combined and expressed in levelized (i.e., annualized) dollars per unit of floor area. The energy values (either cost for electricity or energy use for both electricity and gas) represent total building consumption. Thus, the electricity values include electricity use for non-space conditioning end uses, such as lighting. For electricity, annual kWh/sqft, as well as summer and winter capacity values (W/sqft) are reported.

We now illustrate the breakeven gas price calculation with an example. For this example, we consider a gas alternative for the retail building prototype in the BUG service territory. The example will draw upon the information presented in Tables 5-2 (technology costs), B-2 (intermediate values for BUG), in order to derive a result presented in Table 5-11 (gas breakeven prices for BUG, measure cost +0%).

Table B-1. Intermediate Values for Fuel-Switching Analysis—LILCo.

Packaged HVAC

	Reference Cases		Gas Alternatives			
	1	2	1	2	3	
Heat Type	El Res	El HP	Gas	Descnt	Gas	
Cool Type	El Comp	El Comp	El Comp	Descnt	Gas Eng	Units
OFFICE						
Lvl. Install+O&M	0.26	0.30	0.27	0.56	0.39	$/sqft.yr
Ann. Elect. Cost	1.56	1.50	1.32	1.18	0.79	$/sqft.yr
Elect. Consumption	23.1	21.9	17.8	14.5	15.8	kWh/sqft.y
Summer Capacity	5.0	5.0	5.0	4.9	1.2	W/sqft
Winter Capacity	2.2	1.9	1.1	0.8	1.1	W/sqft
Gas Consumption	6.6	6.6	37.6	24.3	58.5	kBtu/sqft.y
RETAIL						
Lvl. Install+O&M	0.30	0.34	0.31	0.64	0.45	$/sqft.yr
Ann. Elect. Cost	1.42	1.22	1.01	1.10	0.68	$/sqft.yr
Elect. Consumption	21.4	17.0	12.4	12.3	9.9	kWh/sqft.y
Summer Capacity	4.1	4.1	4.1	4.8	2.1	W/sqft
Winter Capacity	5.9	4.1	2.1	2.0	2.1	W/sqft
Gas Consumption	5.8	5.8	53.1	26.5	78.0	kBtu/sqft.y
SUPERMARKET						
Lvl. Install+O&M	0.52	0.59	0.53	1.11	0.77	$/sqft.yr
Ann. Elect. Cost	3.92	3.67	3.30	3.33	2.86	$/sqft.yr
Elect. Consumption	68.5	62.8	54.4	54.1	51.3	kWh/sqft.y
Summer Capacity	8.8	6.8	8.8	9.1	6.2	W/sqft
Winter Capacity	11.0	9.0	6.2	6.1	6.2	W/sqft
Gas Consumption	14.4	14.4	92.3	99.6	123.4	kBtu/sqft.y
RESTAURANT						
Lvl. Install+O&M	0.45	0.51	0.46	0.95	0.66	$/sqft.yr
Ann. Elect. Cost	1.92	1.55	1.16	0.93	0.86	$/sqft.yr
Elect. Consumption	33.6	25.2	16.4	12.9	13.0	kWh/sqft.y
Summer Capacity	3.9	3.9	3.9	3.2	2.6	W/sqft
Winter Capacity	8.3	5.5	2.6	2.2	2.6	W/sqft
Gas Consumption	86.1	86.1	177.5	168.8	207.1	kBtu/sqft.y
WAREHOUSE						
Lvl. Install+O&M	0.27	0.31	0.28	0.58	0.40	$/sqft.yr
Ann. Elect. Cost	0.98	0.83	0.67	0.82	0.79	$/sqft.yr
Elect. Consumption	15.2	11.3	7.4	7.8	6.1	kWh/sqft.y
Summer Capacity	3.1	3.1	3.1	4.2	0.2	W/sqft
Winter Capacity	0.2	0.2	0.2	0.2	0.2	W/sqft
Gas Consumption	2.9	2.9	42.3	17.3	58.5	kBtu/sqft.y

Central HVAC - Heating

	Reference Case	Gas Alternatives		
	1	1	2	
Heat Type	El Boil	Std Gas	Hieff Gas	Units
OFFICE				
Lvl. Install+O&M	0.04	0.04	0.06	$/sqft.yr
Ann. Elect. Cost	2.66	1.38	1.38	$/sqft.yr
Elect. Consumption	53.6	21.1	21.1	kWh/sqft.y
Summer Capacity	4.3	4.3	4.3	W/sqft
Winter Capacity	1.6	1.6	1.6	W/sqft
Gas Consumption	6.6	75.8	72.0	kBtu/sqft.y
RETAIL				
Lvl. Install+O&M	0.05	0.06	0.09	$/sqft.yr
Ann. Elect. Cost	2.48	1.15	1.15	$/sqft.yr
Elect. Consumption	49.6	15.6	15.6	kWh/sqft.y
Summer Capacity	4.0	4.0	4.0	W/sqft
Winter Capacity	3.3	3.3	3.3	W/sqft
Gas Consumption	5.8	78.2	74.2	kBtu/sqft.y
HOSPITAL				
Lvl. Install+O&M	0.04	0.05	0.07	$/sqft.yr
Ann. Elect. Cost	2.83	1.17	1.17	$/sqft.yr
Elect. Consumption	60.2	18.0	18.0	kWh/sqft.y
Summer Capacity	3.6	3.6	3.6	W/sqft
Winter Capacity	2.0	2.0	2.0	W/sqft
Gas Consumption	23.4	113.5	108.5	kBtu/sqft.y

Table B-1. Intermediate Values for Fuel-Switching Analysis—LILCo.

Central HVAC - Cooling

	Reference Case	Gas Alternatives			
	1	1	2	3	
Cool Type	El Comp	Gas Abs	Gas Eng	Gas Eng w/HR	Units
OFFICE					
Lvl. Install+O&M	0.07	0.19	0.18	0.20	$/sqft.yr
Ann. Elect. Cost	1.38	1.17	1.08	1.15	$/sqft.yr
Elect. Consumption	21.1	17.9	16.3	17.6	kWh/sqft.y
Summer Capacity	4.3	3.6	3.4	3.6	W/sqft
Winter Capacity	1.6	1.3	1.1	1.3	W/sqft
Gas Consumption	75.8	133.6	121.3	98.0	kBtu/sqft.y
RETAIL					
Lvl. Install+O&M	0.12	0.31	0.29	0.32	$/sqft.yr
Ann. Elect. Cost	1.15	0.90	0.81	0.88	$/sqft.yr
Elect. Consumption	15.6	13.0	11.7	12.7	kWh/sqft.y
Summer Capacity	4.0	2.9	2.5	2.8	W/sqft
Winter Capacity	3.3	2.9	2.6	2.8	W/sqft
Gas Consumption	78.2	127.4	117.7	97.7	kBtu/sqft.y
HOSPITAL					
Lvl. Install+O&M	0.17	0.43	0.41	0.44	$/sqft.yr
Ann. Elect. Cost	1.17	0.91	0.83	0.92	$/sqft.yr
Elect. Consumption	18.0	14.8	14.0	14.0	kWh/sqft.y
Summer Capacity	3.6	2.5	2.1	2.1	W/sqft
Winter Capacity	2.0	1.8	2.0	2.0	W/sqft
Gas Consumption	113.5	144.3	151.1	131.2	kBtu/sqft.y

Central HVAC - Cogen

	Reference Case	Gas Alternatives				
	1	1	2	3	4	
Heat Type	Gas Boil	Cogen	Cogen	Cogen	Cogen	
Cool Type	El Comp	El Comp	Abs/El	El Comp	Abs/El	Units
OFFICE						
Lvl. Install+O&M	0	0.33	0.35	0.33	0.35	$/sqft.yr
Ann. Elect. Cost	1.38	1.06	1.03	0.69	0.67	$/sqft.yr
Elect. Consumption	21.1	14.1	14.0	8.5	8.4	kWh/sqft.y
Summer Capacity	4.3	4.0	3.8	2.9	2.7	W/sqft
Winter Capacity	1.6	0.9	0.9	0.2	0.2	W/sqft
Gas Consumption	75.8	111.7	112.4	175.7	175.7	kBtu/sqft.y
RETAIL						
Lvl. Install+O&M	0	0.74	0.79	0.74	0.79	$/sqft.yr
Ann. Elect. Cost	1.15	0.79	0.72	0.15	0.02	$/sqft.yr
Elect. Consumption	15.6	8.0	7.3	1.2	0.1	kWh/sqft.y
Summer Capacity	4.0	4.0	3.8	0.8	0.2	W/sqft
Winter Capacity	3.3	0.1	0.0	0.1	0.0	W/sqft
Gas Consumption	78.2	117.9	123.3	215.2	221.6	kBtu/sqft.y
HOSPITAL						
Lvl. Install+O&M	0	0.32	0.34	0.32	0.34	$/sqft.yr
Ann. Elect. Cost	1.17	0.81	0.76	0.53	0.51	$/sqft.yr
Elect. Consumption	18.0	10.3	9.5	6.3	6.3	kWh/sqft.y
Summer Capacity	3.6	3.4	3.3	2.2	2.2	W/sqft
Winter Capacity	2.0	0.6	0.6	0.6	0.6	W/sqft
Gas Consumption	113.5	153.0	160.3	200.1	200.1	kBtu/sqft.y

Table B-2. Intermediate Values for Fuel-Switching Analysis—BUG.

Packaged HVAC

	Reference Cases		Gas Alternatives			
	1	2	1	2	3	
Heat Type	El Res	El HP	Gas	Descnt	Gas	
Cool Type	El Comp	El Comp	El Comp	Descnt	Gas Eng	Units
OFFICE						
Lvl. Install + O&M	0.26	0.30	0.27	0.56	0.39	$/sqft.yr
Ann. Elect. Cost	1.46	1.41	1.26	1.13	0.73	$/sqft.yr
Elect. Consumption	23.1	21.9	17.8	14.5	15.8	kWh/sqft.yr
Summer Capacity	5.0	5.0	5.0	4.9	1.2	W/sqft
Winter Capacity	2.2	1.9	1.1	0.8	1.1	W/sqft
Gas Consumption	6.6	6.6	37.6	24.3	58.5	kBtu/sqft.yr
RETAIL						
Lvl. Install + O&M	0.30	0.34	0.31	0.64	0.45	$/sqft.yr
Ann. Elect. Cost	1.30	1.13	0.96	1.06	0.63	$/sqft.yr
Elect. Consumption	21.4	17.0	12.4	12.3	9.9	kWh/sqft.yr
Summer Capacity	4.1	4.1	4.1	4.8	2.1	W/sqft
Winter Capacity	5.9	4.1	2.1	2.0	2.1	W/sqft
Gas Consumption	5.8	5.8	53.1	26.5	78.0	kBtu/sqft.yr
SUPERMARKET						
Lvl. Install + O&M	0.52	0.59	0.53	1.11	0.77	$/sqft.yr
Ann. Elect. Cost	3.61	3.40	3.07	3.11	2.65	$/sqft.yr
Elect. Consumption	68.5	62.9	54.4	54.1	51.3	kWh/sqft.yr
Summer Capacity	8.8	8.8	8.8	9.1	6.2	W/sqft
Winter Capacity	11.0	9.0	6.2	6.1	6.2	W/sqft
Gas Consumption	14.4	14.4	92.3	99.8	123.4	kBtu/sqft.yr
RESTAURANT						
Lvl. Install + O&M	0.45	0.51	0.46	0.95	0.66	$/sqft.yr
Ann. Elect. Cost	1.76	1.43	1.09	0.87	0.80	$/sqft.yr
Elect. Consumption	33.6	25.2	16.4	12.9	13.0	kWh/sqft.yr
Summer Capacity	3.9	3.9	3.9	3.2	2.6	W/sqft
Winter Capacity	8.3	5.5	2.6	2.2	2.6	W/sqft
Gas Consumption	86.1	86.1	177.5	168.8	207.1	kBtu/sqft.yr
WAREHOUSE						
Lvl. Install + O&M	0.27	0.31	0.28	0.59	0.40	$/sqft.yr
Ann. Elect. Cost	0.93	0.79	0.65	0.79	0.73	$/sqft.yr
Elect. Consumption	15.2	11.3	7.4	7.8	6.1	kWh/sqft.yr
Summer Capacity	3.1	3.1	3.1	4.2	0.2	W/sqft
Winter Capacity	0.2	0.2	0.2	0.2	0.2	W/sqft
Gas Consumption	2.9	2.9	42.3	17.3	58.5	kBtu/sqft.yr

Central HVAC - Heating

	Reference Case	Gas Alternatives		
	1	1	2	
Heat Type	El Boil	Std Gas	Hieff Gas	Units
OFFICE				
Lvl. Install + O&M	0.04	0.04	0.06	$/sqft.yr
Ann. Elect. Cost	2.47	1.30	1.30	$/sqft.yr
Elect. Consumption	53.6	21.1	21.1	kWh/sqft.yr
Summer Capacity	4.3	4.3	4.3	W/sqft
Winter Capacity	1.6	1.6	1.6	W/sqft
Gas Consumption	6.6	75.8	72.0	kBtu/sqft.yr
RETAIL				
Lvl. Install + O&M	0.05	0.06	0.09	$/sqft.yr
Ann. Elect. Cost	2.30	1.07	1.07	$/sqft.yr
Elect. Consumption	49.6	15.6	15.6	kWh/sqft.yr
Summer Capacity	4.0	4.0	4.0	W/sqft
Winter Capacity	3.3	3.3	3.3	W/sqft
Gas Consumption	5.8	78.2	74.2	kBtu/sqft.yr
HOSPITAL				
Lvl. Install + O&M	0.04	0.05	0.07	$/sqft.yr
Ann. Elect. Cost	2.63	1.10	1.10	$/sqft.yr
Elect. Consumption	60.2	18.0	18.0	kWh/sqft.yr
Summer Capacity	3.6	3.6	3.6	W/sqft
Winter Capacity	2.0	2.0	2.0	W/sqft
Gas Consumption	23.4	113.5	108.5	kBtu/sqft.yr

Table B-2. Intermediate Values for Fuel-Switching Analysis—BUG.

Central HVAC - Cooling

	Reference Case	Gas Alternatives			
	1	1	2	3	
Cool Type	El Comp	Gas Abs	Gas Eng	Gas Eng w/HR	Units
OFFICE					
Lvl. Install + O&M	0.07	0.19	0.18	0.20	$/sqft.yr
Ann. Elect. Cost	1.30	1.10	1.01	1.08	$/sqft.yr
Elect. Consumption	21.1	17.9	16.3	17.6	kWh/sqft.yr
Summer Capacity	4.3	3.6	3.4	3.6	W/sqft
Winter Capacity	1.6	1.3	1.1	1.3	W/sqft
Gas Consumption	75.8	133.6	121.3	98.0	kBtu/sqft.yr
RETAIL					
Lvl. Install + O&M	0.12	0.31	0.29	0.32	$/sqft.yr
Ann. Elect. Cost	1.07	0.84	0.76	0.82	$/sqft.yr
Elect. Consumption	15.6	13.0	11.7	12.7	kWh/sqft.yr
Summer Capacity	4.0	2.9	2.6	2.8	W/sqft
Winter Capacity	3.3	2.9	2.6	2.8	W/sqft
Gas Consumption	78.2	127.4	117.7	97.7	kBtu/sqft.yr
HOSPITAL					
Lvl. Install + O&M	0.17	0.43	0.41	0.44	$/sqft.yr
Ann. Elect. Cost	1.10	0.85	0.77	0.85	$/sqft.yr
Elect. Consumption	18.0	14.8	14.0	14.0	kWh/sqft.yr
Summer Capacity	3.6	2.5	2.1	2.1	W/sqft
Winter Capacity	2.0	1.8	2.0	2.0	W/sqft
Gas Consumption	113.5	144.3	151.1	131.2	kBtu/sqft.yr

Central HVAC - Cogen

	Reference Case	Gas Alternatives				
	1	1	2	3	4	
Heat Type	Gas Boil	Cogen	Cogen	Cogen	Cogen	
Cool Type	El Comp	El Comp	Abs/El	El Comp	Abs/El	Units
OFFICE						
Lvl. Install + O&M	0	0.33	0.35	0.33	0.35	$/sqft.yr
Ann. Elect. Cost	1.30	1.01	0.97	0.66	0.64	$/sqft.yr
Elect. Consumption	21.1	14.1	14.0	8.5	8.4	kWh/sqft.yr
Summer Capacity	4.3	4.0	3.8	2.9	2.7	W/sqft
Winter Capacity	1.6	0.9	0.9	0.2	0.2	W/sqft
Gas Consumption	75.8	111.7	112.4	175.7	175.7	kBtu/sqft.yr
RETAIL						
Lvl. Install + O&M	0	0.74	0.79	0.74	0.79	$/sqft.yr
Ann. Elect. Cost	1.07	0.76	0.69	0.15	0.02	$/sqft.yr
Elect. Consumption	15.6	8.0	7.3	1.2	0.1	kWh/sqft.yr
Summer Capacity	4.0	4.0	3.8	0.8	0.2	W/sqft
Winter Capacity	3.3	0.1	0.0	0.1	0.0	W/sqft
Gas Consumption	78.2	117.9	123.3	215.2	221.6	kBtu/sqft.yr
HOSPITAL						
Lvl. Install + O&M	0	0.32	0.34	0.32	0.34	$/sqft.yr
Ann. Elect. Cost	1.10	0.77	0.73	0.50	0.49	$/sqft.yr
Elect. Consumption	18.0	10.3	9.5	6.3	6.3	kWh/sqft.yr
Summer Capacity	3.6	3.4	3.3	2.2	2.2	W/sqft
Winter Capacity	2.0	0.6	0.6	0.6	0.6	W/sqft
Gas Consumption	113.5	153.0	160.3	200.1	200.1	kBtu/sqft.yr

Table B-3. Intermediate Values for Fuel-Switching Analysis—NFG.

Packaged HVAC

	Reference Cases 1	2	Gas Alternatives 1	2	3	
Heat Type	El Res	El HP	Gas	Descnt	Gas	
Cool Type	El Comp	El Comp	El Comp	Descnt	Gas Eng	Units
OFFICE						
Lvl. Install+O&M	0.25	0.28	0.26	0.53	0.37	$/sqft.yr
Ann. Elect. Cost	1.41	1.33	1.02	0.81	0.77	$/sqft.yr
Elect. Consumption	25.1	23.6	17.8	13.8	16.3	kWh/sqft.y
Summer Capacity	4.6	4.7	4.6	4.2	1.3	W/sqft
Winter Capacity	2.6	2.3	1.2	0.8	1.2	W/sqft
Gas Consumption	6.6	6.6	48.0	23.4	62.5	kBtu/sqft.y
RETAIL						
Lvl. Install+O&M	0.29	0.33	0.30	0.62	0.43	$/sqft.yr
Ann. Elect. Cost	1.75	1.39	0.82	0.80	0.68	$/sqft.yr
Elect. Consumption	24.3	19.0	19.0	11.1	9.9	kWh/sqft.y
Summer Capacity	3.6	3.6	3.6	3.7	2.2	W/sqft
Winter Capacity	7.6	5.6	5.6	2.1	2.2	W/sqft
Gas Consumption	5.8	5.8	70.8	18.5	86.1	kBtu/sqft.y
SUPERMARKET						
Lvl. Install+O&M	0.43	0.49	0.45	0.93	0.65	$/sqft.yr
Ann. Elect. Cost	4.42	3.95	2.93	2.91	2.76	$/sqft.yr
Elect. Consumption	76.1	68.6	53.0	52.3	51.0	kWh/sqft.y
Summer Capacity	7.9	7.9	7.9	8.0	6.2	W/sqft
Winter Capacity	13.6	11.4	6.2	6.2	6.2	W/sqft
Gas Consumption	14.4	14.4	138.5	141.1	157.3	kBtu/sqft.y
RESTAURANT						
Lvl. Install+O&M	0.44	0.50	0.45	0.94	0.66	$/sqft.yr
Ann. Elect. Cost	2.61	1.99	0.98	0.75	0.87	$/sqft.yr
Elect. Consumption	41.0	30.7	15.4	11.8	13.4	kWh/sqft.y
Summer Capacity	3.2	3.2	3.2	2.1	2.6	W/sqft
Winter Capacity	10.7	8.0	2.6	2.2	2.6	W/sqft
Gas Consumption	86.2	86.1	218.5	195.3	234.0	kBtu/sqft.y
WAREHOUSE						
Lvl. Install+O&M	0.27	0.31	0.28	0.57	0.40	$/sqft.yr
Ann. Elect. Cost	0.81	0.65	0.43	0.46	0.77	$/sqft.yr
Elect. Consumption	17.5	13.0	7.0	7.0	6.2	kWh/sqft.y
Summer Capacity	2.7	2.7	2.7	3.3	0.2	W/sqft
Winter Capacity	0.2	0.2	0.2	0.2	0.2	W/sqft
Gas Consumption	2.8	2.8	55.4	11.9	62.5	kBtu/sqft.y

Central HVAC - Heating

	Reference Case 1	Gas Alternatives 1	2	
Heat Type	El Boil	Std Gas	Hieff Gas	Units
OFFICE				
Lvl. Install+O&M	0.04	0.05	0.07	$/sqft.yr
Ann. Elect. Cost	2.57	1.15	1.15	$/sqft.yr
Elect. Consumption	60.2	21.0	21.0	kWh/sqft.y
Summer Capacity	4.2	4.2	4.2	W/sqft
Winter Capacity	1.6	1.6	1.6	W/sqft
Gas Consumption	6.6	90.3	85.6	kBtu/sqft.y
RETAIL				
Lvl. Install+O&M	0.06	0.07	0.09	$/sqft.yr
Ann. Elect. Cost	2.66	1.07	1.07	$/sqft.yr
Elect. Consumption	59.3	15.5	15.5	kWh/sqft.y
Summer Capacity	3.7	3.7	3.7	W/sqft
Winter Capacity	3.4	3.4	3.4	W/sqft
Gas Consumption	5.8	99.3	94.1	kBtu/sqft.y
HOSPITAL				
Lvl. Install+O&M	0.05	0.06	0.08	$/sqft.yr
Ann. Elect. Cost	3.05	0.98	0.98	$/sqft.yr
Elect. Consumption	73.9	16.8	16.8	kWh/sqft.y
Summer Capacity	3.2	3.2	3.2	W/sqft
Winter Capacity	2.0	2.0	2.0	W/sqft
Gas Consumption	23.4	145.1	138.3	kBtu/sqft.y

Table B-3. Intermediate Values for Fuel-Switching Analysis—NFG.

Central HVAC - Cooling

	Reference Case	Gas Alternatives			
	1	1	2	3	
Cool Type	El Comp	Gas Abs	Gas Eng	Gas Eng w/HR	Units
OFFICE					
Lvl. Install + O&M	0.07	0.19	0.18	0.19	$/sqft.yr
Ann. Elect. Cost	1.15	0.96	0.90	0.96	$/sqft.yr
Elect. Consumption	21.0	18.0	16.5	17.8	kWh/sqft.y
Summer Capacity	4.2	3.6	3.4	3.6	W/sqft
Winter Capacity	1.6	1.3	1.1	1.3	W/sqft
Gas Consumption	90.3	143.3	131.1	109.1	kBtu/sqft.y
RETAIL					
Lvl. Install + O&M	0.11	0.29	0.27	0.30	$/sqft.yr
Ann. Elect. Cost	1.07	0.89	0.81	0.87	$/sqft.yr
Elect. Consumption	15.5	13.0	11.9	12.8	kWh/sqft.y
Summer Capacity	3.7	2.8	2.4	2.7	W/sqft
Winter Capacity	3.4	2.9	2.7	2.9	W/sqft
Gas Consumption	99.3	143.4	134.0	114.7	kBtu/sqft.y
HOSPITAL					
Lvl. Install + O&M	0.15	0.39	0.37	0.40	$/sqft.yr
Ann. Elect. Cost	0.98	0.82	0.81	0.86	$/sqft.yr
Elect. Consumption	16.8	14.2	14.1	14.9	kWh/sqft.y
Summer Capacity	3.2	2.4	2.1	2.4	W/sqft
Winter Capacity	2.0	1.8	2.0	2.0	W/sqft
Gas Consumption	145.1	155.2	170.2	155.3	kBtu/sqft.y

Central HVAC - Cogen

	Reference Case	Gas Alternatives				
	1	1	2	3	4	
Heat Type	Gas Boil	Cogen	Cogen	Cogen	Cogen	
Cool Type	El Comp	El Comp	Abs/El	El Comp	Abs/El	Units
OFFICE						
Lvl. Install + O&M	0	0.33	0.35	0.33	0.35	$/sqft.yr
Ann. Elect. Cost	1.15	0.78	0.76	0.48	0.48	$/sqft.yr
Elect. Consumption	21.0	13.1	13.0	8.4	8.3	kWh/sqft.y
Summer Capacity	4.2	3.8	3.6	2.8	2.6	W/sqft
Winter Capacity	1.6	0.9	1.0	0.2	0.3	W/sqft
Gas Consumption	90.3	130.0	130.9	184.7	184.9	kBtu/sqft.y
RETAIL						
Lvl. Install + O&M	0	0.74	0.79	0.74	0.79	$/sqft.yr
Ann. Elect. Cost	1.07	0.44	0.39	0.08	0.00	$/sqft.yr
Elect. Consumption	15.5	6.5	5.8	1.0	0.0	kWh/sqft.y
Summer Capacity	3.7	3.6	3.5	0.5	0.0	W/sqft
Winter Capacity	3.4	0.1	0.0	0.1	0.0	W/sqft
Gas Consumption	99.3	146.6	151.3	228.4	236.5	kBtu/sqft.y
HOSPITAL						
Lvl. Install + O&M	0	0.32	0.34	0.34	0.34	$/sqft.yr
Ann. Elect. Cost	0.98	0.50	0.46	0.35	0.34	$/sqft.yr
Elect. Consumption	16.8	8.0	7.2	5.2	5.0	kWh/sqft.y
Summer Capacity	3.2	3.0	2.9	1.8	1.8	W/sqft
Winter Capacity	2.0	0.6	0.6	0.6	0.6	W/sqft
Gas Consumption	145.1	190.0	196.8	225.2	225.1	kBtu/sqft.y

The base technology is a packaged HVAC system that relies on gas for heating and electricity for cooling (referred to as "Gas Alternative 1" in Table B-2) and the gas option being considered is a packaged gas-fired engine system that provides both heating and cooling (referred to as "Gas Alternative 3" in Table B-2).

From Table 5-2, the capital costs of the base technology is \$828/ton with O&M costs of \$50.4/ton.yr. Given a measure lifetime of 15 years, the total annualized cost of this option (see Table B-2) is \$0.31/sqft.yr (= CIC_1 + OMC_1).[1] Table B-2 also reports annualized electricity costs at \$0.95/sqft.yr (= ELC_1) and gas consumption at 53.1 kBtu/sqft.yr (GQ_1).

From Table 5-2, the capital cost of the gas alternative is \$1442/ton with annual O&M costs of \$50.4/ton.yr, leads to total annualized costs of \$0.45/sqft.yr (= CIC_2 + OMC_2). Table B-2 reports annualized electricity costs at \$0.63/sqft.yr (= ELC_2) and gas consumption at 78.0 kBtu/sqft.yr (GQ_2).

Substitution of these values into equation 4 yields a gas breakeven price of \$7.31/Dth (see Table 5-11). Since the range of likely gas avoided costs (\$2 to \$4/Dth) is less than \$7.31/DTh, the gas cooling alternative is more cost-effective than the base electric cooling technology on a lifecycle basis at the assumed discount rate. In other words, given the current range of gas avoided costs, the extra capital cost of the gas cooling technology (relative to the electric cooling technology), despite the increase in gas use, is more than offset by the decrease in electricity use, valued at long-run avoided costs.

Conversely, if the gas breakeven cost turns out to be lower than the range of gas avoided

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[1] The formula for annualization is

$$A_N = \frac{r(1+r)^n}{(1+r)^n - 1}$$

with r = 5%, n = 15, the annualization factor is 0.09634. This converts the capital cost of \$828/ton (see Table 5-2) to \$79.8/ton.yr (= 828 x 0.09634). Adding the annual non-fuel O&M cost of \$50.4/ton.yr (see Table 5-2) yields a total annualized cost of \$130.2/ton.yr (= 79.8 + 50.4).

costs, the base electric technology would remain more cost-effective on a lifecycle basis than the gas technology. In these cases, the added cost of the gas alternative, along with the increase in gas use, is not offset by the decrease in electricity use. Put another way, under this scenario, gas must be very cheap for the gas alternative to compete successfully against the assumed base electric technology. If, for example, the gas breakeven cost is negative, then the gas alternative will never be cost-effective at any gas price.

A Final Note on the Information Presented in Tables B-1 to B-3

The data presented in this Appendix are intended to support a range of analyses related to fuel-switching. This Appendix has presented an example of how the gas breakeven price can be derived using intermediate information presented in the Chapter. In what follows, we describe the derivation of (1) installed equipment capacity and, for the cogeneration options, (2) annual net heat rates.

Installed equipment capacity can be derived by annualizing measure capital and O&M cost information (from Table 5-2 to 5-5) with intermediate gas breakeven price information (from Tables B-1 to B-3).

Referring to the BUG retail building example previously described, the total annualized cost of this option developed from the measure cost data in Table 5-2 ($130.2/ton.yr, see footnote 1), when combined with the building-specific information in Table B-2 ($0.31/sqft.yr), leads to an installed cooling capacity of 420 sqft/ton (= 130.2/0.31). A summary of the results of these calculations, for each of the building types examined in this study, is provided in Table B-4.

Cogeneration net heat rates can also be calculated from the information presented in Tables B-1 to B-3. For this example, we derive the net heat rate for the hospital cogeneration system (Gas Alternative 1) in LILCo service territory. Net heat rate is simply the increase in gas use divided by the decrease in electricity use. In this case, referring to Table B-1, the net heat rate is (153.0 - 113.5) / (18.0 - 10.3) = 5130 Btu/kWh.

Table B-4. System Sizing for Commercial Fuel Switching Analysis.

	Central Office	Pkg Office	Central Retail	Pkg Retail	Hospital	Supmkt	Restaur	Ware-house
Floor area	75,000	75,000	5,000	5,000	386,900	21,300	3,084	25,700
Downstate								
Cool state kbtu/hr	1,348	1,854	144	142	15,442	1,045	130	657
Heat size kbtu/hr	2,106	2,538	202	260	12,586	2,151	195	1,182
Cogen size kbtu/hr	341		51		1707			
Upstate								
Cool state kbtu/hr	1,296	1,775	134	137	13,892	876	128	653
Heat size kbtu/hr	2,376	2,559	218	265	14,564	2,270	215	1,199
Cogen size kbtu/hr	341		51		1,707			
Downstate								
Cool size btu/sqft	17.97	24.72	28.80	28.44	39.91	49.04	42.15	25.56
Heat size btu/sqft	28.08	33.84	40.40	51.94	32.48	100.99	63.16	45.97
Upstate								
Cool size btu/sqft	17.28	23.67	26.90	27.34	35.91	41.13	41.60	25.42
Heat size btu/sqft	31.68	34.12	43.20	52.98	37.64	106.59	69.65	46.64

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Berkshire Gas
Utility Type	gas
Program	Residential Conservation (Low Income)
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	1/91
Program End Date	1/92
Annual Data Start Date	7/91
Annual Data End Date	7/92
Annual # Eligible Customers	1584
Annual # Participants	14
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	4476
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	11.7
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.9%
Cumulative Participation Rate	0.9%
Annual Therms Saved/Participant	320
Annual Therms Saved as % Gas Sales	0.02%
Cumul. Therms Saved as % Gas Sales	0.02%
Levelized Utility Cost ($/Dtherm): annual data	3.40
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Tony Contrino
Phone Number	(413) 442 1511

Program Description

Free audits are offered. Grants average $1370/home. Households must have incomes below 175% of the federal poverty level. Weatherization measures performed, including installation of attic insulation, storm windows, air sealing, setback thermostats, space and wate heater upgrades, low-flow showerheads, faucet aerators, tank wraps, pipe insulation, and water heater setbacks.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Berkshire Gas
Utility Type	gas
Program	Residential Conservation (Multi-family)
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	1/91
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	1/92
Annual # Eligible Customers	5794
Annual # Participants	174
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	36772
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	89.4
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	3.0%
Cumulative Participation Rate	3.0%
Annual Therms Saved/Participant	211
Annual Therms Saved as % Gas Sales	0.16%
Cumul. Therms Saved as % Gas Sales	0.16%
Levelized Utility Cost ($/Dtherm): annual data	3.15
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Tony Contrino
Phone Number	(413) 442 1511

Program Description

Program available to landlords with buildings of up to 4 units. Free audits. Grants of up to $375/unit offered. The option of zero-interest financing is available. Weatherization measures are performed, including the installation of attic insulation storm windows, air sealing, setback thermostats, space and water heater upgrades, low-flow showerheads, faucet aerators, tank wraps, pipe insulation, and water heater setbacks.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Berkshire Gas
Utility Type	gas
Program	Residential Conservation (Non-Low Income)
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	1/91
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	1/92
Annual # Eligible Customers	12896
Annual # Participants	10
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	2880
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	21.5
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.1%
Cumulative Participation Rate	0.1%
Annual Therms Saved/Participant	288
Annual Therms Saved as % Gas Sales	0.01%
Cumul. Therms Saved as % Gas Sales	0.01%
Levelized Utility Cost ($/Dtherm): annual data	9.69
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Tony Contrino
Phone Number	(413) 442 1511

Program Description

Homeowners and renters are eligible. Participants are chosen randomly. Free audits. Grants averaging $1270/unit, $150 grant for air sealing, and the option of zero-interest financing. Weatherization measures are performed, including the installation of attic insulation storm windows, air sealing, setback thermostats, space and water heater upgrade low-flow showerheads, faucet aerators, tank wraps, pipe insulation, and water heater setbacks.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Boston Gas
Utility Type	gas
Program	Attic Insulation Program
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	3/91
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	1/92
Annual # Eligible Customers	270000
Annual # Participants	1900
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	270000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	1600.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.7%
Cumulative Participation Rate	0.7%
Annual Therms Saved/Participant	142
Annual Therms Saved as % Gas Sales	0.07%
Cumul. Therms Saved as % Gas Sales	0.07%
Levelized Utility Cost ($/Dtherm): annual data	7.67
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Tom Ryan
Phone Number	(617) 742 8400x203

Program Description

Free audit offered. If customer has less than 6" insulation, a 50% subsidy is offered for installation of R30 attic insulation. Low-income customers receive 100% subsidy.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Boston Gas
Utility Type	gas
Program	Domestic Hot Water Heater
Program Type	RHT
Pilot or Full-Scale Program	full
Program Start Date	10/90
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	450000
Annual # Participants	32000
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	1500000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	1400.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	7.1%
Cumulative Participation Rate	7.1%
Annual Therms Saved/Participant	47
Annual Therms Saved as % Gas Sales	0.41%
Cumul. Therms Saved as % Gas Sales	0.41%
Levelized Utility Cost ($/Dtherm): annual data	0.75
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Tom Ryan
Phone Number	(617) 742 8400x203

Program Description

Free installation of low-flow showerheads, water heater wraps, 6 feet of pipe insulation, and other water heater retrofit measures.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Boston Gas
Utility Type	gas
Program	Home Heating Control Program
Program Type	RHT
Pilot or Full-Scale Program	full
Program Start Date	3/91
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	270000
Annual # Participants	3300
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	570000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	1000.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	1.2%
Cumulative Participation Rate	1.2%
Annual Therms Saved/Participant	173
Annual Therms Saved as % Gas Sales	0.16%
Cumul. Therms Saved as % Gas Sales	0.16%
Levelized Utility Cost ($/Dtherm): annual data	1.41
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Tom Ryan
Phone Number	(617) 742 8400x203

Program Description

50% subsidy offered for the installation of clock thermostats or boiler resets. Low-incom customers and renters receive 100% subsidy. According to the utility, the boiler reset rarely gets installed.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Boston Gas
Utility Type	gas
Program	Multifamily Plan
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	1991
Program End Date	
Annual Data Start Date	1/91
Annual Data End Date	1/92
Annual # Eligible Customers	
Annual # Participants	6575
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	260000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	40
Annual Therms Saved as % Gas Sales	0.07%
Cumul. Therms Saved as % Gas Sales	0.07%
Levelized Utility Cost ($/Dtherm): annual data	n/a
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Tom Ryan
Phone Number	(617) 742 8400x203

Program Description

This program is available to multifamily building owners who pay the building's utility bills. For buildings with less than 50 units, 50% subsidies are available for installatic of a prescribed list of measures. For buildings with at least 50 units, free energy audit are performed and a 50% subsidy is available for the installation of all cost-effective measures. Buildings with at least 50% low-income residents receive 100% subsidy.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Connecticut Natural Gas
Utility Type	gas
Program	Set-Back Thermostat Program
Program Type	RHT
Pilot or Full-Scale Program	Full
Program Start Date	11/89
Program End Date	-
Annual Data Start Date	1/90
Annual Data End Date	12/91
Annual # Eligible Customers	
Annual # Participants	265
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	882
Annual Therms Saved	26584
Cumul. Therms Saved	88480
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	47.5
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	75.1
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	100
Annual Therms Saved as % Gas Sales	0.02%
Cumul. Therms Saved as % Gas Sales	0.07%
Levelized Utility Cost ($/Dtherm): annual data	2.31
Levelized Utility Cost ($/Dtherm): cumul. data	1.10
Utility Contact	Leslie Stophel
Phone Number	(203) 727 3458

Program Description

Free installation of set-back thermostats offered.

Comments

Mailings on the program were sent to a select group of customers. Annual data are for 1991, and cumulative data are for January 1990 through December 1991.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Connecticut Natural Gas
Utility Type	gas
Program	Weatherization & Attic Insulation Program
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	11/89
Program End Date	-
Annual Data Start Date	11/89
Annual Data End Date	1/92
Annual # Eligible Customers	33192
Annual # Participants	1844
Annual # Projects	
Cumul # Eligible Customers	33192
Cumul # Participants	2752
Annual Therms Saved	130371
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	275.9
Annual Indirect Utility Cost (1000s$)	82.8
Annual Total Utility Cost (1000s$)	358.7
Cumul. Direct Utility Cost (1000s$)	608.3
Cumul. Indirect Utility Cost (1000s$)	182.5
Cumul. Total Utility Cost (1000s$)	790.8
Annual Participation Rate	5.6%
Cumulative Participation Rate	8.3%
Annual Therms Saved/Participant	71
Annual Therms Saved as % Gas Sales	0.10%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	3.56
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Leslie Stophel
Phone Number	(203) 727 3458

Program Description

For customers with less than R5 attic insulation, free insulation is installed. If needec other weatherization measures are also installed free of charge, such as weatherstripping and caulking of doors and windows, door sweeps, outlet gaskets, switch gaskets, low-flow showerheads, faucet aerators, and water heater wraps.

Comments

Cumulative data are for January 1990 through September 1991. Annual data are for October 1990 through October 1991. Indirect costs are assumed to be 30% of direct costs.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Elizabethtown Gas
Utility Type	gas
Program	Assistance Sealup Program
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	10/84
Program End Date	-
Annual Data Start Date	4/86
Annual Data End Date	3/87
Annual # Eligible Customers	15000
Annual # Participants	1824
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	97000
Cumul. Therms Saved	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	n/a
Annual Indirect Utility Cost (1000s$)	n/a
Annual Total Utility Cost (1000s$)	506.2
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	12.2%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	53
Annual Therms Saved as % Gas Sales	0.06%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	6.76
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Georgia Hartnett
Phone Number	(908) 289 5000x6102

Program Description

Free audit performed. A subsidy of up to $200/home was offered for weatherization measure including water heater wrap, showerhead flow restrictor, door sweeps, outlet gaskets, weatherstripping, caulking, attic hatch insulation, plastic window sheets, and other measures. As of 1992, a rebate of up to $1000 per home is offered.

Comments

Gas savings data are engineering estaimates adjusted based on billing analyses.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Elizabethtown Gas
Utility Type	gas
Program	Furnace/ Boiler Rebate Program
Program Type	RHT
Pilot or Full-Scale Program	full
Program Start Date	4/85
Program End Date	-
Annual Data Start Date	4/86
Annual Data End Date	3/87
Annual # Eligible Customers	130000
Annual # Participants	1018
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	73000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	90.2
Annual Indirect Utility Cost (1000s$)	79.8
Annual Total Utility Cost (1000s$)	170.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.8%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	72
Annual Therms Saved as % Gas Sales	0.04%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	1.87
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Georgia Hartnett
Phone Number	(908) 289 5000x6102

Program Description

Rebates offered for upgrading either a boiler or furnace above a fixed AFUE rating. The rebate varies depending on the size and efficiency of the boiler or furnace.

Comments

Customer shows proof of purchase in order to receive rebate.
Gas savings data are engineering estimates adjusted based on billing analyses.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Elizabethtown Gas
Utility Type	gas
Program	Regular Sealup Program
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	10/84
Program End Date	-
Annual Data Start Date	4/86
Annual Data End Date	3/87
Annual # Eligible Customers	130000
Annual # Participants	796
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	27000
Cumul. Therms Saved	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	n/a
Annual Indirect Utility Cost (1000s$)	n/a
Annual Total Utility Cost (1000s$)	41.6
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.6%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	34
Annual Therms Saved as % Gas Sales	0.02%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	2.00
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Georgia Hartnett
Phone Number	(908) 289 5000x6102

Program Description

Free audit is performed. For a $10 fee, a water heater blanket is installed. If custome: has a blanket, three other low-cost efficiency measures are performed for a fee. These measures include: low-flow showerheads, faucet aerators, window and door weatherstripping, door sweeps, and water pipe insulation.

Comments

The utility is dropping this program in 1993. The gas savings data are engineering estimates adjusted based on billing analyses.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Elizabethtown Gas
Utility Type	gas
Program	Set-back Thermostat Rebate Program
Program Type	RHT
Pilot or Full-Scale Program	full
Program Start Date	1/86
Program End Date	-
Annual Data Start Date	4/86
Annual Data End Date	3/87
Annual # Eligible Customers	130000
Annual # Participants	459
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	153000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	4.4
Annual Indirect Utility Cost (1000s$)	20.2
Annual Total Utility Cost (1000s$)	24.6
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.4%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	333
Annual Therms Saved as % Gas Sales	0.09%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.21
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Georgia Hartnett
Phone Number	(908) 289 5000x6102

Program Description

A $10 rebate is given to participants who install a setback thermostat.

Comments

The utility has proposed dropping this program in 1993. Gas savings data are engineering estimates adjusted based on billing analyses.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Elizabethtown Gas
Utility Type	gas
Program	Water Heater Rebate Program
Program Type	RHT
Pilot or Full-Scale Program	full
Program Start Date	4/85
Program End Date	-
Annual Data Start Date	4/86
Annual Data End Date	3/87
Annual # Eligible Customers	72000
Annual # Participants	2598
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	36000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	142.5
Annual Indirect Utility Cost (1000s$)	38.3
Annual Total Utility Cost (1000s$)	180.8
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	3.6%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	14
Annual Therms Saved as % Gas Sales	0.02%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	4.03
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Georgia Hartnett
Phone Number	(908) 289 5000x6102

Program Description

A rebate of $50 per heater is offered to customers who install a water heater which meets certain efficiency standards.

Comments

Customer shows proof of purchase in order to receive rebate. Gas savings data are engineering estimates adjusted based on billing analyses.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Elizabethtown Gas
Utility Type	gas
Program	Weatherization Low-Interest Loan
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	10/84
Program End Date	-
Annual Data Start Date	4/86
Annual Data End Date	3/87
Annual # Eligible Customers	130000
Annual # Participants	89
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	167000
Cumul. Therms Saved	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	33.1
Annual Indirect Utility Cost (1000s$)	35.9
Annual Total Utility Cost (1000s$)	69.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.1%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	1876
Annual Therms Saved as % Gas Sales	0.10%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.54
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Georgia Hartnett
Phone Number	(908) 289 5000x6102

Program Description

Free audit performed. Zero-interest loans of $500-$4,000 are offered to households earning less than $30,000 per year. Low-interest loans are offered to households earning more than $30,000 per year. Measures installed include attic insulation, weatherstripping, caulking, low-flow showerheads, faucet aerators, duct and water pipe insulation, clock thermostats, storm windows and doors, attic vent fans, and water heater timer control. Measures must have no more than a ten-year customer payback.

Comments

The utility has proposed dropping this program due to under-subscription. Gas savings data are engineering estimates adjusted based on billing analyses.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Madison Gas & Electric
Utility Type	combo
Program	High-Efficiency Water Heater Rebates
Program Type	RHT
Pilot or Full-Scale Program	
Program Start Date	
Program End Date	-
Annual Data Start Date	6/90
Annual Data End Date	5/91
Annual # Eligible Customers	78500
Annual # Participants	688
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	40301
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	13.7
Annual Indirect Utility Cost (1000s$)	4.1
Annual Total Utility Cost (1000s$)	17.8
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.9%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	59
Annual Therms Saved as % Gas Sales	0.05%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.35
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Stoffs
Phone Number	(608) 252 7906

Program Description

A $25 rebate is offered for the installation of high-efficiency water heaters with an ene factor of .58 to .60.

Comments

Customer shows proof of purchase in order to receive rebate. Indirect costs are assumed to be 30% of direct costs.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Madison Gas & Electric
Utility Type	combo
Program	Large C&I Conservation Services
Program Type	C&I:A&I
Pilot or Full-Scale Program	full
Program Start Date	
Program End Date	-
Annual Data Start Date	6/90
Annual Data End Date	5/91
Annual # Eligible Customers	
Annual # Participants	
Annual # Projects	168
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	139499
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	74.8
Annual Indirect Utility Cost (1000s$)	22.4
Annual Total Utility Cost (1000s$)	97.2
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	n/a
Annual Therms Saved as % Gas Sales	0.15%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.90
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Stoffs
Phone Number	(608) 252 7906

Program Description

Participants must use at least 25,000 therms/year but not be among the top 100 customers in fuel use. A free audit is performed. A rebate of $250 per piece of equipment is offered for upgrading to high-efficiency furnaces. 25% of the cost of pipe insulation is rebated. For each steam trap replaced, a rebate of $30 is available. Other eligible measures include installation of vent dampers, boiler water resets, setback thermostats, infrared heating, boiler tune-ups, low-flow showerheads, energy management systems, and custom measures. The incentive for custom measures is decided on a case-by-case basis

Comments

Indirect costs are assumed to be 30% of direct.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Madison Gas & Electric
Utility Type	combo
Program	Large C&I New Construction
Program Type	C&INC
Pilot or Full-Scale Program	full
Program Start Date	
Program End Date	-
Annual Data Start Date	6/90
Annual Data End Date	5/91
Annual # Eligible Customers	
Annual # Participants	
Annual # Projects	38
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	225513
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	154.2
Annual Indirect Utility Cost (1000s$)	46.3
Annual Total Utility Cost (1000s$)	200.5
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	n/a
Annual Therms Saved as % Gas Sales	0.24%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.58
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Stoffs
Phone Number	(608) 252 7906

Program Description

Participants must use at least 25,000 therms per year. Rebates are available for the installation of vent dampers, boiler water resets, setback thermostats, infrared heating, low-flow showerheads, and energy management systems. Rebates for custom measures are decided on a case-by-case basis.

Comments

Indirect costs are assumed to be 30% of direct.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Madison Gas & Electric
Utility Type	combo
Program	Low-Flow Showerhead Installation
Program Type	RHT
Pilot or Full-Scale Program	
Program Start Date	
Program End Date	-
Annual Data Start Date	6/90
Annual Data End Date	5/91
Annual # Eligible Customers	78500
Annual # Participants	1742
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	114927
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	28.0
Annual Indirect Utility Cost (1000s$)	8.4
Annual Total Utility Cost (1000s$)	36.4
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	2.2%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	66
Annual Therms Saved as % Gas Sales	0.14%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.41
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Stoffs
Phone Number	(608) 252 7906

Program Description

Free low-flow showerheads are given to participants.

Comments

Indirect costs are assumed to be 30% of direct.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Madison Gas & Electric
Utility Type	combo
Program	Major Accounts Program
Program Type	C&I:A&I
Pilot or Full-Scale Program	full
Program Start Date	
Program End Date	-
Annual Data Start Date	6/90
Annual Data End Date	5/91
Annual # Eligible Customers	
Annual # Participants	
Annual # Projects	688
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	40301
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	32.3
Annual Indirect Utility Cost (1000s$)	9.7
Annual Total Utility Cost (1000s$)	42.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	n/a
Annual Therms Saved as % Gas Sales	0.04%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	1.35
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Stoffs
Phone Number	(608) 252 7906

Program Description

Participants must use at least 25,000 therms/year and be among the 125 largest customers. A free audit is performed. A rebate of $250 per piece of equipment is offered for the upgrading to high-efficiency furnaces. 25% of the cost of pipe insulation is rebated. For each steam trap replaced, a rebate of $30 is available. Other eligible measures include installation of vent dampers, boiler water resets, setback thermostats, infrared heating, boiler tune-ups, low-flow showerheads, energy management systems, and custom measures. The incentive for custom measures is decided on a case-by-case basis

Comments

Indirect costs are assumed to be 30% of direct costs.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Madison Gas & Electric
Utility Type	combo
Program	Residential Weatherization
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	
Program End Date	-
Annual Data Start Date	6/90
Annual Data End Date	5/91
Annual # Eligible Customers	78500
Annual # Participants	291
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	3298
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	5.6
Annual Indirect Utility Cost (1000s$)	1.7
Annual Total Utility Cost (1000s$)	7.3
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.4%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	11
Annual Therms Saved as % Gas Sales	0.004%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	2.86
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Stoffs
Phone Number	(608) 252 7906

Program Description

An audit is available but not mandatory. Depending on the type of insulation installed, rebates of $10-$50 are offered. Clock thermostats receive a $10 rebate. Pipe wraps receive a $25 rebate (water heater pipe wraps are free). Storm door installation receives a $5-$10 rebate. Low-flow showerheads are available at no charge.

Comments

Customer shows proof of purchase for rebates, except for free items.
Indirect costs are assumed to be 30% of direct.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Madison Gas & Electric
Utility Type	combo
Program	Small C&I Conservation Services
Program Type	C&I:A&I
Pilot or Full-Scale Program	full
Program Start Date	
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	1/92
Annual # Eligible Customers	
Annual # Participants	
Annual # Projects	1457
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	135788
Cumul. Therms Saved	n/a
Adjustments	
Annual Direct Utility Cost (1000s$)	287.2
Annual Indirect Utility Cost (1000s$)	86.2
Annual Total Utility Cost (1000s$)	373.4
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	n/a
Annual Therms Saved as % Gas Sales	0.14%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	3.56
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Stoffs
Phone Number	(608) 252 7906

Program Description

Participants must use less than 25,000 therms/year.
A free audit is performed. A rebate of $250 per piece of equipment is offered for the upgrading to high-efficiency furnaces. 25% of the cost of pipe insulation is rebated. For each steam trap replaced, a rebate of $30 is available. Other eligible measures include installation of vent dampers, boiler water resets, setback thermostats, infrared heating, boiler tune-ups, low-flow showerheads, energy management systems, and custom measures. The incentive for custom measures is decided on a case-by-case basis

Comments

Indirect costs are assumed to be 30% of direct.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Madison Gas & Electric
Utility Type	combo
Program	Small C&I New Construction
Program Type	C&INC
Pilot or Full-Scale Program	full
Program Start Date	
Program End Date	-
Annual Data Start Date	6/90
Annual Data End Date	5/91
Annual # Eligible Customers	
Annual # Participants	
Annual # Projects	261
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	74705
Cumul. Therms Saved	199489
Adjustments	
Annual Direct Utility Cost (1000s$)	276.6
Annual Indirect Utility Cost (1000s$)	83.0
Annual Total Utility Cost (1000s$)	359.6
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	n/a
Annual Therms Saved as % Gas Sales	0.08%
Cumul. Therms Saved as % Gas Sales	0.21%
Levelized Utility Cost ($/Dtherm): annual data	3.13
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Stoffs
Phone Number	(608) 252 7906

Program Description

The participant must use less than 25,000 therms per year.
A free audit is performed. A rebate of $250 per piece of equipment is offered for the upgrading to high-efficiency furnaces. 25% of the cost of pipe insulation is rebated. For each steam trap replaced, a rebate of $30 is available. Other eligible measures include installation of vent dampers, boiler water resets, setback thermostats, infrared heating, boiler tune-ups, low-flow showerheads, energy management systems, and custom measures. The incentive for custom measures is decided on a case-by-case basis

Comments

Indirect costs are assumed to be 30% of direct.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Northern States Power-WI
Utility Type	combo
Program	Appliance Efficiency Rebate
Program Type	RHT
Pilot or Full-Scale Program	full
Program Start Date	1984
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	70000
Annual # Participants	171
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	85000
Cumul. Therms Saved	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	n/a
Annual Indirect Utility Cost (1000s$)	n/a
Annual Total Utility Cost (1000s$)	86.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.2%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	497
Annual Therms Saved as % Gas Sales	0.18%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.81
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Duane Lom
Phone Number	(715) 839 2431

Program Description

Rebates of $25 (EF=.59+) and $35 (EF=.58+) are offered for upgrading gas water heaters.

Comments

Gas savings are based on engineering estimates.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Northern States Power-WI
Utility Type	combo
Program	Boiler/Steam Trap Efficiency Improvement
Program Type	C&I:A&I
Pilot or Full-Scale Program	full
Program Start Date	1990
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	26000
Annual # Participants	35
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	542400
Cumul. Therms Saved	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	38.8
Annual Indirect Utility Cost (1000s$)	58.0
Annual Total Utility Cost (1000s$)	2000.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.1%
Cumulative Participation Rate	0.1%
Annual Therms Saved/Participant	15497
Annual Therms Saved as % Gas Sales	1.34%
Cumul. Therms Saved as % Gas Sales	1.34%
Levelized Utility Cost ($/Dtherm): annual data	4.78
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Duane Lom
Phone Number	(715) 839 2431

Program Description

Free inspections of steam traps. Inspection and efficiency testing of boilers costs customer no more than $100. Customers must have boilers in the 400-10,00 MBtu input range to be eligible.

Comments

Gas savings are based on engineering estimates.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Northern States Power-WI
Utility Type	combo
Program	Low-Income Weatherization
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	1983
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	16837
Annual # Participants	91
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	30000
Cumul. Therms Saved	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	167.6
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.5%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	330
Annual Therms Saved as % Gas Sales	0.06%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	7.23
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Duane Lom
Phone Number	(715) 839 2431

Program Description

A free audit is performed. Eligible measures include shell insulation ,heating equipment retrofits and tune-ups and upgrades. For single-family units, the maximum rebate per unit is $2500. For 1-4 unit rental dwellings, rebates of 50% of the measures' costs are offered, up to a $5000 maximum per building. For buildings with 5 or more units, the rebate is $7000 per building for both electric and gas-saving measures.

Comments

Gas savings are based on engineering estimates.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Pacific Gas & Electric
Utility Type	combo
Program	Appliance Efficiency Incentives
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/91
Annual # Eligible Customers	3500000
Annual # Participants	36357
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	2091000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	3745.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	1.0%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	58
Annual Therms Saved as % Gas Sales	0.10%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	2.32
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Ed Mah
Phone Number	(415) 973 8587

Program Description

An audit is available to participants but not mandatory. According to the utility, the audit is seldom performed. Ceiling insulation receives a rebate of $100 for single family and $75 for multifamily dwellings. A $1 rebate for filter replacements is avialabe. Low-fl showerhead installation receives a $4 rebate. A $5 coupon is available for water heater blankets.

Comments

Customer submits proof of purchase.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Pacific Gas & Electric
Utility Type	combo
Program	Customized Rebates: Commercial
Program Type	C&I:Gnrl
Pilot or Full-Scale Program	full
Program Start Date	1987
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/91
Annual # Eligible Customers	197756
Annual # Participants	95
Annual # Projects	39
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	526978.9
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.048%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	5547
Annual Therms Saved as % Gas Sales	0.06%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	n/a
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Diane Calden
Phone Number	(415) 973 8575

Program Description

Custom projects fall under this program. A rebate of $0.20 per first year therm savings is available, up to 50% of the incremental project costs.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Pacific Gas & Electric
Utility Type	combo
Program	Customized Rebates: Industrial
Program Type	C&I:Gnrl
Pilot or Full-Scale Program	full
Program Start Date	1987
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/91
Annual # Eligible Customers	2494
Annual # Participants	46
Annual # Projects	9
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	3041022
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	n/a
Annual Indirect Utility Cost (1000s$)	n/a
Annual Total Utility Cost (1000s$)	n/a
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	1.8%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	66109
Annual Therms Saved as % Gas Sales	0.19%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	n/a
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Diane Calden
Phone Number	(415) 973 8575

Program Description

Custom projects fall under this program. A rebate of $0.20 per first year therm savings is available, up to 50% of the incremental project costs.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Pacific Gas & Electric
Utility Type	combo
Program	Direct Rebates: Commercial
Program Type	C&I:Gnrl
Pilot or Full-Scale Program	full
Program Start Date	1984
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/91
Annual # Eligible Customers	197756
Annual # Participants	5811
Annual # Projects	1553515
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	999493.4
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	2.9%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	172
Annual Therms Saved as % Gas Sales	0.11%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	n/a
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Diane Calden
Phone Number	(415) 973 8575

Program Description

Installation of setback thermostats eligible for a $60 rebate each, Water heater blankets $5 each, heat recovery measures for water heaters $2/MBtu input, heater recovery for refrigeration system $150/compressor hp, and ceiling insulation $0.15/square foot.

Comments

Customer submits proof of purchase.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Pacific Gas & Electric
Utility Type	combo
Program	Direct Assistance: Weatherization
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/91
Annual # Eligible Customers	760000
Annual # Participants	60757
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	3736556
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	16360.2
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	8.0%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	62
Annual Therms Saved as % Gas Sales	0.17%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	5.67
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Ed Mah
Phone Number	(415) 973 8587

Program Description

A free audit is performed. Weatherization measures and heating equipment upgrades are available at no cost. Up to $200 in home repairs are also available.

Comments

The annual budget is a rough estimate made by utility staff.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Peoples Gas, Light, & Coke
Utility Type	gas
Program	Efficient Gas Heating Equipment Incenti
Program Type	RHT
Pilot or Full-Scale Program	
Program Start Date	1984
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	1/92
Annual # Eligible Customers	398000
Annual # Participants	3124
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	495000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	196
Annual Indirect Utility Cost (1000s$)	62
Annual Total Utility Cost (1000s$)	258.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.8%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	158
Annual Therms Saved as % Gas Sales	0.04%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.42
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Ken Balaskovits
Phone Number	(312) 431 4144

Program Description

An incentive payment of $250 is offered to customers who purchase a furnace with an AFUE rating of at least 80%. The participant must show proof of purchase to receive rebate.

Comments

The gas savings estimates are based on billing analyses.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Pacific Gas & Electric
Utility Type	combo
Program	Direct Rebates: Industrial
Program Type	C&I:Gnrl
Pilot or Full-Scale Program	full
Program Start Date	1984
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/91
Annual # Eligible Customers	4494
Annual # Participants	716
Annual # Projects	84461
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	8078084
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	172.2
Annual Indirect Utility Cost (1000s$)	51.7
Annual Total Utility Cost (1000s$)	223.9
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	15.9%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	11282
Annual Therms Saved as % Gas Sales	0.50%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	n/a
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Diane Calden
Phone Number	(415) 973 8575

Program Description

Installation of setback thermostats eligible for a $60 rebate each, Water heater blankets $5 each, heat recovery measures for water heaters $2/MBtu input, heater recovery for refrigeration system $150/compressor hp, and ceiling insulation $0.15/square foot.

Comments

Indirect costs assumed to be 30% of direct. Direct expenditures are a rough estimate made by the utility.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Peoples Gas, Light, & Coke
Utility Type	gas
Program	Efficient Gas Heating Equipment Incentive
Program Type	RHT
Pilot or Full-Scale Program	
Program Start Date	1984
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	1/92
Annual # Eligible Customers	398000
Annual # Participants	3124
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	495000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	196
Annual Indirect Utility Cost (1000s$)	62
Annual Total Utility Cost (1000s$)	258.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.8%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	158
Annual Therms Saved as % Gas Sales	0.04%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.42
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Ken Balaskovits
Phone Number	(312) 431 4144

Program Description

An incentive payment of $250 is offered to customers who purchase a furnace with an AFUE rating of at least 80%. The participant must show proof of purchase to receive rebate.

Comments

The gas savings estimates are based on billing analyses.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Peoples Gas, Light, & Coke
Utility Type	gas
Program	Multifamily Low-Interest Loan Program
Program Type	R:A&I
Pilot or Full-Scale Program	pilot
Program Start Date	1984
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	1/92
Annual # Eligible Customers	26000
Annual # Participants	22
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	146000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	334.0
Annual Indirect Utility Cost (1000s$)	320.0
Annual Total Utility Cost (1000s$)	654.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.1%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	6636
Annual Therms Saved as % Gas Sales	0.01%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	5.80
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Ken Balaskovits
Phone Number	(312) 431 4144

Program Description

Free audit performed. Low-interest loans offered for performing recommended measures from audit.

Comments

319 buildings have performed recommended measures. Budget is an estimate derived from the utility's Least Cost Plan.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Public Service Electric & Gas
Utility Type	combo
Program	Weatherization Low-interest Loan Program
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	1984
Program End Date	-
Annual Data Start Date	4/86
Annual Data End Date	3/87
Annual # Eligible Customers	
Annual # Participants	1691
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	168000
Cumul. Therms Saved	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	817.0
Annual Indirect Utility Cost (1000s$)	835.3
Annual Total Utility Cost (1000s$)	1652.3
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	99
Annual Therms Saved as % Gas Sales	0.02%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	12.74
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Charles Coccaro
Phone Number	(201) 430 7245

Program Description

Free audit performed. Low-interest loan of $500-$4,000 offered to households earning less than $50,000 per year. Zero-interest financing available to households earning less than $30,000 per year. Measures covered include insulation, weatherstripping, caulkng, low-flow showerheads, faucet aerators, duct and water pipe insulation, storm windows and doors, attic vent fans, water heater timer control, and other custom measures.

Comments

Gas savings are engineering estimates.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	San Diego Gas & Electric
Utility Type	gas
Program	Low-Flow Showerhead Program
Program Type	RHT
Pilot or Full-Scale Program	full
Program Start Date	1990
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	653678
Annual # Participants	29581
Annual # Projects	42199
Cumul # Eligible Customers	653678
Cumul # Participants	40577
Annual Therms Saved	876920
Cumul. Therms Saved	1249287
Adjustments	fr
Annual Direct Utility Cost (1000s$)	97.9
Annual Indirect Utility Cost (1000s$)	80.9
Annual Total Utility Cost (1000s$)	178.8
Cumul. Direct Utility Cost (1000s$)	134.9
Cumul. Indirect Utility Cost (1000s$)	101.3
Cumul. Total Utility Cost (1000s$)	236.2
Annual Participation Rate	4.5%
Cumulative Participation Rate	6.2%
Annual Therms Saved/Participant	30
Annual Therms Saved as % Gas Sales	0.20%
Cumul. Therms Saved as % Gas Sales	0.29%
Levelized Utility Cost ($/Dtherm): annual data	0.26
Levelized Utility Cost ($/Dtherm): cumul. data	0.24
Utility Contact	Yole Whiting
Phone Number	(619) 696 4054

Program Description

Utility gives low-flow showerhead kits to the County Water Authority, who distributes the free low-flow showerheads to single- and multi-family homes.

Comments

For the first 2 1/2 years of the program, the utility estimated a 0% free-ridership. In 1993, the utility has estimated that there will be some free-ridership, although it is expected to be small.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	South Jersey Gas
Utility Type	gas
Program	Assistance Sealup Program
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	
Program End Date	-
Annual Data Start Date	4/86
Annual Data End Date	3/87
Annual # Eligible Customers	
Annual # Participants	713
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	46000
Cumul. Therms Saved	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	n/a
Annual Indirect Utility Cost (1000s$)	n/a
Annual Total Utility Cost (1000s$)	166.1
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	65
Annual Therms Saved as % Gas Sales	0.01%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	4.68
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Joan Sweeney
Phone Number	(609) 561 9000x255

Program Description

Free audit is performed. $250-$750 per home is applied to weatherization measures, including water heater wraps, showerhead flow restrictors, door sweeps, outlet gaskets, weatherstripping, caulking, attic hatch insulation, plastic window sheets, and other custom measures.

Comments

Gas savings are engineering estimates.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	South Jersey Gas
Utility Type	gas
Program	Regular Sealup Program
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	
Program End Date	-
Annual Data Start Date	4/86
Annual Data End Date	3/87
Annual # Eligible Customers	
Annual # Participants	177
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	80000
Cumul. Therms Saved	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	n/a
Annual Indirect Utility Cost (1000s$)	n/a
Annual Total Utility Cost (1000s$)	30.3
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	452
Annual Therms Saved as % Gas Sales	0.02%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.49
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Joan Sweeney
Phone Number	(609) 561 9000x255

Program Description

Free audit performed. For a $10 fee, water heater blanket is installed. If customer has a blanket, for a $10 fee, 1 low-flow showerhead, 2 faucet aerators, 30 feet of water heater pipe insulation, and 1 door sweep are installed as well as 3 windows and 1 door are weatherstripped.

Comments

Gas savings are engineering estimates.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	South Jersey Gas
Utility Type	gas
Program	Space & Water Heating Financing
Program Type	RHT
Pilot or Full-Scale Program	
Program Start Date	
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	210646
Annual # Participants	520
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	478308
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	n/a
Annual Indirect Utility Cost (1000s$)	n/a
Annual Total Utility Cost (1000s$)	n/a
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.2%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	920
Annual Therms Saved as % Gas Sales	0.14%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	n/a
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Joan Sweeney
Phone Number	(609) 561 9000x255

Program Description

Special low-interest financing offered for installing energy-efficient furnaces and/or boilers.

Comments

No direct costs since this is only a financing program. Administrative costs are a rough estimate made by the utility.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	South Jersey Gas
Utility Type	gas
Program	Weatherization Low-interest Loan Program
Program Type	R:A&I
Pilot or Full-Scale Program	full
Program Start Date	
Program End Date	-
Annual Data Start Date	4/86
Annual Data End Date	3/87
Annual # Eligible Customers	
Annual # Participants	268
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	180000
Cumul. Therms Saved	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	n/a
Annual Indirect Utility Cost (1000s$)	n/a
Annual Total Utility Cost (1000s$)	152.3
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	672
Annual Therms Saved as % Gas Sales	0.05%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	1.10
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Joan Sweeney
Phone Number	(609) 561 9000x255

Program Description

Free audit is performed. For households earning less than $30,000/year, zero-interest financing of $500-$4,000 is offered for installing recommended measures. Low interest financing is offered ot households earning less than $50,000/yr.

Comments

Gas savings are engineering estimates.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Southern California Gas
Utility Type	gas
Program	Appliance Efficiency Program
Program Type	RHT
Pilot or Full-Scale Program	
Program Start Date	2/90
Program End Date	-
Annual Data Start Date	7/90
Annual Data End Date	2/91
Annual # Eligible Customers	3100000
Annual # Participants	
Annual # Projects	
Cumul # Eligible Customers	3100000
Cumul # Participants	
Annual Therms Saved	756000
Cumul. Therms Saved	973000
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	7566
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	9018
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	n/a
Annual Therms Saved as % Gas Sales	0.03%
Cumul. Therms Saved as % Gas Sales	0.04%
Levelized Utility Cost ($/Dtherm): annual data	8.03
Levelized Utility Cost ($/Dtherm): cumul. data	7.44
Utility Contact	Martin Crundall
Phone Number	(213) 244 3686

Program Description

This program offers incentives for single and multifamily customers to replace old, inefficient gas water heaters and furnaces with high-efficiency gas equipment. Furnaces must have an AFUE rating of 78%+ to receive a rebate; single family storage water heaters must have an energy factor of .60+; central storage and non-storage water heaters must have a thermal efficiency of 80%+ to be eligible for rebates.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Southern California Gas
Utility Type	gas
Program	Commercial Equipment Replacement Upgrade
Program Type	C&I:A&I
Pilot or Full-Scale Program	full
Program Start Date	2/89
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/92
Annual # Eligible Customers	220000
Annual # Participants	1620
Annual # Projects	
Cumul # Eligible Customers	188000
Cumul # Participants	
Annual Therms Saved	7737219
Cumul. Therms Saved	14072219
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	5145
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	8513
Annual Participation Rate	0.7%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	4776
Annual Therms Saved as % Gas Sales	0.18%
Cumul. Therms Saved as % Gas Sales	0.32%
Levelized Utility Cost ($/Dtherm): annual data	0.53
Levelized Utility Cost ($/Dtherm): cumul. data	0.49
Utility Contact	Martin Crundall
Phone Number	(213) 244 3686

Program Description

Utility pays 50% of the cost of an audit. Either 20% of the installation costs of the recommended measures are rebated or fixed rebates per piece of equipment installed are offered. Installation of efficient gas space heating receives between $5 and $15 per MBtu depending on the AFUE rating of the installed equipment. Installation of efficient water heaters receives a rebate of between $2.50 - $38.25 depending on the AFUE rating. Pipe wraps receive $2 per foot installed. R19 ceiling insulation installation receives a rebate of $0.25 per square foot. Tank insulation receives a rebate of $1.50 per foot. Various other incentives are offered for installation of efficient boilers, cooking equipment, dryers, and gas engines. Miscellaneous other measures receive a rebate of $1.50 per installed MBtu.

Comments

Number of participants is based on number of measures installed; the utility noted that the ratio of participants to measures installed is roughly 1:1.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Southern California Gas
Utility Type	gas
Program	Direct Assistance Program
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	1983
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/92
Annual # Eligible Customers	1300000
Annual # Participants	32221
Annual # Projects	
Cumul # Eligible Customers	1300000
Cumul # Participants	66841
Annual Therms Saved	4003000
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	12770
Annual Indirect Utility Cost (1000s$)	3831.0
Annual Total Utility Cost (1000s$)	16601.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	2.5%
Cumulative Participation Rate	5.1%
Annual Therms Saved/Participant	124
Annual Therms Saved as % Gas Sales	0.15%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	5.37
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Martin Crundall
Phone Number	(213) 244 3686

Program Description

100% subsidies for low-income customers to perform weatherization measures such as installation of faucet aerators, pipe wraps, and evaporative cooler vent covers.

Comments

Budget and number of eligible customers are based on rough estimates made by utility. Indirect costs were assumed to be 30% of direct costs.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Southern California Gas
Utility Type	gas
Program	High Efficiency New Commercial Buildings
Program Type	C&INC
Pilot or Full-Scale Program	full
Program Start Date	
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/92
Annual # Eligible Customers	
Annual # Participants	264
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	3317538
Cumul. Therms Saved	4040538
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	972.1
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	1899.1
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	12566
Annual Therms Saved as % Gas Sales	0.08%
Cumul. Therms Saved as % Gas Sales	0.09%
Levelized Utility Cost ($/Dtherm): annual data	0.19
Levelized Utility Cost ($/Dtherm): cumul. data	0.31
Utility Contact	Martin Crundall
Phone Number	(213) 244 3686

Either 20% of the installation costs of the recommended measures are offered as a rebate or fixed rebates per piece of equipment installed are offered. Installation of efficient gas space heating receives $2.50 per installed MBtu for a heater with an AFUE rating of 75-80%. Heaters with 81-85% AFUE raing receive a $9/MBtu rebate; 87-100% effficient heaters receive a $15/MBtu rebate. Water heater installations receive a rebate of between $2.50 - $38.25 rebate depending on the AFUE rating. $2 per foot of pipe wrap is offered. $0.25 per square foot of R19 ceiling insulation is offered. $1.50 per square foot of tank insulation is offered. Various other incentives are offered for installation of efficient boilers, cooking equipment, dryers, and gas engines. A $1.50/installed MBtu is available for miscellaneous other energy-efficient measures.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Southern California Gas
Utility Type	gas
Program	High Efficiency New Home Program
Program Type	RNC
Pilot or Full-Scale Program	
Program Start Date	2/90
Program End Date	-
Annual Data Start Date	7/90
Annual Data End Date	2/91
Annual # Eligible Customers	80000
Annual # Participants	
Annual # Projects	
Cumul # Eligible Customers	80000
Cumul # Participants	
Annual Therms Saved	207000
Cumul. Therms Saved	231000
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	1480
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	2103
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	n/a
Annual Therms Saved as % Gas Sales	0.01%
Cumul. Therms Saved as % Gas Sales	0.01%
Levelized Utility Cost ($/Dtherm): annual data	4.65
Levelized Utility Cost ($/Dtherm): cumul. data	5.92
Utility Contact	Martin Crundall
Phone Number	(213) 244 3686

Program Description

A rebate of $150 is offered for the installation of 78-87.9% AFUE gas space heater. $450 is offered for 88%+ efficient space heaters. A rebate of $75 is offered for the installation of gas water heaters with an energy factor of .6+. $0.14 per square foot is offered for installation of R11-R15 wall insulation.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Southern California Gas
Utility Type	gas
Program	Industrial Equipment Replacement/Heat Recc
Program Type	C&I:A&I
Pilot or Full-Scale Program	full
Program Start Date	2/90
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/92
Annual # Eligible Customers	20000
Annual # Participants	293
Annual # Projects	
Cumul # Eligible Customers	25000
Cumul # Participants	
Annual Therms Saved	7677630
Cumul. Therms Saved	13333530
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	4169
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	6439
Annual Participation Rate	1.5%
Cumulative Participation Rate	1.5%
Annual Therms Saved/Participant	26204
Annual Therms Saved as % Gas Sales	0.18%
Cumul. Therms Saved as % Gas Sales	0.31%
Levelized Utility Cost ($/Dtherm): annual data	0.44
Levelized Utility Cost ($/Dtherm): cumul. data	0.39
Utility Contact	Martin Crundall
Phone Number	(213) 244 3686

Program Description

Utility pays for 50% of the audit costs. Upgrading space heaters receives a rebate of $7/ MBtu. Boiler upgrades receive a rebate of $70/hp. Dryer upgrades receive a rebate of $2/ MBtu. Furnace, kiln, and oven upgrades receive a rebate of $1.85/MBtu. Process cooking equipment receives a rebate of $2/MBtu. Other miscellaneous measures receive a rebate of $2.65/MBtu. The heat recovery portion of the program offers a rebate of 50% of the istallation costs or $0.50/therm saved, whichever is less, for heat recovery projects.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Southern California Gas
Utility Type	gas
Program	New and Innovative Multi-family Program
Program Type	RNC
Pilot or Full-Scale Program	full
Program Start Date	2/90
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/92
Annual # Eligible Customers	80000
Annual # Participants	1016
Annual # Projects	
Cumul # Eligible Customers	80000
Cumul # Participants	2503
Annual Therms Saved	43000
Cumul. Therms Saved	105000
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	916.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	1400.0
Annual Participation Rate	1.3%
Cumulative Participation Rate	3.1%
Annual Therms Saved/Participant	42
Annual Therms Saved as % Gas Sales	0.002%
Cumul. Therms Saved as % Gas Sales	0.004%
Levelized Utility Cost ($/Dtherm): annual data	13.86
Levelized Utility Cost ($/Dtherm): cumul. data	8.67
Utility Contact	Martin Crundall
Phone Number	(213) 244 3686

Program Description

Installation of 78-87.9% AFUE space heaters receives a rebate of $150, 88%+ AFUE space heaters $450. Installation of .6+ EF water heaters receives a rebate of $75 (installation of central water heaters: $295). Combination water and space heating units with an energy factor of .6+ receives a rebate of $200. Installation of R11-R15 wall insulation receives a rebate of $0.14 per square foot.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Southern California Gas
Utility Type	gas
Program	Residential Weatherization
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	
Program End Date	-
Annual Data Start Date	7/90
Annual Data End Date	2/92
Annual # Eligible Customers	3100000
Annual # Participants	
Annual # Projects	
Cumul # Eligible Customers	3100000
Cumul # Participants	
Annual Therms Saved	1811000
Cumul. Therms Saved	1904000
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	3570
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	4065
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	n/a
Annual Therms Saved as % Gas Sales	0.07%
Cumul. Therms Saved as % Gas Sales	0.07%
Levelized Utility Cost ($/Dtherm): annual data	2.55
Levelized Utility Cost ($/Dtherm): cumul. data	2.76
Utility Contact	Martin Crundall
Phone Number	(213) 244 3686

Program Description

For single family dwellings, a rebate of $75 is available for installation of a water heater with and energy factor of .6+. Owners of multifamily buildings are eligible to receive a $300 rebate for installation of an 80% efficient central water heater, $800 for an 80-89.9% efficient central heater, and $1600 for a 90%+ efficient heater. Multifamily building owners are also eligible to receive a $400 incentive for purchase of an 88-93.9% efficient furnace and a $600 incentive for a 94%+ efficient furnace. Single families are eligible to receive a $220 rebate for installing 600 square feet of R19 attic insulation and multifamily dwellings are eligible to receive $100 for installation of 400 square feet of R19 attic insulation. $267 rebate is offered for the installation of 25 feet of R3 duct wrap. $90 rebate for the installation of 20 linear feet of weatherstripping and caulking in single family dwellings ($75 rebate for multifamily units). An R6 water heater blanket installation receives a rebate of $10.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Washington Gas Light
Utility Type	gas
Program	Comm. & Multifamily Water Heater Replacement
Program Type	C&I:GNRL
Pilot or Full-Scale Program	pilot
Program Start Date	1/89
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	9/92
Annual # Eligible Customers	
Annual # Participants	
Annual # Projects	
Cumul # Eligible Customers	18500
Cumul # Participants	171
Annual Therms Saved	300000
Cumul. Therms Saved	1800000
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	
Cumul. Direct Utility Cost (1000s$)	3883.0
Cumul. Indirect Utility Cost (1000s$)	3600.0
Cumul. Total Utility Cost (1000s$)	7483.0
Annual Participation Rate	n/a
Cumulative Participation Rate	0.9%
Annual Therms Saved/Participant	
Annual Therms Saved as % Gas Sales	0.16%
Cumul. Therms Saved as % Gas Sales	0.96%
Levelized Utility Cost ($/Dtherm): annual data	n/a
Levelized Utility Cost ($/Dtherm): cumul. data	3.34
Utility Contact	Adrian Chapman
Phone Number	(703) 750 7538

Program Description

An incentive of $85 per 10,000 Btu input rating is offered to customers who install water heating equipment with a thermal efficiency of at least 80%. Participants also receive a free energy audit.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Washington Gas Light
Utility Type	gas
Program	Multi-family Rehabilitation
Program Type	RHT
Pilot or Full-Scale Program	pilot
Program Start Date	1/89
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	25000
Annual # Participants	300
Annual # Projects	
Cumul # Eligible Customers	25000
Cumul # Participants	600
Annual Therms Saved	
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	169.5
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	339.0
Annual Participation Rate	1.2%
Cumulative Participation Rate	2.4%
Annual Therms Saved/Participant	n/a
Annual Therms Saved as % Gas Sales	n/a
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	n/a
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Adrian Chapman
Phone Number	(703) 750 7538

Program Description

An incentive of $500 per piece of equipment is offered for replacing either furnaces or boilers with 80%+ AFUE models. Rebates go to the developers and contractors of low-income housing. Participants are also required to implement building shell weatherization measures.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Washington Gas Light
Utility Type	gas
Program	Residential Boiler/Furnace Replacement
Program Type	RHT
Pilot or Full-Scale Program	pilot
Program Start Date	1/89
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	90000
Annual # Participants	200
Annual # Projects	
Cumul # Eligible Customers	90000
Cumul # Participants	600
Annual Therms Saved	25000
Cumul. Therms Saved	150000
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	240.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	1720.0
Annual Participation Rate	0.2%
Cumulative Participation Rate	0.7%
Annual Therms Saved/Participant	125
Annual Therms Saved as % Gas Sales	0.02%
Cumul. Therms Saved as % Gas Sales	0.13%
Levelized Utility Cost ($/Dtherm): annual data	7.70
Levelized Utility Cost ($/Dtherm): cumul. data	9.20
Utility Contact	Adrian Chapman
Phone Number	(703) 750 7538

Program Description

Incentives are offered for boilers and furnaces as follows: (1) $650 for a 90%+ AFUE boiler; (2) $550 for a 90%+ furnace or 84-89% boiler; and (3) $250 for a 80-89% furnace or 80-83% boiler. Participants also receive a free computerized energy survey.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Washington Gas Light
Utility Type	gas
Program	Residential Weatherization
Program Type	R:A&I
Pilot or Full-Scale Program	pilot
Program Start Date	1/89
Program End Date	12/91
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	90000
Annual # Participants	800
Annual # Projects	
Cumul # Eligible Customers	90000
Cumul # Participants	2400
Annual Therms Saved	56000
Cumul. Therms Saved	336000
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	380.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	1140.0
Annual Participation Rate	0.9%
Cumulative Participation Rate	2.7%
Annual Therms Saved/Participant	70
Annual Therms Saved as % Gas Sales	0.05%
Cumul. Therms Saved as % Gas Sales	0.29%
Levelized Utility Cost ($/Dtherm): annual data	8.79
Levelized Utility Cost ($/Dtherm): cumul. data	4.39
Utility Contact	Adrian Chapman
Phone Number	(703) 750 7538

Program Description

Free computerized audits are performed. In addition, low-income customers receive free weatherization measures. Non-low-income customers must pay for measures installed.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Natural Gas
Utility Type	gas
Program	Blueprint for Savings: C&I Heating Upgrade
Program Type	C&I:Gnrl
Pilot or Full-Scale Program	full
Program Start Date	1989
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	22000
Annual # Participants	667
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	1587829
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	519.9
Annual Indirect Utility Cost (1000s$)	519.9
Annual Total Utility Cost (1000s$)	1039.8
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	3.0%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	2381
Annual Therms Saved as % Gas Sales	1.06%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.53
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Frohlich
Phone Number	(414) 637 7681

Program Description

An incentive of 15% of the cost of purchasing and installing efficient gas and space heati equipment is offered. An interest rate buydown financing option is an alternative incentive.

Comments

Indirect costs were estimated to be equal to direct costs, based on analysis of utility data.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Gas
Utility Type	gas
Program	Existing Commercial Customer Conservation
Program Type	C&I:A&I
Pilot or Full-Scale Program	full
Program Start Date	10/90
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	10/91
Annual # Eligible Customers	21150
Annual # Participants	1834
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	851019
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	2362.2
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	8.7%
Cumulative Participation Rate	8.7%
Annual Therms Saved/Participant	464
Annual Therms Saved as % Gas Sales	0.40%
Cumul. Therms Saved as % Gas Sales	0.40%
Levelized Utility Cost ($/Dtherm): annual data	3.59
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Luc Piessens
Phone Number	(414) 291 6959

Program Description

Free energy audit offered. $100 incentive for upgrading furnace. 50% of the cost of of flue dampers is rebated (to a maximum of $260). 10% of the cost of infrared heating is rebated (to a maximum of $1000). 50% of the cost of setback thermostats is rebated (to a maximum of $75). 10% of the cost of upgrading boilers is rebated (to a maximum of of $1000). 50% of the cost of boiler tune-ups is rebated (maximum $100). 50% of the cost of remote sensing thermostats is rebated (maximum $295). 50% of the cost of installi low-flow showerheads. 20% of the cost of materials for weatherization is rebated (maximum $1500).

Comments

In 1992, the weatherization incentive was increased to 40% of the cost of materials.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Fuel & Light
Utility Type	gas
Program	Furnace Rebate Program
Program Type	RHT
Pilot or Full-Scale Program	
Program Start Date	1987
Program End Date	12/91
Annual Data Start Date	1/90
Annual Data End Date	12/91
Annual # Eligible Customers	43223
Annual # Participants	32
Annual # Projects	
Cumul # Eligible Customers	43223
Cumul # Participants	63
Annual Therms Saved	7088
Cumul. Therms Saved	14175
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.1%
Cumulative Participation Rate	0.1%
Annual Therms Saved/Participant	225
Annual Therms Saved as % Gas Sales	0.02%
Cumul. Therms Saved as % Gas Sales	0.03%
Levelized Utility Cost ($/Dtherm): annual data	n/a
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Tim Brick
Phone Number	(414) 682 8241

Program Description

An incentive of 10% of the materials and installation cost is offered for installing a 90%+ AFUE furnace.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Gas
Utility Type	gas
Program	Large C&I Conservation: New Equipment
Program Type	C&I:A&I
Pilot or Full-Scale Program	full
Program Start Date	10/90
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	10/91
Annual # Eligible Customers	3400
Annual # Participants	25
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	2097821
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	4013.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.7%
Cumulative Participation Rate	0.7%
Annual Therms Saved/Participant	83247
Annual Therms Saved as % Gas Sales	0.98%
Levelized Utility Cost ($/Dtherm): annual data	0.98%
Levelized Utility Cost ($/Dtherm): cumul. data	1.53
Cumul. Levelized Cost ($/therm)	n/a
Utility Contact	Luc Piessens
Phone Number	(414) 291 6959

Program Description

Free audit is performed. An incentive of 35% of the equipment costs of the recommended measures is offered, up to a maximum of $30,000. Only measures which replace existing equipment are eligible (no retrofits).

Comments

The number of participating customers is a rough estimate derived from utility data.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Gas
Utility Type	gas
Program	Large C&I Conservation: Retrofit Equipment
Program Type	C&I:A&I
Pilot or Full-Scale Program	full
Program Start Date	10/90
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	10/91
Annual # Eligible Customers	3400
Annual # Participants	17
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	909790
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	1239.3
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.5%
Cumulative Participation Rate	0.5%
Annual Therms Saved/Participant	54154
Annual Therms Saved as % Gas Sales	0.43%
Cumul. Therms Saved as % Gas Sales	0.43%
Levelized Utility Cost ($/Dtherm): annual data	1.76
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Luc Piessens
Phone Number	(414) 291 6959

Program Description

Free audit is performed. An incentive of 35% of the equipment costs of the recommended measures is offered, up to a maximum of $30,000. Measures can either replace existing equipment or retrofit existing equipment.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Gas
Utility Type	gas
Program	Large C&I Steam Trap Operation & Maintena
Program Type	C&I:A&I
Pilot or Full-Scale Program	full
Program Start Date	10/90
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	10/91
Annual # Eligible Customers	3400
Annual # Participants	19
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	468768
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	92.5
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.6%
Cumulative Participation Rate	0.6%
Annual Therms Saved/Participant	24672
Annual Therms Saved as % Gas Sales	0.22%
Cumul. Therms Saved as % Gas Sales	0.22%
Levelized Utility Cost ($/Dtherm): annual data	0.26
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Luc Piessens
Phone Number	(414) 291 6959

Program Description

Free audit is performed. $7 per trap is offered for customer to establish a computerized steam trap maintenance program. Maximum incentive per facility is $300. The equipment gas usage must exceed 50,000 therms/year in order for the customer to be eligible.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Gas
Utility Type	gas
Program	Large Multi-family Conservation
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	10/90
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	10/91
Annual # Eligible Customers	4900
Annual # Participants	254
Annual # Projects	
Cumul # Eligible Customers	4900
Cumul # Participants	635
Annual Therms Saved	751235
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	1846.5
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	5.2%
Cumulative Participation Rate	13.0%
Annual Therms Saved/Participant	2958
Annual Therms Saved as % Gas Sales	0.16%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	3.18
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Luc Piessens
Phone Number	(414) 291 6959

Program Description

Free audits are performed. Rebates of 10-50% of the cost of recommended measures are offered. Measures include installation of vent dampers, low-flow showerheads, boiler upgrades and tune-ups, weatherization measures, and remote sensing thermostats.

Comments

The number of eligible customers using the utility assumption that the measure to customer ratio is 3:1.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Gas
Utility Type	gas
Program	Large Multi-family New Construction
Program Type	RNC
Pilot or Full-Scale Program	
Program Start Date	10/90
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	10/91
Annual # Eligible Customers	530
Annual # Participants	424
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	73590
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	245.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	80.0%
Cumulative Participation Rate	80.0%
Annual Therms Saved/Participant	174
Annual Therms Saved as % Gas Sales	0.02%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	2.17
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Luc Piessens
Phone Number	(414) 291 6959

Program Description

The building must have a total energy performance level equal to 3 Btu per sqaure foot per degree-day. $100 to $150 per multifamily unit is paid to developer or builder meeting this energy performance level.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Gas
Utility Type	gas
Program	New Commercial Construction Conservation
Program Type	C&INC
Pilot or Full-Scale Program	full
Program Start Date	10/90
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	10/91
Annual # Eligible Customers	
Annual # Participants	139
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	47385
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	141.7
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	342
Annual Therms Saved as % Gas Sales	0.02%
Cumul. Therms Saved as % Gas Sales	0.02%
Levelized Utility Cost ($/Dtherm): annual data	1.95
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Luc Piessens
Phone Number	(414) 291 6959

Program Description

A $100 incentive is offered for installing an efficient furnace. 10% of the cost of infrar heating rebated (maximum $1000). 50% of the cost of setback thermostats is rebated (maximu $75). 10% of the cost of upgrading boilers and installing controls is rebated (maximum of $1000). 50% cost of installing low-flow showerheads. 10% of the purchase price of installing high-efficiency cooking equipment is rebated. Customer-designed measures are rebated on a case-by-case basis.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Gas
Utility Type	gas
Program	Residential Conservation
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	1989
Program End Date	12/91
Annual Data Start Date	9/90
Annual Data End Date	10/91
Annual # Eligible Customers	321500
Annual # Participants	13890.9
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	2101032
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	6065.1
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	4.3%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	151
Annual Therms Saved as % Gas Sales	0.46%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	3.74
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Luc Piessens
Phone Number	(414) 291 6959

Program Description

Free audits are performed. Installations of furnaces with AFUE ratings of 88%+ and boiler with AFUE ratings of 82%+ receive a $100 rebate ($200 if renter). 20% of the cost of insulation is rebated (maximum of $100 per dwelling). Installation of high-efficiency water heaters receives a rebate of $100 ($125 if renter). Custom measures receive 3% of first year savings (maximum $100 per measure).

Comments

Number of participants was estimated by the utility to be equal to 95% of the installed measures.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Gas
Utility Type	gas
Program	Residential New Construction
Program Type	RNC
Pilot or Full-Scale Program	
Program Start Date	1989
Program End Date	-
Annual Data Start Date	6/89
Annual Data End Date	10/91
Annual # Eligible Customers	321500
Annual # Participants	598
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	92447
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	271.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.2%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	155
Annual Therms Saved as % Gas Sales	0.02%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	1.91
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Luc Piessens
Phone Number	(414) 291 6959

Program Description

To be eligible, a home must go beyond the current building codes and general practice for envelope, furnace, and water heater efficiency. Rebates of $100 per home are offered to qualifying homes. A $75 bonus is offered for installation of R5-R9 insulation and a $150 bonus for R10 insulation. Custom rebates are also offered.

Comments

Number of participants was estimated by the utility to be equal to 95% of the installed measures.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Natural Gas
Utility Type	gas
Program	Savings Plus: Low-Income Weatherization R
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	1989
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	23500
Annual # Participants	255
Annual # Projects	1275
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	97631
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	420.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	1.1%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	383
Annual Therms Saved as % Gas Sales	0.04%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	5.57
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Frohlich
Phone Number	(414) 637 7681

Program Description

A free audit is offered but seldom performed. 30% of the installation costs of the recommended measures is rebated. Eligible measures include installation of setback therm stats, insulation, air conditioner covers, space and water heater upgrades and tune-ups, boiler resets, low-flow showerheads, and custom measures.

Comments

The number of eligible customers uses the utility assumption that the measure to customer ratio is 5:1. The budget assumes that 1/3 of the total Low-Income Weatherization Program budget goes to rental customers.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Natural Gas
Utility Type	gas
Program	Savings Plus: Homeowner
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	1989
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	164500
Annual # Participants	6346
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	1062800
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	742.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	3.9%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	167
Annual Therms Saved as % Gas Sales	0.40%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.90
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Frohlich
Phone Number	(414) 637 7681

Program Description

A free audit is offered, but is rarely performed according to the utility. An incentive of $75 is offered for upgrading furnace equipment to efficienct models.A $50 incentive is offered for upgrading water heating equipment. 15% of the cost of installing insulation is rebated, up to a maximum of $75 per dwelling. Additional measures rebated include setback thermostats, air conditioner covers, heater tune-ups, boiler resets, and low-flow showerheads. Custom measures are also rebated on a case-by-case basis.

Comments

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Natural Gas
Utility Type	gas
Program	Savings Plus: Low-Income Weatherization Hom
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	1989
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	23500
Annual # Participants	86
Annual # Projects	430
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	178277
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	800.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.4%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	2073
Annual Therms Saved as % Gas Sales	0.07%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	5.81
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Frohlich
Phone Number	(414) 637 7681

Program Description

A free audit is performed. A 100% subsidy of recommended measures is offered. Measures rebated include installation of setback thermostats, all insulation, air conditioner covers, space and water heater upgrades and tune-ups, boiler resets, low-flow showerheads, and custom measures.

Comments

The number of eligible customers uses the utility assumption that the measure to customer ratio is 5:1. The budget assumes that 2/3 of the total Low-Income Weatherization Program budget goes to homeowners.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Natural Gas
Utility Type	gas
Program	Savings Plus: Rental
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	1989
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	70500
Annual # Participants	1086
Annual # Projects	5430
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	384170
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	223.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	1.5%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	354
Annual Therms Saved as % Gas Sales	0.15%
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	0.75
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Bob Frohlich
Phone Number	(414) 637 7681

Program Description

A free audit is offered but seldom performed. 15% of the installation costs of the recommended measures is rebated. Eligible measures include installation of setback thermostats, insulation, air conditioner covers, space and water heater upgrades and tune-ups, boiler resets, and custom measures. Installation of low-flow showerheads receive a $10 rebate. Low-interest financing is another option.

Comments

The number of eligible customers uses the utility assumption that the measure to customer ratio is 5:1.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Wisconsin Gas
Utility Type	gas
Program	Small Multi-family Rental Conservation
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	1989
Program End Date	-
Annual Data Start Date	6/89
Annual Data End Date	10/91
Annual # Eligible Customers	37000
Annual # Participants	7004
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	437144
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	880.2
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	18.9%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	62
Annual Therms Saved as % Gas Sales	0.10%
Cumul. Therms Saved as % Gas Sales	0.10%
Levelized Utility Cost ($/Dtherm): annual data	2.61
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Luc Piessens
Phone Number	(414) 291 6959

Program Description

Free audits are performed. The incentives are the same as for the Residential Conservation program with the exception that installation of efficient gas water heaters receive a rebat of $50 ($75 if renter). Owners of 1-4 unit rental properties are eligible.

Comments

Number of participants was estimated by the utility to be equal to 95% of the installed measures.

APPENDIX C. GAS CONSERVATION PROGRAM DATA

Utility	Yankee Gas
Utility Type	gas
Program	Weatherization Residential Assistance Partne
Program Type	R:A&I
Pilot or Full-Scale Program	
Program Start Date	
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	7000
Annual # Participants	640
Annual # Projects	
Cumul # Eligible Customers	
Cumul # Participants	
Annual Therms Saved	
Cumul. Therms Saved	
Adjustments	
Annual Direct Utility Cost (1000s$)	290.0
Annual Indirect Utility Cost (1000s$)	160.0
Annual Total Utility Cost (1000s$)	450.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	9.1%
Cumulative Participation Rate	n/a
Annual Therms Saved/Participant	n/a
Annual Therms Saved as % Gas Sales	n/a
Cumul. Therms Saved as % Gas Sales	n/a
Levelized Utility Cost ($/Dtherm): annual data	n/a
Levelized Utility Cost ($/Dtherm): cumul. data	n/a
Utility Contact	Brenda Toth
Phone Number	(203) 639 4482

Program Description

Free audit is performed. To qualify, participants must be below 200% of the federal poverty level and must have less than 3.5 inches of attic insulation. Free materials and installation of 12" of attic insulation, water heater wrap, low-flow showerheads, faucet aerators, caulking, weatherstripping, and hot water pipe insulation. The program is done in collaboration with Northeast Utilities, Connecticut Natural Gas, the Connecticut Association for Community Action, and the Connecticut Department of Human Resources.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Baystate Gas Co.
Utility Type	gas
Program	High-Efficiency Heating Conversion
Program Type	C&IHVAC
Pilot or Full-Scale Program	Full
Program Start Date	1990
Program End Date	-
Annual Data Start Date	12/90
Annual Data End Date	11/91
Annual # Eligible Customers	2400
Annual # Participants	7
Annual # Projects	
Annual GWh Saved	n/a
Annual Therms Added	30950
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	n/a
Annual Indirect Utility Cost (1000s$)	n/a
Annual Total Utility Cost (1000s$)	n/a
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.29%
Annual Therms Added/Participant	4421
Annual MWh Saved/Participant	n/a
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.02%
Cumul. Therms Added as % Gas Sales	0.02%
Annual Levelized Cost ($/kWh)	n/a
Utility Contact	Ken Howes
Phone Number	(508) 836 7374

Program Description

Customers can receive prime + 2 financing for switching electric or oil heaters with efficient gas boilers (>80% AFUE), furnaces (>78% AFUE), storage water heaters (>77% thermal efficiency), & non-storage water heaters (>80% thermal efficiency).

Comments

Only data on electric to gas conversions are included.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Baystate Gas Co.
Utility Type	gas
Program	High-Efficiency Heating Conversion
Program Type	RES:HVAC
Pilot or Full-Scale Program	Full
Program Start Date	1990
Program End Date	-
Annual Data Start Date	12/90
Annual Data End Date	11/91
Annual # Eligible Customers	2380
Annual # Participants	75
Annual # Projects	
Annual GWh Saved	2.0
Annual Therms Added	90000
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	n/a
Annual Indirect Utility Cost (1000s$)	n/a
Annual Total Utility Cost (1000s$)	n/a
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	3.15%
Annual Therms Added/Participant	1200
Annual MWh Saved/Participant	27
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.04%
Cumul. Therms Added as % Gas Sales	0.04%
Annual Levelized Cost ($/kWh)	n/a
Utility Contact	Ken Howes
Phone Number	(508) 836 7374

Program Description

Customers can receive 9.9% financing for replacement of electric or oil heaters with efficient furnaces (>85% AFUE), boilers (>80% AFUE), 30 gallon water heaters (EF >.6), 40 gallon water heaters (EF >.59), or 50 gallon water heaters (EF >.58).

Comments

Only data on electric to gas conversions are included.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Boston Gas Co.
Utility Type	gas
Program	Cogeneration Rebate Program
Program Type	C&IGNRL
Pilot or Full-Scale Program	Full
Program Start Date	1985
Program End Date	-
Annual Data Start Date	6/91
Annual Data End Date	5/92
Annual # Eligible Customers	40000
Annual # Participants	4
Annual # Projects	
Annual GWh Saved	0.7
Annual Therms Added	86400
Cumulative GWh Saved	23.9
Cumulative Therms Added	2865600
Adjustments	
Annual Direct Utility Cost (1000s$)	24.0
Annual Indirect Utility Cost (1000s$)	0.0
Annual Total Utility Cost (1000s$)	24.0
Cumul. Direct Utility Cost (1000s$)	24.0
Cumul. Indirect Utility Cost (1000s$)	0.0
Cumul. Total Utility Cost (1000s$)	24.0
Annual Participation Rate	0.01%
Annual Therms Added/Participant	21600
Annual MWh Saved/Participant	180
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.02%
Cumul. Therms Added as % Gas Sales	0.60%
Annual Levelized Cost ($/kWh)	0.003
Utility Contact	Ken Cheo
Phone Number	(617) 323 9210x344

Program Description

Rebates are offered to customers installing gas cogeneration equipment in buildings. Rebates are on a per kW installed basis and depend upon the forecasted hours of operation. Rebates range from $75 per kW installed for equipment with forecasted operation of less than 4500 full load hours per year, to a $200 per kW installed capacity for equipment forecasted to be operated for more than 7500 full load hours per year. The maximum rebate per project is up to 1050 kW at 7500 hours full load operation.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Boston Gas Co.
Utility Type	gas
Program	Gas Air-Conditioning Program
Program Type	C&IHVAC
Pilot or Full-Scale Program	Full
Program Start Date	1988
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	500000
Annual # Participants	16
Annual # Projects	
Annual GWh Saved	1.2
Annual Therms Added	303792
Cumulative GWh Saved	1.9
Cumulative Therms Added	475200
Adjustments	
Annual Direct Utility Cost (1000s$)	180.2
Annual Indirect Utility Cost (1000s$)	0.0
Annual Total Utility Cost (1000s$)	180.2
Cumul. Direct Utility Cost (1000s$)	263.1
Cumul. Indirect Utility Cost (1000s$)	0.0
Cumul. Total Utility Cost (1000s$)	263.1
Annual Participation Rate	0.003%
Annual Therms Added/Participant	18987
Annual MWh Saved/Participant	77
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.06%
Cumul. Therms Added as % Gas Sales	0.10%
Annual Levelized Cost ($/kWh)	0.012
Utility Contact	Ken Cheo
Phone Number	(617) 323 9210x344

Program Description

Customers replacing electric air conditioning equipment with gas systems are eligible to receive a $100 per ton rebate up to a maximum of $50,000 per project. After a utility representative has verified that the gas system has been installed, the customer will receive the rebate within 30 days.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	British Columbia Hydro
Utility Type	elec
Program	Power Smart: Water Heater Conversion
Program Type	C&IHVAC
Pilot or Full-Scale Program	Pilot
Program Start Date	1990
Program End Date	3/91
Annual Data Start Date	4/91
Annual Data End Date	3/92
Annual # Eligible Customers	n/a
Annual # Participants	104
Annual # Projects	
Annual GWh Saved	4.6
Annual Therms Added	n/a
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	t&d,fr
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	60.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Annual Therms Added/Participant	n/a
Annual MWh Saved/Participant	44
Annual Elec. Savings as % Elec. Sales	0.04%
Cumul. Elec. Savings as % Elec. Sales	0.04%
Annual Therms Added as % Gas Sales	n/a
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	0.001
Utility Contact	Gifford Jung
Phone Number	(604) 663 3276

Program Description

Customers can receive cash rebates for replacing electric water heating with efficient gas heating. Buildings with water heaters with 80,000 Btu/hr input can receive $200-$225 upon installation. For larger water heaters, an $800 incentive is offered. Customers who convert their electric dishwasher water temperature booster to gas can receive a $400 or $500 rebate (larger rebate is for larger dishwashers).

Comments

Program offered in collaboration with 2 gas utilities.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	British Columbia Hydro
Utility Type	elec
Program	Power Smart: Water Heater Conversion
Program Type	RES:HVAC
Pilot or Full-Scale Program	Full
Program Start Date	1989
Program End Date	-
Annual Data Start Date	4/91
Annual Data End Date	3/92
Annual # Eligible Customers	50000
Annual # Participants	4825
Annual # Projects	
Annual GWh Saved	21.9
Annual Therms Added	1280748
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	t&d,fr
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	500.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	9.65%
Annual Therms Added/Participant	265
Annual MWh Saved/Participant	5
Annual Elec. Savings as % Elec. Sales	0.19%
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	n/a
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	0.002
Utility Contact	Gifford Jung
Phone Number	(604) 663 3276

Program Description

Customers who replace their electric water heaters with efficient gas models can receive a discount trade-in allowance certificate to reduce installation costs by $100 (central systems in apartments) to $200 (homes).

Comments

The gas utilities estimated the added annual gas load is 28 GJ, or roughly 265 therms, per installation.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Burlington Electric Dept
Utility Type	elec
Program	Heat Exchange
Program Type	RES:HVAC
Pilot or Full-Scale Program	Full
Program Start Date	1991
Program End Date	-
Annual Data Start Date	4/91
Annual Data End Date	3/92
Annual # Eligible Customers	1820
Annual # Participants	188
Annual # Projects	
Annual GWh Saved	1.4
Annual Therms Added	n/a
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	93.3
Annual Indirect Utility Cost (1000s$)	65.7
Annual Total Utility Cost (1000s$)	159.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	10.33%
Annual Therms Added/Participant	n/a
Annual MWh Saved/Participant	8
Annual Elec. Savings as % Elec. Sales	2.12%
Cumul. Elec. Savings as % Elec. Sales	2.12%
Annual Therms Added as % Gas Sales	n/a
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	0.009
Utility Contact	Tom Buckley
Phone Number	(802) 658 0300

Program Description

Customers who switch their electric space heat to gas space heat are eligible to receive either a zero-interest loan or a cash rebate. A free audit is conducted and a heating system is designed by a contractor using direct-vent wall-mounted gas space heaters. BED determines whether any weatherization measures are necessary. If the customer chooses a loan, the costs of the heating system and weatherization measures are paid up-front by BED; the customer keeps 40% of the monthly energy savings and BED collects on the loan with the remaining 60% over a five year period. The rebate covers roughly 10-40% of the materials and installation costs, depending on the type and cost of the heating system installed.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Burlington Electric Dept
Utility Type	elec
Program	Pilot Fuel Substitution Program
Program Type	RES:HVAC
Pilot or Full-Scale Program	Pilot
Program Start Date	1990
Program End Date	2/91
Annual Data Start Date	8/90
Annual Data End Date	2/91
Annual # Eligible Customers	1864
Annual # Participants	44
Annual # Projects	
Annual GWh Saved	0.4
Annual Therms Added	n/a
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	220.6
Annual Indirect Utility Cost (1000s$)	65.4
Annual Total Utility Cost (1000s$)	286.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	2.4%
Annual Therms Added/Participant	n/a
Annual MWh Saved/Participant	8
Annual Elec. Savings as % Elec. Sales	0.13%
Cumul. Elec. Savings as % Elec. Sales	0.13%
Annual Therms Added as % Gas Sales	n/a
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	0.058
Utility Contact	Tom Buckley
Phone Number	(802) 658 0300

Program Description

This pilot installed, free of charge, gas space heaters into 44 single-family and multi-family dwellings into electrically-heated homes. The electric heating system was not removed, but was instead controlled during peak hours. Funding came from a grant from the U.S. Department of Energy.

Comments

An evaluation after the pilot was completed revealed that approximately one-half of the participants never used their electric heat once the gas heat was installed.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Consolidated Edison
Utility Type	combo
Program	Gas Air Conditioning Program
Program Type	HVAC
Pilot or Full-Scale Program	Full
Program Start Date	1988
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	405000
Annual # Participants	15
Annual # Projects	
Annual GWh Saved	3.9
Annual Therms Added	661886
Cumulative GWh Saved	10.4
Cumulative Therms Added	1790914
Adjustments	t&d,fr
Annual Direct Utility Cost (1000s$)	1704
Annual Indirect Utility Cost (1000s$)	1164
Annual Total Utility Cost (1000s$)	2868.0
Cumul. Direct Utility Cost (1000s$)	3334
Cumul. Indirect Utility Cost (1000s$)	2848
Cumul. Total Utility Cost (1000s$)	6182.0
Annual Participation Rate	0.004%
Annual Therms Added/Participant	44126
Annual MWh Saved/Participant	260
Annual Elec. Savings as % Elec. Sales	0.02%
Cumul. Elec. Savings as % Elec. Sales	0.04%
Annual Therms Added as % Gas Sales	0.20%
Cumul. Therms Added as % Gas Sales	0.53%
Annual Levelized Cost ($/kWh)	0.059
Utility Contact	Pamela Wong
Phone Number	212 460 4838

Program Description

This program is available to all commercial and industrial customers and is intended to promote the use of efficient gas-fired absorption, desiccants, engine-driven chillers and heat pumps for cooling purposes as an alternative to electric technology. Rebates range from $100/ton to $500/ton. A loan referral service is offered as well. Beginning in 1991, the utility began offering, in addition to the customer rebate, a manufacturer rebate equal to $50/ton. The utility has recently attached minimum performance standards to eligible gas cooling equipment.

Comments

Cumulative results are for the period between January 1990 and December 1992.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Long Island Lighting Co.
Utility Type	combo
Program	Dollars & Sense: Gas Air Conditioning
Program Type	C&IHVAC
Pilot or Full-Scale Program	Full
Program Start Date	1986
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	9/91
Annual # Eligible Customers	100000
Annual # Participants	16
Annual # Projects	
Annual GWh Saved	3.3
Annual Therms Added	n/a
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	fr,t&d
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.02%
Annual Therms Added/Participant	n/a
Annual MWh Saved/Participant	206
Annual Elec. Savings as % Elec. Sales	0.04%
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	n/a
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	n/a
Utility Contact	Paul Velcenbach
Phone Number	(516) 933 4576

Program Description

Customers switching from electric to gas air conditioning are eligible to receive a rebate of $500 per kW avoided up to a 100 kW maximum. Above 100 kW, customers can receive a $30 per kW avoided.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Madison Gas & Electric
Utility Type	combo
Program	Water Heating Fuel Switch
Program Type	RES:HVAC
Pilot or Full-Scale Program	Full
Program Start Date	1988
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	11000
Annual # Participants	500
Annual # Projects	
Annual GWh Saved	1.5
Annual Therms Added	212876
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	89.1
Annual Indirect Utility Cost (1000s$)	25.3
Annual Total Utility Cost (1000s$)	114.4
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	4.55%
Annual Therms Added/Participant	n/a
Annual MWh Saved/Participant	n/a
Annual Elec. Savings as % Elec. Sales	0.24%
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.27%
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	0.006
Utility Contact	Bob Chrisione
Phone Number	(608) 252 4795

Program Description

This program offers a $100 rebate per water heater switched from MG&E electricity to MG&E natural gas. The participant sends in proof of purchase and gas piping invoices to the utility to receive their rebates.

Comments

The program is promoted through local dealers and through utility advertising and bill insert information.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Madison Gas & Electric
Utility Type	combo
Program	Electric-to-Gas Fuel Switch
Program Type	C&IGNRL
Pilot or Full-Scale Program	Full
Program Start Date	1988
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	n/a
Annual # Participants	n/a
Annual # Projects	
Annual GWh Saved	0.6
Annual Therms Added	638181
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	114.4
Annual Indirect Utility Cost (1000s$)	39.9
Annual Total Utility Cost (1000s$)	154.3
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Annual Therms Added/Participant	n/a
Annual MWh Saved/Participant	n/a
Annual Elec. Savings as % Elec. Sales	0.04%
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.68%
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	0.022
Utility Contact	Bob Chrisione
Phone Number	(608) 252 4795

Program Description

This electric-to-gas fuel-switching program provides incentives to customers to switch particular end-uses. The targeted end-uses are desiccant air-conditioning and gas air-conditioning and other end-uses with high summer electric load that can be switched to gas. Incentives are based on MG&E's custom rebate program. The rebate may not exceed 50% of the project cost or provide the customer with less than a 1 1/2-year payback. The rebate calculation includes variables for the kW and kWh reduction and the project life.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	National Fuel
Utility Type	gas
Program	Appliance Conversion Program
Program Type	RES:GNRL
Pilot or Full-Scale Program	Full
Program Start Date	1988
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	450000
Annual # Participants	79
Annual # Projects	
Annual GWh Saved	0.9
Annual Therms Added	66448
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	117.6
Annual Indirect Utility Cost (1000s$)	35.3
Annual Total Utility Cost (1000s$)	152.9
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.02%
Annual Therms Added/Participant	841
Annual MWh Saved/Participant	11
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.01%
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	0.014
Utility Contact	Philip Goewey
Phone Number	(716) 822 7333

Program Description

The program offers incentives for customers to upgrade gas appliances or to switch electric appliances to high-efficiency gas equipment. Customers installing gas hot water heaters with an energy factor of at least 0.62 were eligible for a $150 rebate per heater. Customers installing 90%+ efficient gas space heaters were eligible for a $300 rebate. Customers installing pilotless, electronic ignition gas cooking and drying equipment were eligible to receive a $35 rebate per piece of equipment.

Comments

Only data on electric-to-gas switches were included here.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	National Fuel
Utility Type	gas
Program	Commercial Building Energy Management
Program Type	C&IGNRL
Pilot or Full-Scale Program	Full
Program Start Date	1991
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	3300
Annual # Participants	3
Annual # Projects	
Annual GWh Saved	0.2
Annual Therms Added	7700
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	1.1
Annual Indirect Utility Cost (1000s$)	2.0
Annual Total Utility Cost (1000s$)	3.1
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.09%
Annual Therms Added/Participant	2567
Annual MWh Saved/Participant	67
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.003%
Cumul. Therms Added as % Gas Sales	0.003%
Annual Levelized Cost ($/kWh)	0.001
Utility Contact	Andy Szajta
Phone Number	(716) 857 7040

Program Description

$1.00/MBtuH input incentive for installation of gas space heating & cooling and water heating equipment.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	National Fuel
Utility Type	gas
Program	ECB - Zero-Interest Loan
Program Type	RES:GNRL
Pilot or Full-Scale Program	Full
Program Start Date	1988
Program End Date	3/92
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	57432
Annual # Participants	209
Annual # Projects	
Annual GWh Saved	0.13
Annual Therms Added	4423
Cumulative GWh Saved	0.14
Cumulative Therms Added	4853
Adjustments	
Annual Direct Utility Cost (1000s$)	0
Annual Indirect Utility Cost (1000s$)	135.5
Annual Total Utility Cost (1000s$)	135.5
Cumul. Direct Utility Cost (1000s$)	0
Cumul. Indirect Utility Cost (1000s$)	412.3
Cumul. Total Utility Cost (1000s$)	412.3
Annual Participation Rate	0.36%
Annual Therms Added/Participant	21
Annual MWh Saved/Participant	1
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.001%
Cumul. Therms Added as % Gas Sales	0.001%
Annual Levelized Cost ($/kWh)	0.084
Utility Contact	Tom Manikowski
Phone Number	(716) 822 7333

Program Description

A zero-interest loan was available to all residential customers who received an audit under the Savings Power program. A variety of gas conservation measures were eligible for the zero-interest loan, as were fuel-switches to 80%+ efficient gas space heating equipment. Only the space heating fuel-switching data is included here.

Comments

The utility now offers low-interest loans, rather than zero-interest loans.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Northern States Power-MN
Utility Type	combo
Program	Furnace & Water Heating Conversion
Program Type	RES:HVAC
Pilot or Full-Scale Program	Full
Program Start Date	1989
Program End Date	11/90
Annual Data Start Date	11/89
Annual Data End Date	10/90
Annual # Eligible Customers	24000
Annual # Participants	1689
Annual # Projects	2534
Annual GWh Saved	n/a
Annual Therms Added	1508270
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	200.3
Annual Indirect Utility Cost (1000s$)	60.1
Annual Total Utility Cost (1000s$)	260.4
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	7.04%
Annual Therms Added/Participant	n/a
Annual MWh Saved/Participant	n/a
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.49%
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	n/a
Utility Contact	Jack Fountain
Phone Number	(612) 229 2437

Program Description

The rebate for converting non-gas water and space heaters to gas equipment is $150. Until 1992, $100 was offered for furnace conversions and $50 for water heater conversions. As of 1992, participants have to convert both water and space heaters to receive the $150 rebate.

Comments

Available during 1990 and 1992 heating seasons, but not in 1991. The change in the incentive structure in 1992 was due to the high free-ridership of the former program.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Orange & Rockland
Utility Type	combo
Program	Non-Electric Cooling Program
Program Type	C&IHVAC
Pilot or Full-Scale Program	Full
Program Start Date	1989
Program End Date	-
Annual Data Start Date	1/90
Annual Data End Date	12/90
Annual # Eligible Customers	13000
Annual # Participants	2
Annual # Projects	
Annual GWh Saved	n/a
Annual Therms Added	346000
Cumulative GWh Saved	
Cumulative Therms Added	n/a
Adjustments	
Annual Direct Utility Cost (1000s$)	412.6
Annual Indirect Utility Cost (1000s$)	43.5
Annual Total Utility Cost (1000s$)	456.1
Cumul. Direct Utility Cost (1000s$)	884.3
Cumul. Indirect Utility Cost (1000s$)	n/a
Cumul. Total Utility Cost (1000s$)	884.3
Annual Participation Rate	0.02%
Annual Therms Added/Participant	173000
Annual MWh Saved/Participant	n/a
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.49%
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	n/a
Utility Contact	Theresa Rohmann
Phone Number	(914) 577 2998

Program Description

Until mid-1992, the air conditioner rebate was $250 per kW deferred. Air conditioners sized above 100 tons were eligible. In order to attract more customers, the program was recently modified. For air conditioners sized under 100 tons, a $380 per ton rebate is offered. For larger units, the rebate has been increased from $250 to $400 per kW deferred.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Pacific Gas & Electric
Utility Type	combo
Program	Natural Gas Homes
Program Type	RES:GNRL
Pilot or Full-Scale Program	Full
Program Start Date	n/a
Program End Date	1989
Annual Data Start Date	3/90
Annual Data End Date	2/91
Annual # Eligible Customers	
Annual # Participants	
Annual # Projects	25379
Annual GWh Saved	35.0
Annual Therms Added	4123000
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	3911.0
Annual Indirect Utility Cost (1000s$)	1173.3
Annual Total Utility Cost (1000s$)	5084.3
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	n/a
Annual Therms Added/Participant	n/a
Annual MWh Saved/Participant	n/a
Annual Elec. Savings as % Elec. Sales	0.15%
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.19%
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	0.012
Utility Contact	Dennis Mahoney
Phone Number	(415) 973 8577

Program Description

An incentive of $200 per home was offered to builders of new homes who installed gas water and space heating. In addition, builders who installed gas dryers and cooking equipment were offered a $20 rebate per unit of equipment.

Comments

The program officially terminated in 1989, although participants who subcribed to the program in late 1989 were carried over into 1990. The program was terminated, according to the utility, because it was a gas marketing program and not an efficiency program. No efficiency standards were required for the gas equipment. The utility has since strengthened its commitment to conservation and will begin offering a residential new construction program, Comfort Homes Program, in spring 1993. The program will -- among other things -- offer rebates to home builders for the installation of high-efficiency gas equipment.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Peoples Gas, Light, & Coke
Utility Type	gas
Program	Gas Air Conditioning Rebate
Program Type	C&IAC
Pilot or Full-Scale Program	Full
Program Start Date	1987
Program End Date	-
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	
Annual # Participants	10
Annual # Projects	
Annual GWh Saved	
Annual Therms Added	1400000
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	1200.0
Annual Indirect Utility Cost (1000s$)	360.0
Annual Total Utility Cost (1000s$)	1560.0
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	
Annual Therms Added/Participant	
Annual MWh Saved/Participant	140000
Annual Elec. Savings as % Elec. Sales	
Cumul. Elec. Savings as % Elec. Sales	
Annual Therms Added as % Gas Sales	
Cumul. Therms Added as % Gas Sales	
Annual Levelized Cost ($/kWh)	
Utility Contact	Charles Janek
Phone Number	(312) 962 4900

Program Description

Rebates are offered for the installation of gas-fired cooling equipment, including gas space cooling as well as process refrigeration equipment. $150/ton is offered for the first 200 tons, and $75/ton thereafter, with a maximum of 1000 tons. In 1992, the $75/ton incentive was reduced to $50/ton.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Peoples Gas Systems
Utility Type	gas
Program	Comm. Electric Resistance Appliance Replacement
Program Type	C&IGNRL
Pilot or Full-Scale Program	Full
Program Start Date	1981
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	9/91
Annual # Eligible Customers	19214
Annual # Participants	1326
Annual # Projects	
Annual GWh Saved	4.6
Annual Therms Added	
Cumulative GWh Saved	9.7
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	58.6
Annual Indirect Utility Cost (1000s$)	17.6
Annual Total Utility Cost (1000s$)	76.2
Cumul. Direct Utility Cost (1000s$)	123.0
Cumul. Indirect Utility Cost (1000s$)	36.9
Cumul. Total Utility Cost (1000s$)	159.9
Annual Participation Rate	6.90%
Annual Therms Added/Participant	
Annual MWh Saved/Participant	
Annual Elec. Savings as % Elec. Sales	
Cumul. Elec. Savings as % Elec. Sales	
Annual Therms Added as % Gas Sales	
Cumul. Therms Added as % Gas Sales	
Annual Levelized Cost ($/kWh)	0.002
Utility Contact	Steve Clark
Phone Number	(813) 272 0032

Program Description

This program offers an incentive of $40/kW deferred to non-residential customers who replace electric appliances with energy-efficient gas appliances. The program applies to all energy-efficient gas appliances including, but not limited to, water heaters and boilers, pulse combustion and other advance technology furnaces, and pulse combustion and other advanced technology fryers and cooking equipment.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Peoples Gas Systems
Utility Type	gas
Program	Gas Space Conditioning Allowance
Program Type	C&IHVAC
Pilot or Full-Scale Program	Full
Program Start Date	1990
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	9/91
Annual # Eligible Customers	n/a
Annual # Participants	3
Annual # Projects	
Annual GWh Saved	7.0
Annual Therms Added	354000
Cumulative GWh Saved	11.7
Cumulative Therms Added	590000
Adjustments	
Annual Direct Utility Cost (1000s$)	17.4
Annual Indirect Utility Cost (1000s$)	5.2
Annual Total Utility Cost (1000s$)	22.6
Cumul. Direct Utility Cost (1000s$)	17.4
Cumul. Indirect Utility Cost (1000s$)	5.2
Cumul. Total Utility Cost (1000s$)	22.6
Annual Participation Rate	n/a
Annual Therms Added/Participant	118000
Annual MWh Saved/Participant	2333
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.16%
Cumul. Therms Added as % Gas Sales	0.26%
Annual Levelized Cost ($/kWh)	0.0003
Utility Contact	Steve Clark
Phone Number	(813) 272 0032

Program Description

Existing gas customers are offered an incentive allowance of $150/ton (maximum 100 tons) to convert from electric space conditioning equipment to energy-efficient gas equipment. The gas equipment must have a COP of at least 0.8.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Peoples Gas Systems
Utility Type	gas
Program	Resid. Electric Resistance Appliance Replacement
Program Type	RES:GNRL
Pilot or Full-Scale Program	Full
Program Start Date	1981
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	9/91
Annual # Eligible Customers	152285
Annual # Participants	12285
Annual # Projects	
Annual GWh Saved	42.8
Annual Therms Added	
Cumulative GWh Saved	163.6
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	4361.2
Annual Indirect Utility Cost (1000s$)	1308.4
Annual Total Utility Cost (1000s$)	5669.6
Cumul. Direct Utility Cost (1000s$)	15268.5
Cumul. Indirect Utility Cost (1000s$)	4580.6
Cumul. Total Utility Cost (1000s$)	19849.1
Annual Participation Rate	8.07%
Annual Therms Added/Participant	
Annual MWh Saved/Participant	
Annual Elec. Savings as % Elec. Sales	
Cumul. Elec. Savings as % Elec. Sales	
Annual Therms Added as % Gas Sales	
Cumul. Therms Added as % Gas Sales	
Annual Levelized Cost ($/kWh)	0.018
Utility Contact	Steve Clark
Phone Number	(813) 272 0032

Program Description

Any current or potential residential customer who replaces electric water heaters, strip central heaters, cooking equipment, clothes dryers, or space heaters with energy-efficient gas equipment is eligible to receive an incentive under this program.
The water heaters must comply with ASHRAE 90 standards. The gas furnaces must be pilotless with an AFUE of at least 0.75. All other gas appliances must use electronic ignition and have no standing pilot light. The incentives are as follows: (1) $440/ water heater; (2) $440/central strip heaters; (3) $75/range; (4) $75/dryer; and (5) $65/ space heater.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Peoples Gas Systems
Utility Type	gas
Program	Residential Home Builder
Program Type	RES:HVAC
Pilot or Full-Scale Program	Full
Program Start Date	1981
Program End Date	-
Annual Data Start Date	10/90
Annual Data End Date	9/91
Annual # Eligible Customers	n/a
Annual # Participants	376
Annual # Projects	
Annual GWh Saved	2.7
Annual Therms Added	91744
Cumulative GWh Saved	25.7
Cumulative Therms Added	876448
Adjustments	
Annual Direct Utility Cost (1000s$)	219.96
Annual Indirect Utility Cost (1000s$)	66.0
Annual Total Utility Cost (1000s$)	285.9
Cumul. Direct Utility Cost (1000s$)	2101.3
Cumul. Indirect Utility Cost (1000s$)	630.4
Cumul. Total Utility Cost (1000s$)	2731.7
Annual Participation Rate	n/a
Annual Therms Added/Participant	244
Annual MWh Saved/Participant	7
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.26%
Cumul. Therms Added as % Gas Sales	2.50%
Annual Levelized Cost ($/kWh)	0.008
Utility Contact	Steve Clark
Phone Number	(813) 272 0032

Program Description

Any builder of a new single family residential dwelling unit who installs energy-efficient gas-fired space and water heating equipment is eligible for an incentive under this program. The incentive is in the form of a cash allowance which covers approximately 70% of the incremental costs of construction associated with piping and venting. On average, the incentive is roughly $670 per home.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Public Service E&G
Utility Type	combo
Program	C&I Gas Air Conditioning Program
Program Type	C&IHVAC
Pilot or Full-Scale Program	Full
Program Start Date	1989
Program End Date	12/92
Annual Data Start Date	1/91
Annual Data End Date	12/91
Annual # Eligible Customers	5000
Annual # Participants	4
Annual # Projects	
Annual GWh Saved	3.4
Annual Therms Added	714153
Cumulative GWh Saved	6.6
Cumulative Therms Added	1381908
Adjustments	
Annual Direct Utility Cost (1000s$)	558.5
Annual Indirect Utility Cost (1000s$)	3.5
Annual Total Utility Cost (1000s$)	562.0
Cumul. Direct Utility Cost (1000s$)	965.3
Cumul. Indirect Utility Cost (1000s$)	32.7
Cumul. Total Utility Cost (1000s$)	998.0
Annual Participation Rate	0.08%
Annual Therms Added/Participant	178538
Annual MWh Saved/Participant	850
Annual Elec. Savings as % Elec. Sales	0.01%
Cumul. Elec. Savings as % Elec. Sales	0.02%
Annual Therms Added as % Gas Sales	0.06%
Cumul. Therms Added as % Gas Sales	0.12%
Annual Levelized Cost ($/kWh)	0.013
Utility Contact	Charles Coccaro
Phone Number	(201) 430 7245

Program Description

The program offered rebates for installation of gas-fired air conditioners as follows: (1) $125/ton for replacement of electric A/C with gas absorption unit; (2) $75/ton for replacement of old gas-fired A/C unit with new unit; (3) $50/ton for installation of gas-fired engine-driven chillers. A minimum of 100 tons must be installed. In addition, the participant had to operate the newly installed equipment using PSE&G gas for at least 5 years.

Comments

As of January 1993, all C&I conservation rebate programs are no longer offered. Instead, PSE&G offers a C&I "Standard Offer" program which is a bidding-type of conservation program which rolls in all the measures formerly offered under C&I rebate programs.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	San Diego G&E
Utility Type	combo
Program	Gas Air Conditioning
Program Type	C&IHVAC
Pilot or Full-Scale Program	Full
Program Start Date	n/a
Program End Date	-
Annual Data Start Date	3/90
Annual Data End Date	2/91
Annual # Eligible Customers	715
Annual # Participants	9
Annual # Projects	
Annual GWh Saved	18.6
Annual Therms Added	3164764
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	645.5
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	1.26%
Annual Therms Added/Participant	351640
Annual MWh Saved/Participant	2067
Annual Elec. Savings as % Elec. Sales	0.23%
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	1.40%
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	0.003
Utility Contact	Linda Linderman
Phone Number	(619) 699 5083

Program Description

The incentive for installing gas air conditioners ranges from $50 to $500 per kW shifted depending on the size of the equipment.

Comments

The program also provides incentives for customers who replace electric air conditioners with thermal energy storage systems. The data reported here is for the gas air conditioning portion of the program.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Snohomish County PUD & Washington Natural Gas
Utility Type	elec & gas
Program	Water Heater Fuel-Switching Program
Program Type	RES:HVAC
Pilot or Full-Scale Program	Pilot
Program Start Date	1991
Program End Date	6/91
Annual Data Start Date	2/91
Annual Data End Date	5/91
Annual # Eligible Customers	1400
Annual # Participants	209
Annual # Projects	
Annual GWh Saved	0.92
Annual Therms Added	
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	62.1
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	14.93%
Annual Therms Added/Participant	n/a
Annual MWh Saved/Participant	4
Annual Elec. Savings as % Elec. Sales	0.03%
Cumul. Elec. Savings as % Elec. Sales	0.03%
Annual Therms Added as % Gas Sales	n/a
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	0.005
Utility Contact	Gary Lintz
Phone Number	(206) 258 8324

Program Description

This joint utility program offers customers incentives equal to those offered previously by Washington Natural Gas. The difference with this program was that both utilities printed their logos on promotional literature to customers, and representatives from both utilities attended in-house meetings with prospective participants. Customers who replaced electric water heaters with 58%+ efficient heaters could lease direct vent heaters for $4.90/month and standard vent heaters for $3.05/month. In addition, up to $200 in installation fees were waived. Participants received a one-year guarantee, and could have an electric heater installed if dissatisfied.

Comments

Presently, a full-scale version of this program is not being offered, even though both utilities reported that the pilot was a success. The program attracted 3 times the participation than a similar program offered earlier by the gas utility.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Washington Water Power
Utility Type	combo
Program	Switch Saver (loan only)
Program Type	RES:HVAC
Pilot or Full-Scale Program	Pilot
Program Start Date	1991
Program End Date	7/91
Annual Data Start Date	3/91
Annual Data End Date	7/91
Annual # Eligible Customers	8452
Annual # Participants	120
Annual # Projects	
Annual GWh Saved	1.2
Annual Therms Added	49650
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	208.4
Annual Indirect Utility Cost (1000s$)	98.1
Annual Total Utility Cost (1000s$)	306.5
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	1.42%
Annual Therms Added/Participant	414
Annual MWh Saved/Participant	10
Annual Elec. Savings as % Elec. Sales	0.04%
Cumul. Elec. Savings as % Elec. Sales	0.04%
Annual Therms Added as % Gas Sales	0.03%
Cumul. Therms Added as % Gas Sales	0.03%
Annual Levelized Cost ($/kWh)	0.020
Utility Contact	Bill Johnson
Phone Number	(509) 482 4046

Program Description

The incentive for single and multi-family participants to switch from electric space and water heating was the availability 12% financing for the cost of materials and installation.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Washington Water Power
Utility Type	combo
Program	Switch Saver (shared savings)
Program Type	RES:HVAC
Pilot or Full-Scale Program	Pilot
Program Start Date	1991
Program End Date	7/91
Annual Data Start Date	3/91
Annual Data End Date	7/91
Annual # Eligible Customers	4526
Annual # Participants	786
Annual # Projects	
Annual GWh Saved	7.5
Annual Therms Added	334120
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	fr
Annual Direct Utility Cost (1000s$)	
Annual Indirect Utility Cost (1000s$)	
Annual Total Utility Cost (1000s$)	1299.2
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	17.37%
Annual Therms Added/Participant	425
Annual MWh Saved/Participant	10
Annual Elec. Savings as % Elec. Sales	0.26%
Cumul. Elec. Savings as % Elec. Sales	0.26%
Annual Therms Added as % Gas Sales	0.18%
Cumul. Therms Added as % Gas Sales	0.18%
Annual Levelized Cost ($/kWh)	0.014
Utility Contact	Bill Johnson
Phone Number	(509) 482 4046

Program Description

The incentive for single and multi-family participants to switch from electric space and water heat was 100% up-front funding of the installation costs, with the customer paying back the utility through monthly savings charges over a 5-year period. Up to $4,400 per joint water/spcae heater change-out and $850 per water heater change-out were offered by the utility.

Comments

The utility is now offering a full-scale, modified version of this program.

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Wisconsin Fuel & Light
Utility Type	gas
Program	Electric-to-Gas Water Heater Program
Program Type	RES:HVAC
Pilot or Full-Scale Program	Full
Program Start Date	n/a
Program End Date	8/91
Annual Data Start Date	1/90
Annual Data End Date	1/91
Annual # Eligible Customers	43223
Annual # Participants	125
Annual # Projects	
Annual GWh Saved	n/a
Annual Therms Added	48000
Cumulative GWh Saved	
Cumulative Therms Added	
Adjustments	
Annual Direct Utility Cost (1000s$)	8.8
Annual Indirect Utility Cost (1000s$)	2.6
Annual Total Utility Cost (1000s$)	11.4
Cumul. Direct Utility Cost (1000s$)	
Cumul. Indirect Utility Cost (1000s$)	
Cumul. Total Utility Cost (1000s$)	
Annual Participation Rate	0.29%
Annual Therms Added/Participant	384
Annual MWh Saved/Participant	n/a
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.11%
Cumul. Therms Added as % Gas Sales	n/a
Annual Levelized Cost ($/kWh)	n/a
Utility Contact	Tim Brick
Phone Number	(414) 682 8241

Program Description

Participants were offered an incentive equal to 10% of cost of materials & installation of the gas water heater.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Wisconsin Natural Gas
Utility Type	gas
Program	Gas Air Conditioning Program
Program Type	C&IHVAC
Pilot or Full-Scale Program	Full
Program Start Date	1989
Program End Date	-
Annual Data Start Date	1/90
Annual Data End Date	1/91
Annual # Eligible Customers	22000
Annual # Participants	1
Annual # Projects	
Annual GWh Saved	n/a
Annual Therms Added	32500
Cumulative GWh Saved	
Cumulative Therms Added	65000
Adjustments	
Annual Direct Utility Cost (1000s$)	6.85
Annual Indirect Utility Cost (1000s$)	0.05
Annual Total Utility Cost (1000s$)	6.9
Cumul. Direct Utility Cost (1000s$)	13.7
Cumul. Indirect Utility Cost (1000s$)	0.1
Cumul. Total Utility Cost (1000s$)	13.8
Annual Participation Rate	0.005%
Annual Therms Added/Participant	32500
Annual MWh Saved/Participant	n/a
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.02%
Cumul. Therms Added as % Gas Sales	0.04%
Annual Levelized Cost ($/kWh)	n/a
Utility Contact	Jeff Klarer
Phone Number	(414) 635 2257

Program Description

Rebates for the installation of gas air conditioners are as follows: (1) steam absorption chillers with a COP of at least 0.9 receive $100/ton; (2) gas engine-driven chillers with a COP of at least 1.2 receive $125/ton; (3) direct-fired absorption chillers with a COP of at least 0.9 receive $150/ton. In addition, a gas cooling credit is offered to participants whose summer air conditioning usage is at least 50% of their total gas summer load. The peak demand charges for the 5 summer months are waived for these customers. According to the utility, this credit equals about $0.08/therm.

Comments

APPENDIX D. ELECTRIC-TO-GAS SUBSTITUTION PROGRAM DATA

Utility	Wisconsin Natural Gas
Utility Type	gas
Program	Gas Space & Water Heating
Program Type	C&IHVAC
Pilot or Full-Scale Program	Full
Program Start Date	1989
Program End Date	-
Annual Data Start Date	1/90
Annual Data End Date	12/90
Annual # Eligible Customers	22000
Annual # Participants	9
Annual # Projects	
Annual GWh Saved	n/a
Annual Therms Added	38500
Cumulative GWh Saved	
Cumulative Therms Added	87600
Adjustments	
Annual Direct Utility Cost (1000s$)	13.3
Annual Indirect Utility Cost (1000s$)	50.2
Annual Total Utility Cost (1000s$)	63.5
Cumul. Direct Utility Cost (1000s$)	36.2
Cumul. Indirect Utility Cost (1000s$)	125
Cumul. Total Utility Cost (1000s$)	161.2
Annual Participation Rate	0.04%
Annual Therms Added/Participant	4529
Annual MWh Saved/Participant	n/a
Annual Elec. Savings as % Elec. Sales	n/a
Cumul. Elec. Savings as % Elec. Sales	n/a
Annual Therms Added as % Gas Sales	0.02%
Cumul. Therms Added as % Gas Sales	0.05%
Annual Levelized Cost ($/kWh)	n/a
Utility Contact	Jeff Klarer
Phone Number	(414) 635 2257

Program Description

Rebates equal to 15% of the installation costs of equipment are offered for the replacement of electric heaters or inefficient gas heaters with efficient gas heaters. Conventional vent water heaters must have an EF between 0.58 and 0.60, depending on the size. Direct vent water heaters must have an EF between 0.55 and 0.57, depending on the size. All infrared space heaters qualify; furnaces must have an 88%+ AFUE rating; boilers and roof-top units must have a 80%+ AFUE rating. Rebates are also offered for space heating controls: (1) 15% of the total costs of boiler cutouts, boiler resets, and setback thermostats is offered; (2) rebate for boiler tune-ups equal $100 per tune-up; (3) for steam trap repair, up to $30 per steam trap is offered, with a miaxumum of 50 steam traps per year; (4) steam trap surveys (to determine which traps are no good) receive a rebate of $3 per steam trap, up to 100 traps per year.

Comments

APPENDIX E
NYGAS OBSERVATIONS

Although NYGAS believes that this study is a good first step in identifying the potential for gas DSM, NYGAS would like to caution the reader in drawing definitive conclusions. NYGAS's concerns are based both on methodological issues and the electric DSM experience with technical vs. achievable potential.

RESIDENTIAL/COMMERCIAL DSM

NYGAS has several concerns regarding the methodology used in this study. Since the implementation and evaluation of gas DSM programs have been limited, it is difficult to determine the impact of our concerns at this time. Only after the utilities have gained practical experience with gas DSM pilot programs and have attained field research data can these concerns be resolved with confidence.

However, we do believe that several factors may have contributed to overstating the gas DSM potential:

I. SAVINGS POTENTIAL

a. The methodology used to determine gas DSM savings examined the incremental efficiency of each additional measure, adjusting for the interactivity of the already installed measures and the added measure. It is uncertain as to whether or not this approach accurately simulates the actual interaction of measures and a customer's installation choices.

b. The ACEEE model consistently overestimates the 1991 gas sales for all three companies and overestimates by 45% for one upstate test site (NFG service territory). One downward calibration adjustment was used to adjust all modeled data (each measure and each housing prototype) for each company. While this is an approach frequently used in technical potential studies, the magnitude of the calibration for NFG is a concern and should be addressed in further research.

c. NYGAS believes that the ACEEE model inadequately addresses the heat transfer between fully attached housing stock and thereby overestimates the heat loss of such stock. This observation is based on colloquial field experience.

II. ECONOMIC POTENTIAL

The economic potential portion of this study may also be overrated.

a. There are additional costs associated with various measures which are not considered. For example, contractor training and quality control procedures which are recommended in the report are not accounted for in the economic analysis.

b. In addition, programs that appear cost-effective may not be economic in practice. Low participation rates may require supplemental costs to effectively market the programs. This is substantiated by the practical experiences of the Center for Neighborhood Technology which discontinued its programs because they were not cost-effective due to lower than expected participation rates.

FUEL SWITCHING

The data and gas equipment technologies originally used in this study are in most cases three or more years old. In addition, several studies referenced when drawing conclusions are old and may be out-dated.

For example, the conclusions in the Residential Fuel-Switching Section did not include the York 3-ton gas heat pump (due to be commercialized in 1994) which may be cost-effective for residential applications.

For commercial fuel switching several new technologies have emerged during the last three years and have not been included in this study. A listing of these technologies can be found in Chapter 5, the Economics of Commercial Gas Fuel Switching for Space Heating and Cooling.

In conclusion, NYGAS believes that this study represents a good first step in estimating energy-efficiency potential. However, better information resulting from implementation and evaluation of utility pilot programs is needed to establish statewide energy policy.